GREENHOUSE GAS EMISSIONS
OF WATER USE AND WASTEWATER GENERATION
BY MUNICIPAL FACILITIES IN SONOMA COUNTY

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Table of Contents

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EXECUTIVE SUMMARY

The purpose of this report was to estimate the energy embedded in water use and wastewater generation by municipal facilities in Sonoma County, California. This is provided in **Table 2.** These values were then entered into software developed by the International Council for Local Environmental Initiatives (ICLEI) for their Climate Protection Campaign, to calculate greenhouse gas (GHG) emissions.

TABLE 2

Embedded Energy Use for Water and Wastewater in Municipal Facilities
Electricity and natural gas purchased from PG&E and NCPA (Healdsburg).

	BUILDINGS					PARKS		
	Floor ft^2	FY00-01 Electricity MWhr	FY01-02 Electricity MWhr	FY00-01 N.gas therms	FY01-02 N.gas therms	Irrigated acres	FY00-01 Electricity MWhr	FY01-02 Electricity MWhr
Sebastopol	26,650	9	8	109	129	6	24	21
Cotati	20,000	10	9	108	145	23	66	67
Sonoma	73,235	16	16	0	0	41	117	115
Rohnert Park	217,172	99	100	1,063	1,425	93	221	234
Windsor	43,400	39	41	0	0	105	226	221
Petaluma	479,446	80	78	0	0	214	428	419
Healdsburg	74,780	28	29	0	0	39	142	141

Table 3 shows the GHG emissions related to water use and wastewater generation by the municipal facilities, and reveals that, as expected, they are very small compared to total GHG emissions from water and wastewater systems serving the entire city's.

TABLE 3

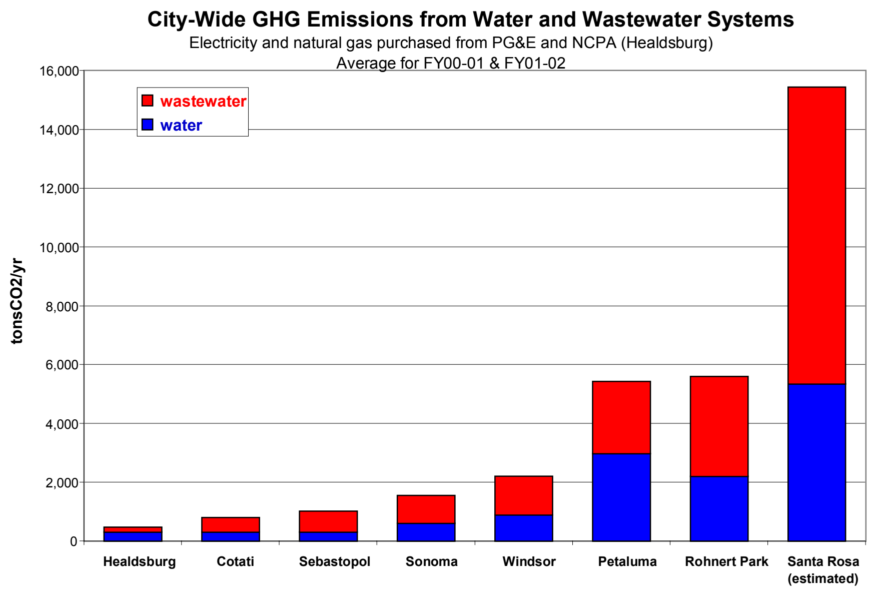
Water and Wastewater GHG Emissions from Municipal Facilities

Electricity and natural gas purchased from PG&E and NCPA (Healdsburg).
Total is for water/wastewater for the entire city (average FY00-01 & FY01-02)

	BUILDINGS FY00-01 tons-CO_2	BUILDINGS FY01-02 tons-CO_2	PARKS FY00-01 tons-CO_2	PARKS FY01-02 tons-CO_2	BLDS+PARKS FY00-02 avg. % of total
Sebastopol	4	4	9	8	1%
Cotati	4	4	24	24	4%
Sonoma	6	6	43	42	3%
Rohnert Park	43	45	80	85	2%
Windsor	14	15	82	80	4%
Petaluma	29	28	156	153	3%
Healdsburg	4	4	21	21	5%

Fig.2 shows the city-wide GHG emissions in Sonoma County. The most immediate conclusion is that decisions about city-wide water and wastewater systems will have a far greater impact than decisions about water use in individual municipal facilities. For example, a decision about replacing an older well pump with a new high-efficiency pump will have a far greater impact than replacing the toilets in City Hall. Decisions about infrastructure, such as choosing the preferred option for upgrading a wastewater treatment plant, will have even more impact.

FIG.2



Calculation of the values in **Table 2 and Table 3** first required careful analysis of water and wastewater systems serving the entire city, and construction of an exhaustive database that will provide a very useful basis for identifying cost-effective reductions in GHG emissions. For example, measurements after upgrading aeration blowers at the Laguna de Santa Rosa Subregional Wastewater Treatment Plant already reveal savings of $175 per tons-$CO_2$ removed. Estimates from an evaluation of energy efficiency for Sonoma County Water Agency's main water supply pumps project savings of $320 per tons-$CO_2$ removed. Energy-efficiency design modifications are underway for two of the Laguna de Santa Rosa Subregional Wastewater Treatment Plant's reclaimed wastewater irrigation pump stations; projected savings are $290-320 per tons-$CO_2$ removed.

A practical way for municipalities to implement a cost-effective GHG emissions reduction program would be to evaluate energy-efficiency alternatives, any time water or wastewater equipment needs replacement or expensive maintenance work. Even before triggering replacement or maintenance, the database assembled for this report could be disaggregated to identify equipment with low energy efficiency, which could be replaced cost-effectively while attracting low interest loans from the California Energy Commission.

Besides GHG reductions from Sonoma County Water Agency's main water supply pumps, the analysis performed for this report reveals that even small improvements in urban landscape irrigation efficiency could result in very large reductions in the Agency's GHG emissions. Thus the Agency faces very little risk from joining the Climate Protection Campaign; in all probability, it could quickly become the highest performer, not only in the North Bay, but nationally.

INTRODUCTION

This report evaluates the Greenhouse Gas (GHG) emissions of water use and wastewater generation by municipal facilities in Sonoma County, California. The facilities include administration buildings, police and fire stations, and parks; essentially any facility in which municipal employees work, and/or where the municipality pays water and wastewater bills. The cities covered in this report are:

- Sebastopol
- Cotati
- Sonoma
- Windsor
- Rohnert Park
- Petaluma
- Healdsburg

GHG emissions are measured in tons of Carbon Dioxide equivalents[1] (tons-CO_2). The GHG emissions in this report were calculated from energy purchased to operate water supply and wastewater treatment, reclamation, and disposal. The focus on purchased energy is in accordance with the guidelines established by the International Council for Local Environmental Initiatives (ICLEI) for their Climate Protection Campaign.

