Addressing Climate Change Concerns at the Municipal Level: A Case Study on the City of Sunnyvale, California

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ABSTRACT

In January 2007, City of Sunnyvale hired consultant KEMA Inc. to complete a greenhouse gas (GHG) emissions inventory for city operations and develop a work plan for emissions reductions and estimated budget for City Council consideration. During this project, KEMA identified potential billing and metering errors, as well as opportunities for building and process optimization in specific City facilities. The GHG inventory also validated the energy savings related to several of the City's recent energy efficiency and cogeneration project installations. By completing a greenhouse gas emissions inventory, City of Sunnyvale found that its energy efficiency and renewable energy initiatives have already reduced GHG emissions to seventeen percent below 1990 levels.

This paper describes the process for estimating GHG emissions and for evaluating the relative merits of different carbon mitigation projects. Many existing energy management tools and efficiency programs can be used to assist government, businesses and other organizations to manage their GHG emissions and to develop realistic climate action plans. This paper will examine different sources for energy savings estimates and deemed savings values associated with common energy efficiency measures. We will also discuss challenges and common concerns expressed by facilities staff when identifying savings opportunities. Based on KEMA's analysis and final report, the City of Sunnyvale City Council approved a GHG emissions reduction target of twenty percent below 1990 levels by 2010 for emissions related to city operations.

Introduction

City of Sunnyvale recognizes the natural environment's role in sustainability and the importance of maintaining a stable climate system for current and future residents. This paper describes the process and implications for the energy efficiency industry in assessing City of Sunnyvale's historic CO_2 emissions trends related to city operations, opportunities and costs of reducing city emissions and recommended targets for future emissions reductions. In general, the City of Sunnyvale project highlights how addressing climate change requires the use of existing energy industry tools and methodologies for understanding energy consumption and energy efficiency opportunities.

Historic and projected emissions trend

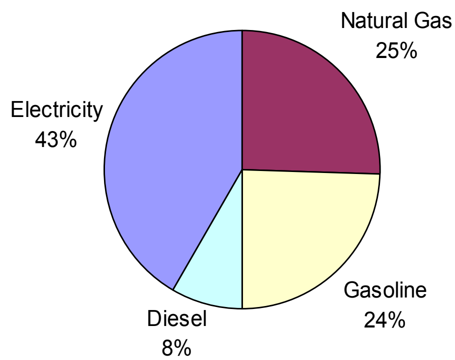
One of the first steps to addressing climate change is to understand the range and magnitude of emissions sources associated with a given entity. Completing a greenhouse gas emissions inventory requires collecting data related to all types of fuel use, including electricity, natural gas, gasoline, and diesel, related to a diverse scope of city operations. City of Sunnyvale was interested in assessing GHG emissions related to fifteen specific building facilities, all traffic signals and street lighting and all fleet vehicles. This exercise provides an invaluable assessment of energy consumption trends and provides significant information about conservation successes, as well as remaining opportunities.

In fiscal year 2005-2006, City of Sunnyvale electricity consumption contributed the largest percentage of their emissions by fuel type, at 43% of city emissions. The GHG emissions were calculated by using Pacific Gas & Electric (PG&E) average emissions factors as submitted to the California Climate

Action Registry. Natural gas, gasoline, and diesel emissions factors were provided by Sustainable Silicon Valley and based on the California Climate Action Registry's General Reporting Protocol. Figure 1 shows the relative contribution of other fuel types to the total city inventory. Natural gas, mostly related to building use, and gasoline consumed in fleet vehicles each contributed roughly a quarter of city emissions. Diesel constituted the smallest percent, at 8%. In general, these results are roughly consistent with other cities who have completed similar GHG inventories.[1]

Together, electricity and natural gas account for 68% of GHG emissions related to city operations. In terms of prioritizing emissions reductions efforts, reducing electricity and natural gas consumption addresses the vast majority of emissions and suggests significant opportunity for energy efficiency to sell itself as a climate change solution to the general public. Currently, much attention related to climate change solutions appears to be focused on carbon offsets, which serve more as a patch rather than a real solution.

