Greenhouse Gas Emission Inventory

for all sectors of

Sonoma County, California

January 2005

Prepared for the

Bay Area Air Quality Management District

and the

Sonoma County Waste Management Agency

by the

Climate Protection Campaign

Greenhouse Gas Emission Inventory for all sectors of Sonoma County, California

January 2005

Abstract

This report,[1] funded by the Bay Area Air Quality Management District, describes the results of the greenhouse gas emissions inventory for all sectors of Sonoma County. This represents Sonoma's first community-wide climate protection effort, and the first climate protection initiative undertaken by a California regional air district. This report is intended to help Sonoma County governments, businesses, and residents reduce their greenhouse gas emissions. Also it aims to inspire other communities to conduct similar inventories, and guide them as they do so.

The following tasks and findings correspond to the study's scope of work.

A. Inventory Sonoma County's greenhouse gases (GHG)
For the inventory we reviewed the science of global climate change, and the relationship between greenhouse gas emissions and criterion air pollutants. We followed emission accounting protocol from Cities for Climate Protection®, and categorized emissions into four sectors:

- Electricity and natural gas
- Vehicular transportation
- Agriculture
- Solid waste

We found that from 1990 to 2000, Sonoma County's GHG emissions increased overall by 28 percent. Key factors for this rise are an increase in vehicle miles traveled of 42.5 percent, and an increase in population of 18 percent.

B. Recommend emission reduction targets
Scientists say that we need to reduce emissions of carbon dioxide, the major GHG, by 50 to 70 percent to stabilize its concentration in the atmosphere, and can succeed in making such reductions using solutions that exist today. After surveying options for GHG reduction targets, we recommend that Sonoma County adopt a 20 percent reduction from 1990 levels by 2010, a bold beginning to align this area's GHG emissions with the scientific imperative.

C. Recommend next steps
We recommend that Sonoma County launch an initiative through which representatives from diverse sectors of the community come together to consider and adopt GHG emissions reduction targets; and create, adopt, and commit to implementing a plan for reaching the target.

[1] This report is posted at www.climateprotectioncampaign.org

Greenhouse Gas Emission Inventory for all sectors of Sonoma County, California

January 2005

Table of Contents

A. Greenhouse gas emission inventory for all sectors of Sonoma County, California

Project background and overview

In August 2002, Sonoma became the first county in the nation where 100 percent of its municipalities—the County and all nine cities—pledged by resolution to measure and reduce their greenhouse gas (GHG) emissions. They joined *Cities for Climate Protection*®, a campaign led by *ICLEI - Local Governments for Sustainability*. Over 600 communities participate in this campaign worldwide, with over 150 of them in the U.S.

The Cities for Climate Protection (CCP) program consists of five milestones:

Milestone One:	Inventory greenhouse gas emission production
Milestone Two:	Set a target for emission reduction
Milestone Three:	Create a plan for meeting the target
Milestone Four:	Implement the plan
Milestone Five:	Monitor progress and adjust as appropriate

Municipalities can focus on GHG emissions produced by their internal operations, on emissions produced by all sectors in the jurisdiction, or first one and then the other. Sonoma municipalities chose to "lead by example," focusing on internal operations first. This study represents Sonoma's first assessment of the greenhouse gas emitted by the whole community.

The County of Sonoma and the City of Santa Rosa completed their GHG emissions inventories—Milestone One—for their internal operations in 2002. The County also set a target—Milestone Two—to reduce the emissions produced by its internal operations by 20% from 2000 to 2010. The remaining eight Sonoma cities completed inventories of the emissions produced by their internal operations in September 2003.[2] In doing so, Sonoma set a second national precedent when 100 percent of its municipalities completed their baseline emission inventories. In 2004, Rohnert Park, Sebastopol, and Cotati set their emission reduction targets – Milestone Two - for their internal operations. All three cities' targets are the same as the County's except Sebastopol's which is 30% from 2000 by 2008.

In 2002 the Sonoma County Mayors' and Council members' Association sent a letter to the Chair of the Board of the Bay Area Air Quality Management District encouraging the district to support climate protection. In June 2003, the Air District Board approved a request for financial support of a two-part study comprised of a GHG inventory for all sectors of Sonoma County, and research regarding actions underway regionally and nationwide in which air quality and climate protection efforts are being integrated. The Sonoma County Waste Management Agency served as administrator for the study.