[1] Other gases, such as methane, also have a greenhouse gas effect.

For water and wastewater systems in Sonoma County, purchased energy includes electricity and natural gas[2]. GHG emissions are produced at the electric utilities' generating plants, and from burning natural gas at wastewater treatment plants. For example, given that the average GHG emissions for PG&E's electricity plants is 0.729 lb-CO_2/KWhr[3], if 1,000 MWhr[4] is purchased from PG&E to pump 100 million gallons (MG) of water from a well, then the well's GHG emissions would be 364.5 tons-CO_2/yr. If 2 MG of this water were used at City Hall, then City Hall's embedded GHG emissions would be 7.29 tons-CO_2.

For water, GHG emissions in this report include energy used by wells and distribution system booster pumps. Some cities receive water from the Sonoma County Water Agency (SCWA), so a fraction of SCWA's GHG emissions are allocated to the city, based on volume.

For wastewater, GHG emissions in this report include energy used by sewage lift pumps, wastewater treatment plants (including natural gas), and pumps for irrigation with reclaimed wastewater. Sebastopol, Cotati, Rohnert Park, and Santa Rosa utilize the Laguna de Santa Rosa Subregional Wastewater Treatment Plant (Laguna Plant), and the plant's GHG emissions are allocated to each city according to wastewater influent volume.

Energy for water and wastewater systems is used and metered for equipment serving an entire city rather than individual municipal facilities. In this report, the embedded energy for an individual facility is estimated from the volumes of water used and wastewater generated by the facility. Using the same example as before, if 1,000 MWhr from PG&E is used to supply 100 MG of water to the entire city, and 2 MG are used at City Hall, City Hall's embedded water supply energy would be 20 MWhr (the embedded GHG emissions would be 7.29 tons-CO_2).

Wastewater volumes for facilities in all cities were estimated from water usage and from each city's community-wide split between indoor and outdoor usage (water used indoors is overwhelmingly discharged to sewer, while outdoor use is mostly for landscape irrigation, i.e. not discharged to sewer). Continuing the previous example, if half of the water supplied to the entire city is eventually discharged as wastewater, City Hall's wastewater volume would be 1 MG. If the wastewater treatment system uses 2,000 MWhr from PG&E to treat the city's entire 50 MG of wastewater, City hall's embedded wastewater treatment energy would be 40 MWhr (the embedded GHG emissions would be 14.58 tons-CO_2).

Only Sebastopol had water meter records for municipal buildings and parks; water usage in other cities was estimated from unit water usage in Sebastopol. To check the range of estimated volumes for each facility, unit water usage was calculated per floor area (gallons/ft^2) and per employee or regular occupant (gallons/person). We recommend that water meters be installed at all municipal facilities, to prevent waste and quantify the effectiveness of efficiency improvements – which should simultaneously reduce costs and GHG emissions.

[2] A relatively insignificant quantity of diesel fuel is used in emergency backup generators, and is not included in this report.
[3] 2,000 lb-CO_2 = 1 tons-CO_2
[4] 1 MWhr = 1,000 KWhr

This report begins by briefly explaining the methodology used to calculate the embedded energy of water and wastewater. The results section of the report first presents a summary of embedded water/wastewater related energy for municipal facilities in each city, as needed by the ICLEI software to calculate their GHG emissions inventory. The results section also discusses city-wide embedded water/wastewater energy and GHG emissions, and compares the cities. To demonstrate the usefulness of the GHG inventory, and the realistic potential for cost effective reduction of GHG emissions, the results section examines the SCWA water supply system and the Laguna Plant in detail. The report ends with a summary of conclusions and recommendations.

METHODOLOGY

This section only summarizes the methodology; details, including quality assurance, are available in a separate report at www.skymetrics.us.

The general method for calculating the embedded energy of water and wastewater for each municipal facility used in this report was:

- Obtain unit GHG emissions factors for electricity generation and for natural gas.
- Obtain monthly energy-use data for systems serving the entire city.
- Obtain monthly volumes of water supply, wastewater treatment plant influent, and reclaimed wastewater irrigation for the entire city.
- Calculate for the entire city, the monthly split between indoor and outdoor water usage, and the monthly unit energy use for water and wastewater.
- Determine the floor areas and number of regular occupants for each municipal building, and the irrigated areas of each city park.
- Calculate annual unit water use for Sebastopol municipal facilities (the only city where annual water usage is metered).
- Calculate the annual water use for each municipal facility in other cities by applying Sebastopol's unit values.
- Calculate monthly water supply and wastewater discharge volumes for each facility.
- Calculate monthly embedded energy for water and wastewater for each facility.
- Calculate annual GHG emissions for each facility.

All cities in this report, except Healdsburg obtain electricity from PG&E, which relies mainly on fossil-fueled plants but also utilizes a significant number of hydro-electric plants. Healdsburg purchases electricity from the Northern California Power Authority (NCPA), which relies mainly on hydro-electricity, but has significant component of natural gas fired plants. For its water supply system, SCWA obtains 25% of its electricity from the hydro-electric plant of the Western Area Power Administration (WAPA), and 75% from PG&E. **Table 1** shows the annual average unit GHG emissions (tons-CO_2/KWhr) for PG&E, NCPA, and WAPA. **Table 1** also shows the unit GHG emission from the combustion of PG&E's natural gas.

TABLE 1

Annual Average Unit GHG Emissions Factors for Purchased Energy[5]

	Electricity	N.Gas
	tons-CO_2/KWhr	tons-CO_2/therm
PG&E[6]	0.729	12.34
NCPA[7]	0.299	-
WAPA[8]	0	-

A database of all energy (electricity and N.gas) accounts for municipal facilities was complied for each city in Fiscal Years 2000-2001 and 2001-2002. The databases were "mined" to extract monthly energy use and cost for wells, booster pumps, sewage lift stations, wastewater treatment plants, and pump stations for irrigation with reclaimed wastewater.

For SCWA, we obtained data from PG&E, from SCWA's central SCADA system, and WAPA monthly invoices. The energy data from SCWA also covered wastewater operations for the City of Sonoma[9]. For the Laguna Plant, including the reclamation system, we obtained information from PG&E.

[5] Derived by Provimetrics (see our companion report, *Electricity and Natural Gas*) from a combination of information provided by ICLEI, PG&E, NCPA, and WAPA. Although the annual average includes higher GHG emissions from "peaker" plants, we did not have sufficient information to calculate unit emissions for different seasons.
[6] Provided by ICLEI.
[7] Specifically for Healdsburg, based on NCPA's allocation of generation plant capacity to the city (reported by Bill Duarte, City of Healdsburg).
[8] WAPA's hydroelectricity has no GHG emissions. WAPA does purchase some peak summer power from other utilities, and beginning in 2005, WAPA will allocate their costs and GHG emissions directly to members (similarly to NCPA).
[9] SCWA operates the Sonoma Valley County Sanitation District, including sewage lift stations, the wastewater treatment plant, and reclaimed wastewater system.