Figure 1. Emissions Contribution to Total City Emissions, by Fuel Type (FY05-06)

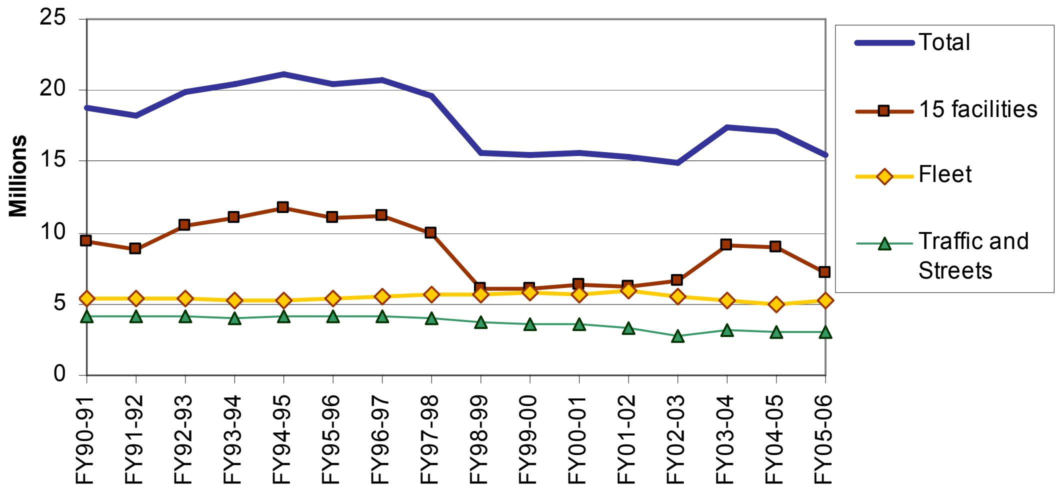


The results of City of Sunnyvale's historic emissions also serve as a type of measurement and verification (M&V) of several recent energy efficiency and resource conservation projects spearheaded by facility staff. Figure 2 shows that consistent with U.S.-wide emissions, in FY05-06, about one third of city emissions result from buildings, one third from transportation fuels and another third from industry.[2] The graph also demonstrates that total city emissions in fiscal year 2005-06 have already been reduced to 17% below 1990 levels of emissions. Furthermore, emissions have been reduced across all categories of city operations, with the largest reductions achieved through reductions at city buildings.

[1] Based on KEMA review of GHG inventories, including City of Hayward, City of Boulder, City of Northampton,

[2] Energy Information Administration. Emissions of Greenhouse Gases in the United States, 2005. From Report #: DOE/EIA-0573(2005). Retrieved from http://www.eia.doe.gov/oiaf/1605/ggrpt/flowchart_figure.html on November 20, 2007

Figure 2. Total City of Sunnyvale Historic Emissions from all Source Categories (lbs of CO_2)

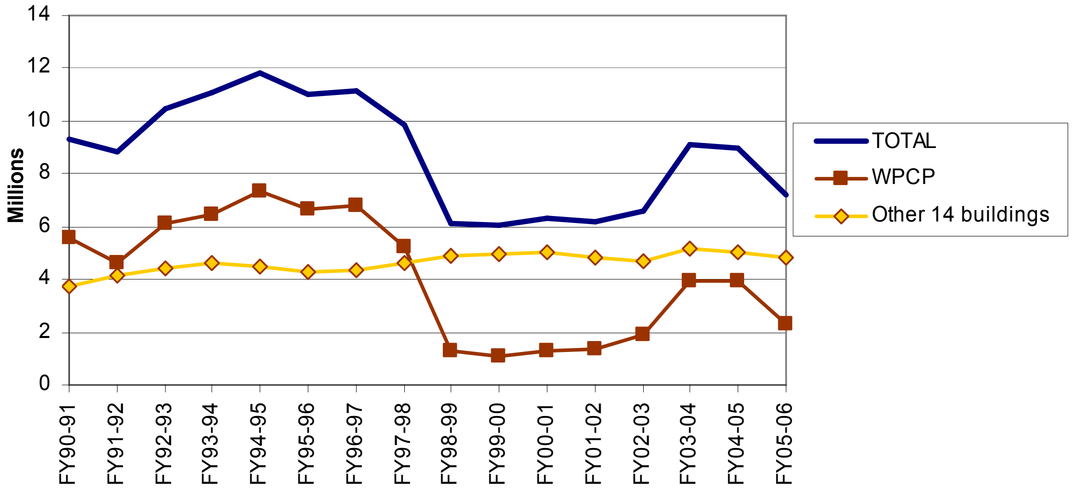


These reductions are primarily due to the installation of a landfill gas powered cogeneration facility at the Water Pollution Control Plant (WPCP), which now uses landfill gas to displace purchased natural gas and produces enough electricity to meet the plant's electricity load. Fleet emissions have also been reduced since around FY01-02, in addition to significant emissions reductions in traffic signals due to LED retrofits in recent years. A further examination of each emissions source category shows how the GHG emissions inventory provides insight into facility operations and energy use trends. As climate change gains urgency in the minds of the public, it is resulting in a renewed interest in understanding how energy is used and conserved in our daily operations.

Fifteen building facilities

Almost half of total city CO_2 emissions were related to fifteen city facilities included in the inventory. Of significant interest is that CO_2 emissions related to the Water Pollution Control Plant (WPCP) on-site processes were on the same order of magnitude as all other 14 building facilities combined. Figure 3 shows how the shape of WPCP emissions trend, with exported electricity emissions netted out, drives the overall CO_2 emissions trend related to all 15 facilities from FY1990-2006. While other city buildings in aggregate have a small, but steady increase in CO_2 emissions since 1990, the WPCP facility has significant variation from year to year.

Figure 3. Historic CO_2 Emissions Trend for 15 City Facilities



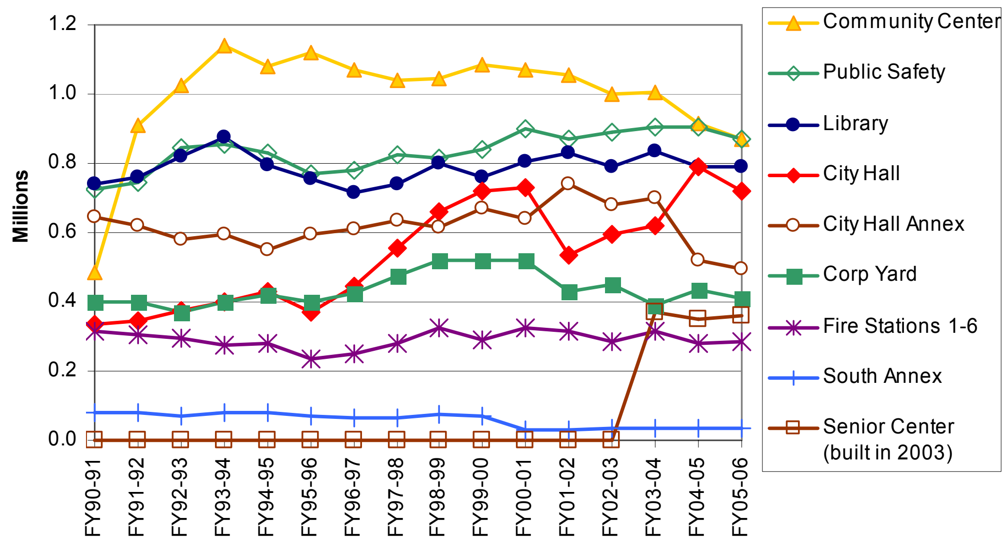
Much of the observable variation in WPCP CO_2 emissions from year to year is due to the plant's cogeneration installation changes. The emissions trend reflects that in 1997, the City began using a portion of the landfill gas (LFG) from the Sunnyvale Landfill to generate heat and power for on-site processes. From 1997 to 2002 this mode of operation reduced, but did not eliminate, routine purchases of electricity from PG&E which accounts for the small portion of CO_2 emitted during those years. Since LFG as a biogenic gas was now displacing fossil fuel-based electricity and natural gas, the city reduced its CO_2 emissions related to WPCP operations.[3]