After gathering energy data for water and wastewater systems serving an entire city, allocations must be made to individual municipal facilities. The most rational basis for allocation is by volume of water supplied to, and wastewater generated by, each facility.

Utilizing the city-wide unit energy use (MWhr/MG) for water and for wastewater, the embedded energy for each facility can be calculated. For example, if all the wells and booster pumps use 1,000 MWhr of electricity to supply 100 MG of water, unit energy use for the city's water supply is 10 MWhr/MG. Then if City Hall uses 2 MG, the embedded energy of water will be 20 MWhr.

To calculate city-wide unit energy use for water, we obtained monthly data for volumes supplied (a) by SCWA to each city, from SCWA's central SCADA computer, and (b) by each local well, from city records. Monthly unit energy use for water supply is calculated by dividing monthly energy use[10] by the total monthly water supply volume.

Wastewater volumes for facilities in all cities were estimated from water usage and from each city's community-wide split between indoor and outdoor usage. Water used indoors is overwhelmingly discharged to sewer, while outdoor use is mostly for landscape irrigation, and not discharged to sewer.

Indoor use is estimated from the lowest monthly water supply volume in winter, when the demand for landscape irrigation volume is (or should be) insignificant. For the Sonoma County cities analyzed in this report, indoor use is fairly constant, so it used to represent a constant monthly wastewater volume. By implication, outdoor use varies greatly from month to month as the demand for landscape irrigation changes (verification of this assumption is discussed in the separate methodology report).

Continuing the previous example for water, if half of the water supplied to the entire city is eventually discharged as wastewater, City Hall's wastewater volume would be 1 MG. If the wastewater treatment system uses 2,000 MWhr of electricity to treat the city's entire 50 MG of wastewater, unit energy use for wastewater would be 40 MWhr/MG. City Hall's embedded wastewater treatment energy would then be 40 MWhr.

Only Sebastopol had water meter records of annual water usage by buildings and parks[11], and none of the facilities in any of the cities had wastewater meters[12]. Annual water usage for all municipal facilities was therefore estimated from annual average unit water usage in Sebastopol, from floor area (in gallons/ft), and from the number of regular occupants (in gallons/person). Although the assumption of equal unit water use for similar facilities in different cities seems doubtful, the results from independent calculations based on floor area and occupants were very close (details in the separate methodology report). In the absence of measured data, this was the best, and only indication of validity.

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[10] By all local wells, pressure booster pumps, and SCWA water supply energy (allocated according to the fraction of water supplied to the city, divided by SCWA's total energy use for water supply).
[11] Petaluma has water meters at municipal facilities, but records were not available for this report.
[12] The lack of wastewater metering is not unusual, nor necessary if water meters are available.

Monthly water use by each facility was calculated by multiplying the estimated annual water use for each facility by the monthly distribution factor of water supply to the entire city[13]. Monthly wastewater discharge from each municipal facility was then calculated by multiplying its monthly water use by the monthly distribution factor of indoor water usage for the entire city[14]. Monthly outdoor usage for landscape irrigation is calculated by subtracting indoor use from total monthly water supply. For city parks, we assume that all water is used for irrigation and none is discharged to sewer.

Embedded energy of water and wastewater for each municipal facility is calculated by multiplying the monthly water (or wastewater) usage for each facility by the monthly unit energy use for the entire city, for water (or wastewater). To prepare for the calculation of GHG emissions, separate calculations must be made for electricity and natural gas. For SCWA water supply, electricity purchased from WAPA must be separated from purchases from PG&E.

The final step is to calculate annual GHG emissions by multiplying the sum of monthly energy use (separated by source) by the GHG emissions factors in **Table 1**.

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[13] Each month's distribution factor was calculated by dividing the monthly volume by the total annual volume.
[14] Each month's distribution factor was calculated by dividing the monthly indoor volume for the entire city by the total monthly water supply for the entire city. Although the assumption is that monthly indoor use (and therefore wastewater generation) is fairly constant in volume throughout the year, the distribution fraction is highly variable because of changing outdoor use.

RESULTS

Municipal Facilities

Table 2 summarizes the embedded purchased energy for water use and wastewater generation by municipal facilities in the cities covered by this report. The reason for separating buildings from parks is because irrigation does not generate wastewater. Differences between the cities are caused mainly by the size and number of municipal facilities and parks, and to a lesser extent by population, micro-climate, and energy use for wastewater.

TABLE 2

Embedded Energy Use for Water and Wastewater in Municipal Facilities

Electricity and natural gas purchased from PG&E and NCPA (Healdsburg).

	BUILDINGS					PARKS		
	Floor ft²	FY00-01 Electricity MWhr	FY01-02 Electricity MWhr	FY00-01 N.gas therms	FY01-02 N.gas therms	Irrigated acres	FY00-01 Electricity MWhr	FY01-02 Electricity MWhr
Sebastopol	26,650	9	8	109	129	6	24	21
Cotati	20,000	10	9	108	145	23	66	67
Sonoma	73,235	16	16	0	0	41	117	115
Rohnert Park	217,172	99	100	1,063	1,425	93	221	234
Windsor	43,400	39	41	0	0	105	226	221
Petaluma	479,446	80	78	0	0	214	428	419
Healdsburg	74,780	28	29	0	0	39	142	141

Table 3 shows the GHG emissions associated with the municipal facilities water/wastewater energy use, and their tiny fraction of each city's entire GHG emissions for water and wastewater. The implication is that municipal activities and decisions regarding water and wastewater systems for the entire city will have a far greater impact than focusing only on municipal facilities. Examples include upgrading well pumps, expanding the use of reclaimed wastewater, and developing city-wide water efficiency programs.

TABLE 3

Water and Wastewater GHG Emissions from Municipal Facilities

Electricity and natural gas purchased from PG&E and NCPA (Healdsburg).
Total is for water/wastewater for the entire city (average FY00-01 & FY01-02)

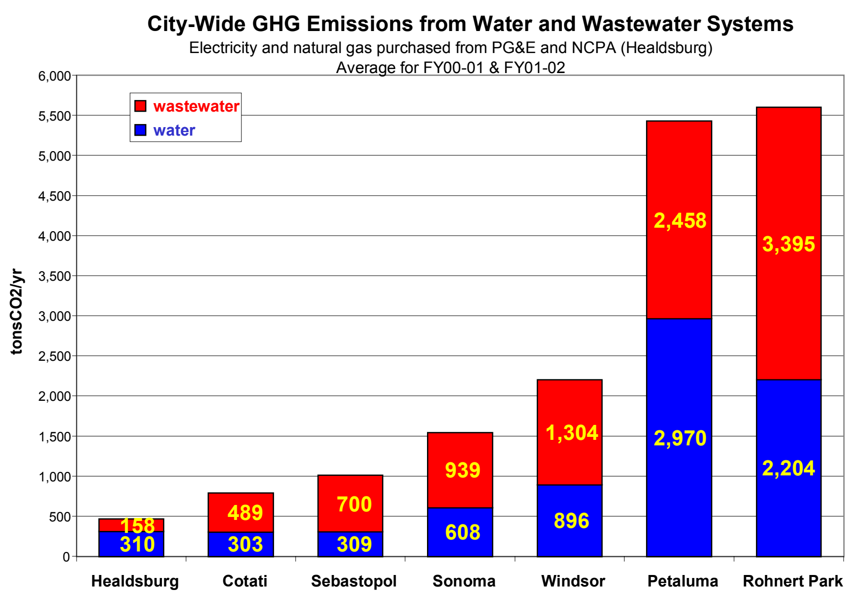
	BUILDINGS FY00-01 tons-CO_2	BUILDINGS FY01-02 tons-CO_2	PARKS FY00-01 tons-CO_2	PARKS FY01-02 tons-CO_2	BLDS+PARKS FY00-02 avg. % of total
Sebastopol	4	4	9	8	1%
Cotati	4	4	24	24	4%
Sonoma	6	6	43	42	3%
Rohnert Park	43	45	80	85	2%
Windsor	14	15	82	80	4%
Petaluma	29	28	156	153	3%
Healdsburg	4	4	21	21	5%

Comparisons between Cities

The intended purpose of this report was to produce **Table 2** for the municipal facilities, but we believe that the most useful information is from the city-wide data and calculations required to produce the table.

Fig.1 compares the GHG emissions, for water and for wastewater for all the cities covered in this report. The most obvious influence is population, which drives the total volume of water used and wastewater generated, and **Fig.2** adds Santa Rosa, which has by far the largest population. The implication is that an effective County-wide program to reduce GHG emissions must include Santa Rosa.

FIG.1



Factoring out the direct influence of population, **Fig.3** recasts **Fig.2** in unit GHG emissions per unit of water supply.

FIG.3

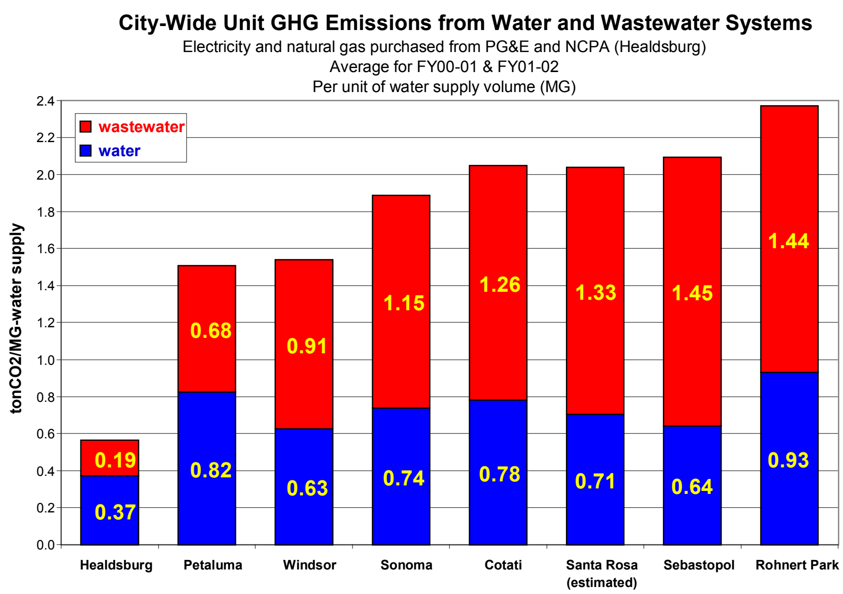


Table 4 summarizes the information in **Fig.3.** In general, the ranking is influenced by the intensity of energy use for wastewater treatment and reclamation. Cotati, Sebastopol, Rohnert Park, and Santa Rosa all utilize the Laguna Plant, which has very advanced treatment processes and a very high degree of reclamation. Rohnert Park's has highest impact because of water, probably because of its reliance on local wells. Healdsburg has the lowest impact, overwhelmingly because of the low GHG emissions from NCPA electricity. Healdsburg's wastewater impact is very small relative to water because the existing wastewater treatment plant was designed only for secondary treatment, and because wastewater is not reclaimed for irrigation. Healdsburg's wastewater impacts will increase significantly when its new treatment plant starts to operate, and when wastewater reclamation is implemented, unless measures to reduce GHG emissions can be integrated into their designs.

TABLE 4

GHG Emissions per Unit Water Supply, for City-Wide Water and Wastewater

Electricity and natural gas purchased from PG&E and NCPA (Healdsburg).
Average FY00-01 & FY01-02

	Water tons-CO_2/MG	Wastewater tons-CO_2/MG	TOTAL tons-CO_2/MG
Healdsburg	0.37	0.19	0.56
Petaluma	0.82	0.68	1.51
Windsor	0.63	0.91	1.54
Sonoma	0.74	1.15	1.89
Cotati	0.78	1.26	2.05
Santa Rosa[15]	0.71	1.33	2.04
Sebastopol	0.64	1.45	2.09
Rohnert Park	0.93	1.44	2.37

The databases gathered for this report could be utilized to identify GHG emissions reductions opportunities in the water and wastewater systems of each city. For example, integration into the planned upgrades of wastewater treatment plants in Healdsburg, Petaluma, and Santa Rosa (also capturing Cotati, Rohnert Park, and Sebastopol), where energy efficiency, water efficiency, and wastewater reclamation measures could be optimized to yield the lowest economic impact on ratepayers.

[15] Based on wastewater treatment and reclamation at the Laguna Plant, and water supplied by SCWA; does not include wells, boster pumps, or lift stations.

Another such example rises from coordinated planning for SCWA's water supply[16] and for the Laguna Plant's expansion of treatment and reclamation[17], where investments in one can produce large benefits in the other, and vice versa (specific examples in the next section on SCWA and the Laguna Plant).

The opportunities offered by planning across jurisdictional boundaries could allow development of county-wide, cost-effective water efficiency programs, such as described in Petaluma's Hold the Flow program[18], where a key barrier to implementation has been the dispersion of benefits and costs between SCWA and the City of Petaluma. Similar issues are relevant to the expansion of Santa Rosa's water efficiency program (and results) to the other cities utilizing the Laguna Plant. GHG emissions reduction efforts offer a possible unifying framework, at least to explore the benefits of collaboration.

SCWA and the Laguna Subregional Wastewater Treatment Plant

Overview

SCWA's water supply system and the Laguna Plant are the largest single water and wastewater facilities in the County, and both offer cost effective opportunities for GHG emissions reduction. All the partner cities in the Laguna Plant (Santa Rosa, Sebastopol, Cotati, and Rohnert Park) are already participating in the Climate Protection Campaign. Although the SCWA is governed by the County Board of Supervisors, that has already committed the County Administration to the Climate Protection Campaign, SCWA is not yet participating in the campaign. We hope that the benefits identified as part of the analysis in this report will encourage SCWA's participation.