In 2002, the City began supplementing the LFG stream with purchased natural gas to begin exporting electricity. Although the WPCP emissions trend shows a resulting increase in CO_2 emissions, internal plant gauges did not reflect a similar increase of natural gas consumed by the cogeneration facility. Conversations and discussions with plant engineers indicate that there may be some issues with the calibration of flow meters within the facility, and the exercise of completing a GHG inventory brought these issues to light. Without the GHG inventory project, WPCP engineers had no idea that increased PG&E bills were not agreeing with facility sub-meter data. The GHG footprint project was important to "auditing" utility bills and ensuring the correct calibration of meters at the WPCP.

Aside from the WPCP, the emissions related to the other 14 facilities appear to have mostly increased due to the addition of the Senior Center in 2002, and increased emissions from City Hall (Figure 4). This is particularly interesting as City Hall recently completed an HVAC retrofit in 2000, which should have resulted in lower energy use and emissions. Unfortunately, the results of the GHG inventory at City Hall show energy consumption to decrease sharply after the HVAC upgrade and then steadily increase again in recent years. This suggests that a building tune-up may be needed for City Hall to ensure that the HVAC system and controls are operating properly.

[3]In accordance with the California Climate Action Registry protocols, this project considered landfill gas to be a "biogenic" source of emissions since the carbon content of landfill and digester gas is due to organic decomposition of "recently sequestered" carbon. Therefore, when the carbon is combusted and released back into the atmosphere, it is not considered additional atmospheric carbon (compared to fossil fuel carbon, which has been sequestered for millennia). The CO_2 will be reabsorbed and sequestered during the next crop of biomass. Consistent with the Intergovernmental Panel on Climate Change, World Resources Institute and U.S. EPA Climate Leaders, the CO_2 from landfill gas combustion is not included in the city inventory of anthropogenic CO_2 emissions.

Figure 4. Historic CO_2 Emissions Trend for 14 City Facilities, Excluding the WPCP (lbs CO_2)



The HVAC replacement for City Hall Annex completed in 2004, however, shows that the project has been successful in reducing energy consumption. The energy conservation effects of this retrofit have been maintained and the CO_2 emissions from City Hall Annex continued to drop in FY05-06. In the future, the CO_2 emissions related to the Library is also expected to decrease since its HVAC system was replaced in 2006, and the contractor recently performed a tune-up of the system in early 2007. The low amount of CO_2 emissions for the Community Center in FY90-91 is related to the complete closure of that facility for a major renovation project.