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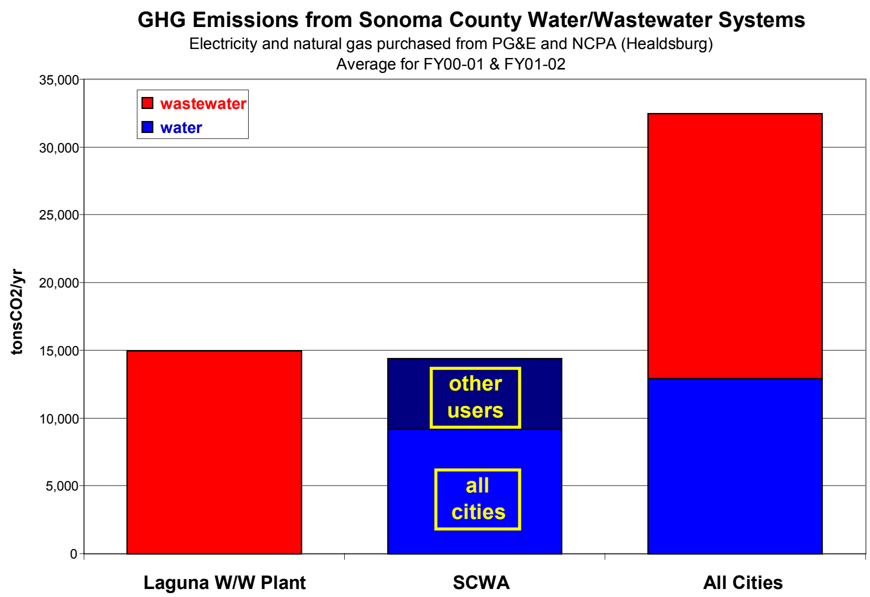
[16] Besides capacity expansion projects, SCWA is leading the development of the Integrated Regional Water Management Plan, to protect and restore fisheries habitat in the Russian and Eel River watersheds, and expand the use of reclaimed wastewater.

[17] The City of Santa Rosa has just released an EIR for the Incremental Recycled Water Project (IRWP), to increase wet weather treatment capacity, and to comply with increasingly stringent effluent standards for toxic pollutants.

[18] *Hold the Flow! Commercial, Industrial, and Institutional Water Efficiency Program*, June 2002. Pacific Technology Associates.

Fig.4 compares the GHG emissions of SCWA's water supply operations and the Laguna Plant to the combined water and wastewater GHG emissions of all the cities in **Figs.2 and 3** (Santa Rosa, Rohnert Park, Petaluma, Sonoma, Healdsburg, Cotati, and Sebastopol[19]). The combined GHG emissions include the entire Laguna Plant, more than half of SCWA, and the local wells, booster pumps, sewage lift pumps, and wastewater treatment/reclamation plants.

FIG.4

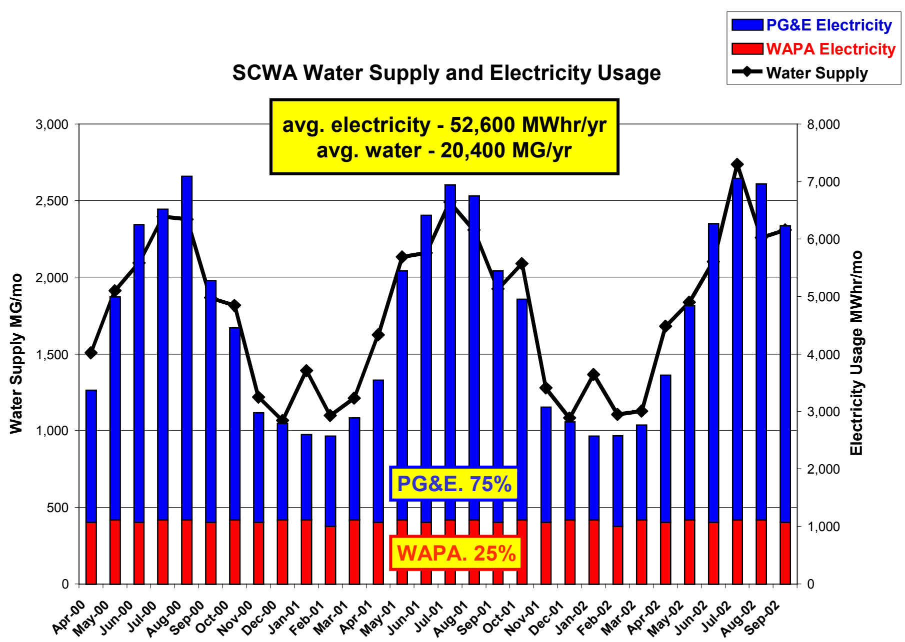


[19] Cloverdale was not part of this report, and data was not available.

SCWA

Fig.5 shows electricity use and water volumes for the SCWA water system. Although the energy split between PG&E and WAPA is 75% to 25%, the split in the $4.7 million annual costs is 91% and 9% respectively. As water demand rises in summer, more of the large pumps (each requiring ~850 KW) must be operated together, and friction losses increase in SCWA's distribution system. Thus the peak demand for water and the highest need for electricity from PG&E coincide with the PG&E's highest rates. Calculations reveal that the unit energy cost of water in summer is $314/MG, while the winter cost is only $127/MG – in other words, landscape irrigation is very costly.

FIG.5



Closely following the enormous disparity in unit energy costs, unit GHG emissions in summer are 0.94 tons-CO_2/MG, and only 0.39 tons-CO_2/MG in winter.

Landscape irrigation is a major driver of SCWA's GHG emissions, and would be even higher if seasonal adjustment were made to reflect the larger GHG emissions of "peaker" plants in PG&E's system.

From a cash flow perspective, electricity bills require 23% of SCWA's annual revenue, and can rise up to 31% in summer months. The heavy reliance on PG&E to meet peak water demands could expose SCWA's customers to rate shocks. Fortunately, several feasible options to reduce electricity costs – while simultaneously reducing GHG emissions. These options include (a) obtaining an additional allocation of electrical power from WAPA[20], (b) improving energy efficiency in the water supply system, and (c) reducing summer water demand.

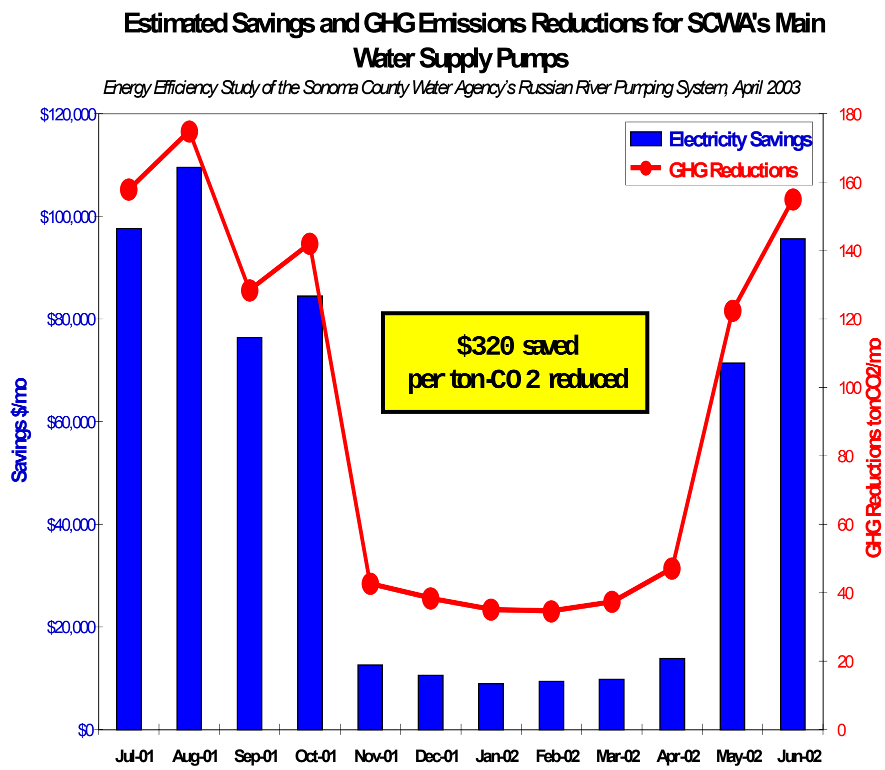
Provimetrics Corporation recently completed an energy efficiency evaluation of SCWA's main pumping system[21], which uses up to 85% of the water supply system's electricity. Three options were evaluated, based on 30-minute data for 2002, obtained from SCWA's central control computer.

[20] As this report was being prepared, we learned that SCWA has secured a much larger allocation of power from WAPA.

[21] *Energy Efficiency Study of the Sonoma County Water Agency's Russian River Pumping System*, April 25, 2003.

Fig.6 shows the energy savings and GHG emissions reductions for the most ambitious option – a combination of (a) pump efficiency upgrades, (b) optimized operating rules for pumps and storage tanks, (c) and energy management software for the central control computer. As expected, the savings and reductions of GHG emissions occur mostly in summer. The estimated implementation cost is $1.9 million, and for annual electricity savings of $600,000, the expected payback period is 3 years. Most importantly for this report, the project could save $320 per tons-$CO_2$ removed[22].

FIG.6



The savings from the energy efficiency project would have been significantly increased if landscape irrigation demands during 2 hot spells could have been reduced. This could be achieved with (a) more landscaping adapted to local conditions, (b) improved irrigation efficiency and controls, and (c) expansion of irrigation with reclaimed wastewater. Reducing peak water demand will not only save annual electricity costs for SCWA, but could also help avoid capital costs for new water supply capacity and watershed restoration.

[22] This is the Present Value over a 20-year life-cycle, with a $1.9 million loan from the CEC for 6 year at 3%, based on the electricity rates during FY01-02.

On the wastewater side, especially for the Laguna Plant, expansion of reclaimed wastewater distribution to residential areas is already being considered, and could be optimized by balancing all costs and savings. This is a very good example of the potential benefits of cross jurisdictional collaboration between SCWA and the Laguna Plant.

Laguna Plant

The Laguna Plant is already implementing several energy efficiency projects and process upgrades that will reduce GHG emissions. Examples of energy efficiency projects include replacing aeration blowers and replacing reclaimed wastewater irrigation pumps. Examples of process upgrades include aeration controls and digestor mixing/heating. The Incremental Recycled Water Project (IRWP) offers many opportunities for reductions in GHG emissions; early integration into planning and design could reduce both capital and operating costs.

Fig.7 shows the Laguna Plant's wastewater influent and irrigation with reclaimed wastewater. On an annual basis, 40-50% of the wastewater influent is reclaimed for irrigation, a very high percentage compared to most other San Francisco Bay Area wastewater treatment plants. **Fig.7** also shows that dry weather influent is declining, even though population has increased. The EIR for the IRWP attributes this to Santa Rosa's aggressive water efficiency program, that could be expanded to other subregional members (i.e. Rohnert Park, Cotati, and Sebastopol). Water efficiency could somewhat reduce electricity demand and GHG emissions in summer when PG&E rates are highest.

FIG.7

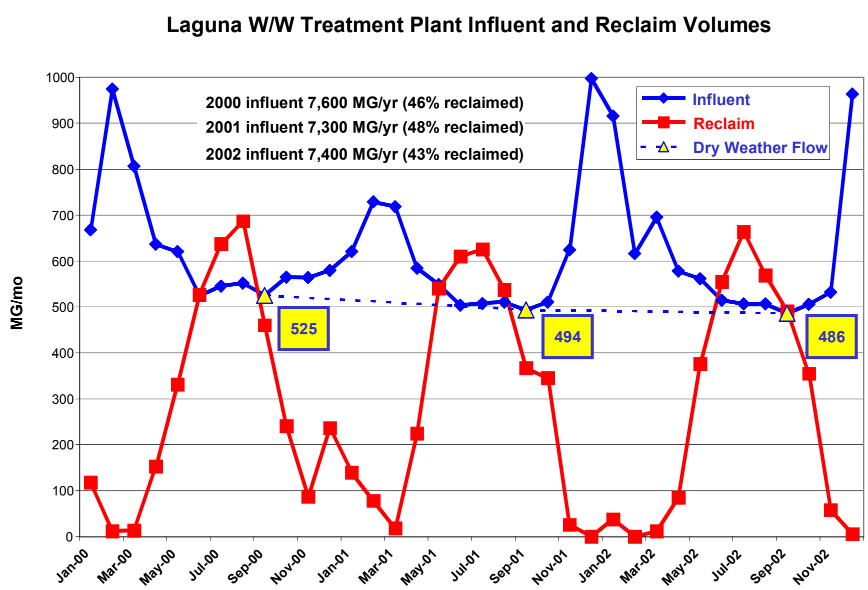
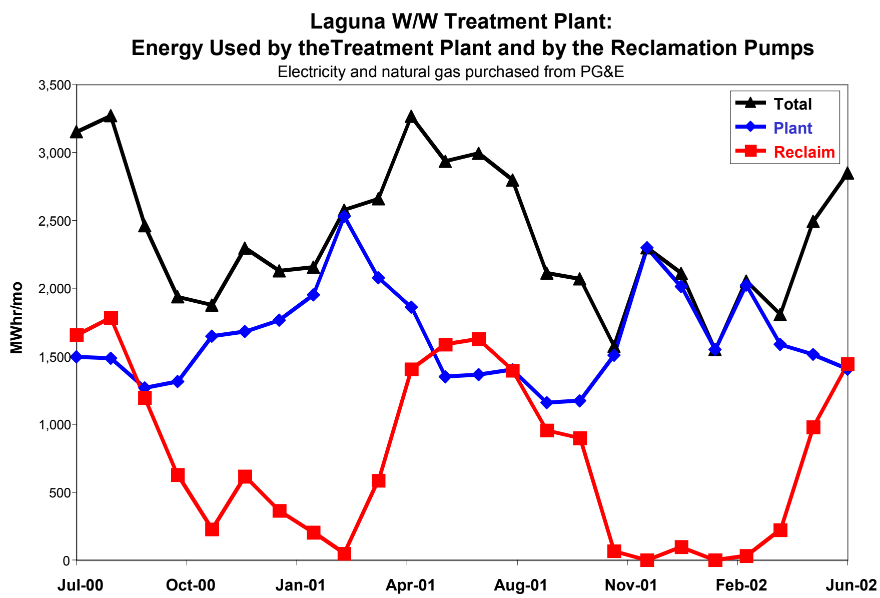