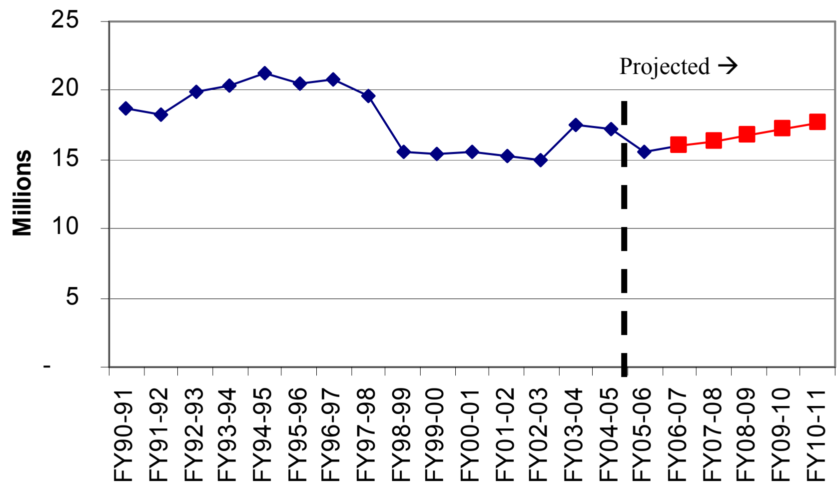
In many ways, the process of completing a GHG emissions inventory is analogous to performing a billing analysis for each building. The advantage of a GHG inventory, however, is that various fuel types are normalized using its carbon content, allowing an organization to take a leadership role in mitigating carbon emissions and manage its risk exposure related to potential climate change regulation. These benefits are in addition to identifying energy efficiency opportunities and validating energy efficiency projects.

Project business as usual (BAU) emissions scenario

In developing a climate action plan, it is not sufficient to quantify the existing GHG footprint and estimate future emissions reductions from the current level of emissions. This is because for most entities, GHG emissions will likely increase in future years without a concerted effort to implement emissions reduction projects. One must compare future reductions with future emissions levels, not current levels. The process for estimating the "business as usual" emissions trend scenario is usually an imprecise process, however, and involves a combination of real data forecasts along with general estimations.

Based on City of Sunnyvale's historic emissions trends, the BAU trend through 2010 was estimated to be relatively flat. The facility staff did recognize, however, that significant emissions savings had been realized historically due to using landfill gas, which was expected to decrease in output in coming years. Based on landfill gas output studies, the projected BAU emissions trend was expected to increase due to reduced landfill gas flow and a corresponding increase in natural gas purchases above current levels. Figure 05 shows how this forecasted trend compares with historic emissions levels.

Figure 05. Projected City Emission Trend (lbs CO_2)



Based on data available during this project, KEMA estimated that City of Sunnyvale was likely to emit approximately 17,590,079 lbs of CO_2 in FY10-11 under a business as usual scenario, which is a 5.5% *increase* above FY90-91 levels. This is a significant difference in emissions in FY05-06, when levels were 17% *below* FY90-91 levels.

Analysis of potential projects

Once energy consumption trends are understood by an organization, the next step is to assess potential projects that may be undertaken to reduce GHG emissions. Since there is virtually an infinite array of CO_2 emissions reduction options available to municipalities wishing to reduce their climate footprints, the task may appear to be overwhelming. In general, it is best to begin by interviewing those who are most knowledgeable about facility operations, and whose cooperation and buy-in is critical to developing a climate action plan that will actually be implemented. These facility staff and engineers are most familiar with studies and audits already completed within buildings and operations and can provide information about upgrades already in the plans.

The project analyzed different types of emissions mitigation projects and used a rough cost-benefit analysis to evaluate different options. To define a range of possible projects for assessment, KEMA also used readily available energy audit studies performed by Pacific Gas & Electric for City of Sunnyvale facilities. Additional projects were identified through meetings with the fleet manager, facilities engineers and other key staff.

As most energy professionals know, the process of estimating energy savings related to general project types can involve a large number of assumptions. In this case, KEMA used common industry assumptions, including savings estimates from the California Energy Commission and California Public Utilities Commission's Database for Energy Efficient Resources (DEER).[4] Pacific Gas & Electric work papers related to energy efficiency program were also used as sources for deemed savings estimates. In most cases, these same resources provided energy (kWh and therm) savings per unit, and cost per unit estimates. Project cost savings are calculated by assuming an average retail cost of $0.14/kWh and $1.20/therm, based on City of Sunnyvale billing data. Table 01 shows the projects that were considered for City of Sunnyvale building facilities.