Fig.8 shows electricity purchased from PG&E by the Laguna Plant, to operate the treatment plant and to pump reclaimed wastewater for irrigation. In summer, more electricity is purchased (at higher rates) for reclamation than for treatment, closely following the monthly flow patterns shown in **Fig.7**.

FIG.8



Electricity purchases from PG&E represent only 60% of the electricity used annually at the Laguna Plant; the other 40% is cogenerated on site, using a combination of biogas produced by the treatment process, and natural gas purchased from PG&E. Based on fuel value, biogas and natural gas are utilized almost equally for cogeneration (49% and 51% respectively). Even though they contribute the same GHG emissions upon combustion, only the purchased natural gas is accounted for in ICLEI's guidelines for the Climate Protection Campaign[23]. From a operational perspective, careful accounting of the biogas helps maximize its production, utilization, and savings from displacing natural gas.

[23] The claim is that natural gas is a fossil-fuel extracted from the earth, releasing sequestered carbon to the atmosphere. Biogas is produced by biological process from carbon that has not been sequestered.

In addition to biogas combustion, another process contribution to GHG emissions at the Laguna Plant is respiration from microorganisms in the activated sludge process. Mechanical aeration provided by large blowers maintains these microorganisms at an artificially high metabolism rate, which means that respiration is also high. This respiration produces large CO2 emissions, which would not occur naturally. To demonstrate the impact, we have estimated a constant respiration rate of 237 tons-CO_2/month[24].

FIG.9

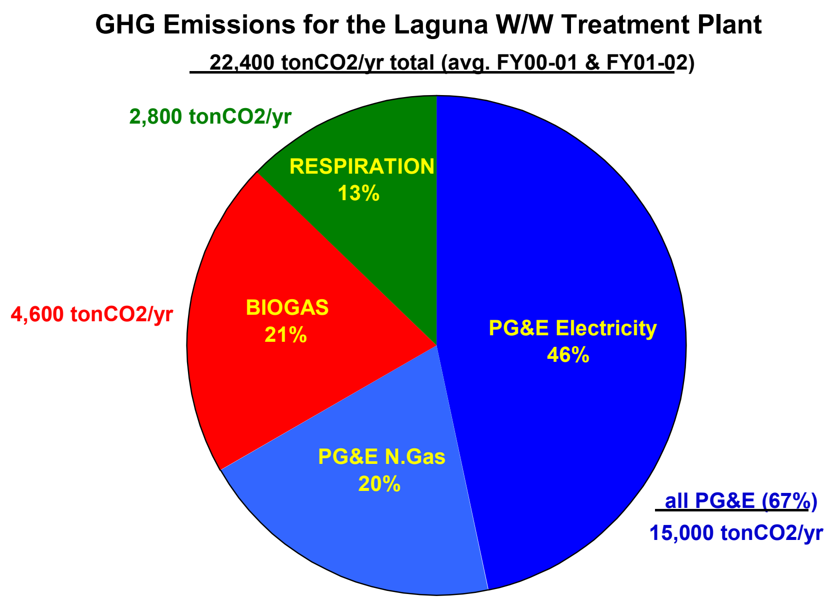


Fig.9 shows that GHG emissions related to PG&E are only 66% of the total, leaving little doubt that biogas (21%) and respiration (13%) should be accounted for in seeking to reduce impacts.

[24] Based on the following assumptions: (a) load-bearing wastewater is 486 MG/mo; (b) activated sludge influent at 200 mg/l BOD with 85% removed (1 mg/l = 8.34 lb/million gal); (c) 50% of oxygen is utilized for oxidation, and 50% for synthesis (no significant decay); (d) 1 mole CO2 generated for 1 mole O2 removed during oxidation.

Fig.10 shows that GHG emissions from treatment processes at the plant (includes pumping effluent to storage ponds) overwhelm the emissions from the reclamation system (85% to 15% respectively). Even in summer, the GHG emissions from reclamation system rise only to 21% of the total. Annual GHG emissions from biogas combustion and respiration are more than twice as large as from the electricity used for irrigation with reclaimed wastewater. The main point is that optimization of the activated sludge process, digestor biogas production, and operation of the cogeneration engines could reduce GHG emissions by minimizing purchases of electricity and N.gas from PG&E.

FIG.10

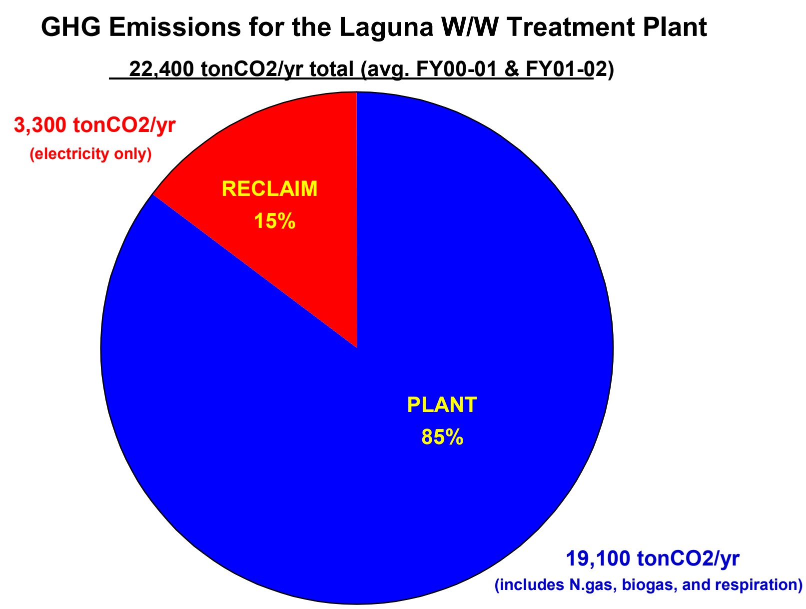
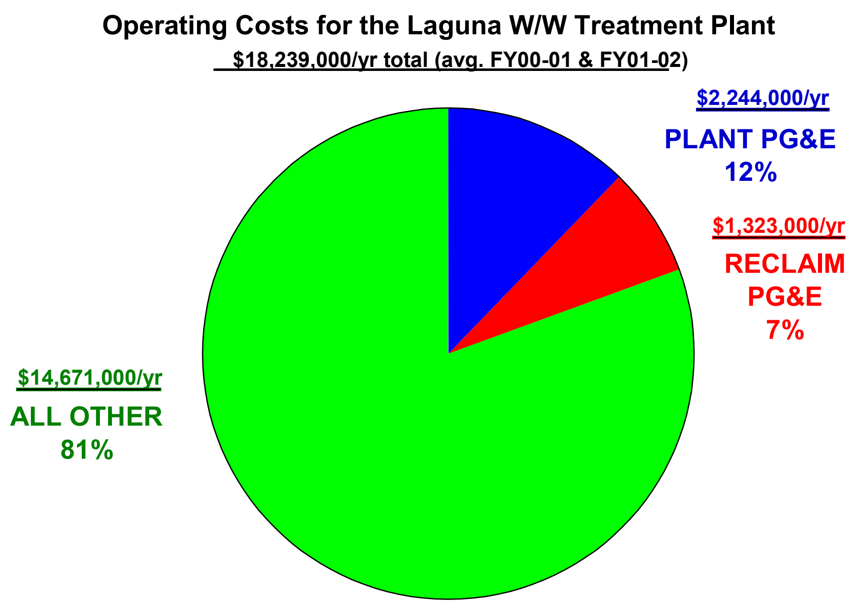