[4] The DEER database can be accessed through http://eega.cpuc.ca.gov/deer/

Table 01. Potential energy efficiency projects in building facilities

Building facility	Project description	Annual electricity savings	Annual natural gas savings	Annual CO_2 benefit	Annual PG&E bill savings	DEER estimated project cost	Sunnyvale estimated cost
		(kWh)	(therms)	(lbs)	($)	($)	($)
All facilities	Vending misers (12)	19,344		11,026	$ 2,708	$ -	$ -
10 facilities	Building optimization	167,823		95,659	$ 23,495	$ 76,000	$ 76,000
City Annex	VFD on HVAC fan motors (30 hp fan)	29,340		16,724	$ 4,108	$ 6,660	$ 12,000
City Hall	VFD on VAV AHU (7.5 hp fan)	7,335		4,181	$ 1,027	$ 1,665	$ 12,000
Community Center	Metal halide to T5 retrofit (6)	2,820		1,608	$ 395	$ 2,370	$ 7,500
Corp Yard	Metal halide to T5 retrofit (6)	5,062		2,886	$ 709	$ 2,370	$ 25,000
Fire stations	2 occupancy sensors	33,272		18,965	$ 4,658	$ 1,547	$ 3,000
Fire stations	Insulate water heater pipes (54 feet)	-	108	1,257	$ 130	$ 54	$ 6,000
Fire stations	Double Pane Windows	1,250	197	3,005	$ 411	$ 24,708	$ 25,000
Fire stations	Window with sunscreen	3,263		1,860	$ 457	$ 1,697	$ 10,000
Library	VFD on AHU (20 hp fan)	19,560		11,149	$ 2,738	$ 4,440	$ 12,000
WPCP	Process optimization	344,896		196,591	$ 48,285	$ 13,304	$ 113,304
WPCP	Lighting retrofit	131,361		4,179	$ 12,248	$ 14,028	$ 20,000
WPCP	Delamping	32,840		1,045	$ 3,087	$ -	$ -

The original table presented to City of Sunnyvale did not include the "Sunnyvale estimated cost" column. When KEMA presented its initial cost estimates to City of Sunnyvale, certain facility staff were sensitive to the portrayal of cost-effective energy efficiency opportunities within municipal buildings. One concern was that some of the initially proposed projects, such as economizer repair and building optimization projects, would reflect poorly on facility staff performance. Since these were based on PG&E site visits, and not KEMA on-site visits, these measures were removed at the discretion of the facility staff. Furthermore, a staff member also returned with revised project cost estimates that, in many cases, were several fold higher than the KEMA estimates. To reconcile the issue, KEMA presented both its estimates and staff estimates, and used staff estimates for the remainder of the project analysis.

In some cases, the project costs estimates appeared to be gross over-estimates of project cost (for example, $25,000 for six metal halide fixtures), but these issues were not resolved due to time and budget constraints. Facility staff also appeared concerned about committing to energy savings associated with different efficiency measures, as numbers submitted to City Council may result in reduced operating budgets for facilities. Therefore, in the process of assessing energy efficiency opportunities, climate action plan developers must be sensitive to the concerns of facility staff. Although these issues may also arise under traditional energy audits of facilities, the difference with climate action plans is that often these projects are not commissioned or managed by facility engineers and staff directly, as facility energy audits often are. In this case, the City of Sunnyvale GHG footprint study was managed by staff in the solid waste and recycling department.

In addition to energy efficiency, KEMA also assessed the costs and benefits of certain renewable energy technologies for municipal buildings. Other appropriate measures were identified for fleet operations and include fuel saving estimates related to city operational policies that encourage the purchase of fuel efficient vehicles and renewable fuels.

Cost and carbon impact of different levels of action

Given the wide variety of emission reduction opportunities, the projects presented in the previous section were then grouped together to assess the financial and carbon impact of different levels of action by City of Sunnyvale. The projects were grouped into three tiers: Most favorable, moderately attractive and potentially appropriate projects, using payback period as a criteria for cost-attractiveness.

Projects classified as Tier 1 were initially selected for low payback period (less than 5 years) and high emissions reductions. Based on discussions with city staff, however, the project list was revised to include additional projects, some of which have payback periods as long as 18 years. While 18 years is generally considered a long payback period, city planning horizons do allow for longer payback returns. It was clear, however, that city staff were valuing other project attributes besides mere cost savings.

Some of the projects were included due to significant public interest, such as solar installations and hybrid vehicles. Projects such as solar PV also met broader city goals, such as establishing City of Sunnyvale as a leader in solar energy. Hybrid vehicles were included in the Tier 1 grouping, since they have a positive appearance and can serve as a visible demonstration of the City's commitment to sustainable practices. In prioritizing projects for implementation, cost is not always a primary driver and other considerations such as leadership and visible demonstrations of environmental work can be equally important to municipal clients and City Council members.

Table 2 below displays the final group of projects that grouped as Tier 1 projects, listed in order of payback period. If Tier 1 projects are implemented (with city-owned solar), then emissions were estimated to be reduced by approximately 1,628,071 lbs of CO_2. The total city emissions by FY10-11 are estimated to be around 15,962,009 lbs CO_2, which is a 15.0% decrease in emissions compared to FY90-91.

Table 2. Emission Reduction Projects Classified as Tier 1

Specific target	Project description	Annual CO_2 benefit	Annual operating cost	Sunnyvale estimated project cost	Simple payback
		(lbs)	($)	($)	(yrs)
All facilities	Vending misers (12)	11,026	$ (2,708)	$ -	-
Fleet	Policy to replace with higher mpg	1,472	$ (231)	$ -	-
WPCP	Delamping	1,045	$ (3,087)	$ -	-
Fire stations 1-6	2 occupancy sensors	18,965	$ (4,658)	$ 3,000	0.64
WPCP	Lighting retrofit	4,179	$ (12,248)	$ 20,000	1.63
WPCP	Process optimization	196,591	$ (48,285)	$ 113,304	2.35
City Annex	VFD on HVAC fan motors	16,724	$ (4,108)	$ 12,000	2.92
10 facilities	Building optimization	96,659	$ (23,495)	$ 76,000	3.23
Library	VFD on AHU	11,149	$ (2,738)	$ 12,000	4.38
City Hall	VFD on VAV AHU	4,181	$ (1,027)	$ 12,000	11.69
Street lighting	Replace 150 watt HPS with LED	151,540	$ (37,220)	$ 576,030	15.48
Fleet	4 hybrid vehicles	7,949	$ (1,248)	$ 19,800	15.87
Street lighting	Replace 200 watt HPS with LED	681,931	$ (167,492)	$ 2,990,925	17.86
13 facilities	*442 solar PV system (city-owned) with rebate	359,798	$ (88,371)	$ 1,531,500	17.33
13 facilities	*442 solar PV system (PPA)	359,798	$ 6,312	$ -	none
Fleet	5% biodiesel	65,863	$ -	$ 5,000	none
TOTAL (with solar city-owned)		**1,628,071**	**$ (396,917)**	**$ 5,371,559**	**13.5**

A similar process was used to group projects into Tier 2 and Tier 3 groups. In general, all types of carbon offsets and renewable energy certificate (RECs) projects were grouped into Tier 3, since they represent annual expenditures for emissions reductions to occur elsewhere. For most climate action plans, these measures are generally considered as a last resort, after all cost-effective emissions reduction projects within a municipality have been implemented. Furthermore, many entities wish to demonstrate concrete action and changes within their own operations, rather than appear to be "buying" their way out of the problem. Sometimes, however, offsets or RECs can be purchased to meet a GHG reduction goal shortfall within a short timeframe, since most facility upgrades take significant time to plan and implement.