FIG.11



For perspective, **Fig.11** shows that utility costs are only 19% of $18 million total annual operating costs for the Laguna Plant. Amortization of capital costs represents approximately 40% of annual costs. The implications are that (a) capital intensive upgrades anticipated in the IRWP will have a far larger impact on the budget than utility costs, and (b) modifications to improve energy efficiency and reduce GHG emissions run a relatively low risk of impacting the operating budget.

Replacement of aeration blowers demonstrates the Laguna Plant management's willingness to invest in energy efficiency (aeration consumed approximately 25% of electricity use by the treatment process). Provimetrics identified the project and its potential savings, successfully applied for a California Energy Commission (CEC) loan[25], and prepared the performance based bid specification in 2002.

Two new high-efficiency blowers were installed in May 2003. Santa Rosa staff completed the project for $1.1 million out of the authorized CEC loan of $1.5 million. The project should pay for itself in 4.6 years, at current PG&E rates. Recently measured performance of the new blowers suggests reductions of 775 tons-CO_2/yr in GHG emissions[26]. Most importantly for this report, the project will save $175 per tons-$CO_2$ removed[27].

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[25] At 3% for 6 years.
[26] Based on reductions of 2,100 MWhr/yr in electrical energy, and 114 KW in peak electrical power demand.
[27] This is the Present Value over a 20-year life-cycle.

Two more energy-efficiency projects were initiated by the Laguna Plant managers. The Rohnert Park pump station is currently the largest in the reclaimed wastewater distribution system, and the North pump station is typical of farm-operated irrigation systems. Provimetrics identified the efficiency improvements and their potential savings, then successfully applied for a CEC loan[28] early in 2003. Laguna Plant staff has just selected an engineering company for detailed design.

The anticipated reductions in GHG emissions[29] are 140-150 tons-CO_2/yr. Estimated capital cost (CEC loan) is $400,000-420,000. The Present Value of the project should be $810,000-970,000, providing a 5.0-5.7 year payback period, at current PG&E rates. Most importantly for this report, the project will save $290-320 per tons-$CO_2$ removed[30].

CONCLUSIONS AND RECOMMENDATIONS

The most immediate conclusion is that decisions about water and wastewater services to the entire city are likely to have a far greater impact than decisions about water use in individual municipal facilities. This is because, as shown in **Table 3**, GHG emissions from municipal facilities are a small fraction of the total water/wastewater GHG emissions for an entire city. For example, a decision about replacing an older well pump with a new high-efficiency pump will have a far greater impact than replacing the toilets in City Hall. Decisions about infrastructure, such as choosing the preferred option for upgrading a wastewater treatment plant, will have even more impact.

Improving the energy efficiency of water and wastewater systems can even yield savings while reducing GHG emissions. For example, measurements after upgrading aeration blowers at the Laguna Plant reveal savings of $175 per tons-$CO_2$ removed. Estimates from an evaluation of energy efficiency for SCWA's main water supply pumps project savings of $320 per tons-$CO_2$ removed. Energy-efficiency design modifications are underway for two of the Laguna Plant's reclaimed wastewater irrigation pump stations; projected savings are $290-320 per tons-$CO_2$ removed.

Combining these two preceding conclusions yields the first recommendation for a continuing GHG emissions reduction program: Any time water or wastewater equipment needs replacement or expensive maintenance work, evaluate options improving energy-efficiency.

Even before triggering replacement or maintenance, the database assembled for this report could be disaggregated to identify equipment with low energy efficiency, which could be replaced cost-effectively while attracting low interest loans from the CEC.

[28] At 3% for 6 years.
[29] Based on reductions of 390-420 MWhr/yr in electrical energy, and 160-210 KW in peak electrical power demand.
[30] This is the Present Value over a 20-year life-cycle.

On a larger scale, the database could help provide an integrated evaluation of options under consideration in SCWA's water supply plans and the Laguna Plant's Incremental Recycled Water Project. In particular, relationships between water and wastewater such as those aggregated into **Table 4,** provide a basis for optimizing combinations of options for increasing water supply, improving water efficiency, increasing wastewater treatment capacity, and expanding wastewater reclamation. A joint program to identify cost-effective reductions in GHG emissions might ease initial jurisdictional barriers, i.e. the first evaluations could be performed outside the framework of existing regulation-driven projects.

Before such large scale integration of infrastructure planning, the potential reductions in GHG emissions from energy efficiency improvements to SCWA's main supply pumps, and the practical means to reduce the GHG impacts of landscape irrigation demands reveal that SCWA faces very little risk from joining the Climate Protection Campaign. In all probability, it could quickly become the highest performer, not only in the North Bay, but nationally.

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John has been involved in many industrial water efficiency projects that have reduced wastewater volumes and loads by 30-90%, with operational savings that pay for the capital investment in 0.5-2.0 years. He has helped develop innovative incentive programs for industrial and commercial water efficiency and wastewater reduction for several SF Bay Area cities. John has advised and assisted several San Francisco Bay area environmental and community organizations on sustainable water and wastewater solutions, and has participated in negotiations to resolve disputes over environmental impacts.

John has a B.Sc. in Civil Engineering and a M.Sc. in Environmental Engineering from the Technion in Israel, where the focus of his education was design and operation of wastewater treatment systems. His Ph.D. is from Stanford University's department of Civil Engineering, where his research focused on solar cogeneration, energy efficiency, and waste minimization in the food-processing industry.