Table 3 summarizes the estimated emissions and cost impacts of different levels of action according to the above categorization of projects. Tier 1 projects are considered to be the most attractive due to economic and social reasons. Tier 1 + 2 plus offsets provides insight on what the potential costs for meeting the recommended Sustainable Silicon Valley target of 20% below 1990 levels would be.

Table 3. Comparison of Cost and Carbon Impact of Different Levels of Action

FY10-11 scenario	Emissions reduction relative to FY90-91	Lbs of CO_2 reduced from BAU scenario	Estimated incremental cost to city	Total simple payback
Business as usual (BAU)	- 6.3%	0	$ 0	n/a
Tier 1 projects	- 15.0%	1,628,071	$ 5,371,559	13.5 years
Tier 1 + 2 projects	- 17.1%	2,033,304	$ 7,613,404	18.1 years
Tier 1 + 2 plus offsets	- 20%	2,572,539	$ 7,615,610	18.1 years

The results of this analysis demonstrate that an emissions reduction goal of 20% below 1990 levels by 2010 may be a reasonably ambitious goal for City of Sunnyvale, with a target of 10% below FY90-91 levels being a very achievable goal. Ultimately, in September 2007, after reviewing the results of the KEMA study, the City of Sunnyvale City Council voted to approve the more ambitious goal of 20% below 1990 levels by 2010.

Conclusion

Overall, the greenhouse gas footprint and climate action plan project provided City of Sunnyvale with an in-depth understanding of energy consumption across diverse facility operations. The process of collecting and analyzing billing data for each facility showed City of Sunnyvale which energy efficiency initiatives had been highly successful. HVAC upgrades in certain facilities were visibly saving energy, while others had no savings after a few years, suggesting an opportunity for facility engineers to revisit the building take action to improve operations. Furthermore, the process identified possible meter and billing errors, when the PG&E billing data did not conform to the city's understanding of how its cogeneration facility was operating.

The GHG inventory process is a comprehensive approach to energy management across non-traditional "facility types" including fleet operations, wastewater cogeneration facility, street lights and traffic signals, in addition to traditional commercial office facilities. Rather than assessing these operations separately, the project allowed City of Sunnyvale to holistically prioritize projects for GHG emissions reduction.

Additionally, the project leveraged existing energy efficiency efforts at City of Sunnyvale and utilized traditional energy efficiency approaches, such as whole building energy audits and utility-provided energy savings estimates. Although it is debatable how accurate deemed savings estimates can be for site specific projects, these general savings numbers can provide a useful "rule-of-thumb" for prioritizing projects for further research and refinement of cost estimates. These numbers, however, are not always acceptable to facility staff who are responsible for overseeing the capital and operating budgets.

As described in this paper, sometimes these stakeholders over-estimate costs and develop conservative savings estimates in order to secure sufficient operating budget from the City budget process. While understandable, this conservative approach may result in a sense that emissions reduction projects are more costly than what we would typically expect. When using inflated cost estimates for GHG emissions reductions projects, it may cause policymakers to adopt less ambitious emissions targets than are truly cost-effective.

The KEMA project with City of Sunnyvale provides a case study on the issues that municipalities and organizations may encounter when grappling with the issue of climate change and how to reduce GHG emissions. In most cases, a climate action plan allows organizations to look at operations holistically for energy efficiency opportunities that are usually also cost saving opportunities. Climate action plans can be developed from existing energy efficiency studies and solar feasibility studies, without necessarily requiring additional on-site work. Since almost all GHG emissions are the result of energy use, the climate action plan provides a useful platform for performing a comprehensive billing analysis of energy consumption across several fuel types. The fact that GHG emission and energy use are inextricably linked provides energy professionals with an important opportunity to use existing industry practices in a new way to address one of the most important environmental issues of our time.