[2] References for inventory reports are listed under Resources, page 47.

This report of Sonoma County's emissions inventory is intended for use by other communities as an example of how to inventory their GHG emissions. The report on the second part of the study, Phase 2, will be issued separately.

Project work statement

Phase 1. Inventory of the greenhouse gases emitted in Sonoma County

	Task	Description	Corresponding CCP Milestone
A.	Analysis: Inventory of GHG emissions	Greenhouse gas emission inventory for Sonoma County broken down into at least three sources – residential, business, and governmental.	Milestone One – Inventory
B.	Recommendations: Targets	Recommendations for GHG emission reduction targets for Sonoma County.	Milestone Two – Target
C.	Recommendations: Next Steps	Recommendations for next steps for reducing GHG emissions in Sonoma County, and how these next steps relate to the BAAQMD's Air Quality Plans.	Milestone Three - Plan
D.	Research: Input from stakeholders	A list of the stakeholders involved in producing the inventory report with copies of minutes of meetings with stakeholders	Not applicable
E.	Public outreach	Copies of newspaper articles and other print media coverage, if any, for these efforts listed above.	Not applicable

Phase 2. Integration of air quality and climate protection efforts and the BAAQMD's role

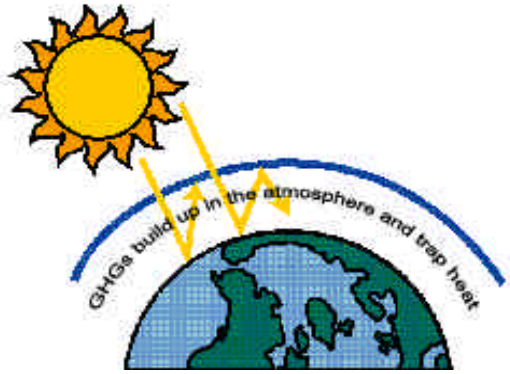
	Task	Description
A.	Research: District-wide inventory	Inventory of climate protection efforts throughout the Bay Area Air Quality Management District, and identification of the best models for climate protection found in the District. Description of the coordination, if any, between climate protection and air quality in these efforts.
B.	Research: Nationwide review	Description of the results of a nationwide review of how climate protection and air quality management are being connected and coordinated at the regional level. Identification of the most effective models for making this connection.
C.	Analysis: Relation between plans	Analysis of the relation between the BAAQMD's Air Quality Plans and climate protection plans, including identification of the overlaps, gaps, and areas of synergy.
D.	Recommendations: Model ordinance(s)	Model ordinance(s) for local government that addresses and integrate climate protection and air quality management.
E.	Recommendations: Model framework	Description of a model framework for programs – local, regional, and multi-county – that both protect the climate and improve air quality.
F.	Recommendations: Next steps	Description of recommended next steps for the BAAQMD.
G.	Resources: Possible funding sources	A list of possible funding sources for climate protection and clean air efforts.
H.	Resources: Other	A list of resources for more information about the above.
I.	Research: Source of information	A list of the stakeholders involved in producing the report with copies of minutes of meetings with stakeholders.
J.	Final Report	A presentation to the BAAQMD Board with the results of the project.

Global climate change: Description and significance

Heat from the sun is trapped near the Earth's surface by naturally occurring gases. This greenhouse effect stabilizes earth's temperature at an average of approximately 60°F, making Earth habitable for humankind.

The major greenhouse gas from human activity, carbon dioxide (CO_2), is produced when gasoline, diesel, natural gas, coal and other fossil fuels combust. Methane (CH_4), the second most important greenhouse gas from human activity, is a byproduct of organic decomposition.

As human population and consumption has increased, so has the amount of greenhouse gas emitted into Earth's atmosphere. In the mid 1850s there was about 280 parts per million of carbon dioxide in the atmosphere; now there is about 379. Human activity has increased the blanket of heat-trapping gas surrounding the Earth, magnified the greenhouse effect, and increased Earth's average temperature by an average of more than 1°F over the last 100 years.



Climate change is caused by a manmade blanket of carbon dioxide that surrounds the earth and traps in heat.

Scientists prefer the term climate change to global warming because climatic changes vary across the planet, from place to place and season to season. With climate change comes extreme weather – both record-breaking hotter and colder temperatures, both droughts and floods. For example, between 1995 and 1998 there were a record 33 hurricanes in the U.S. In August 2004, Hurricane Charley with winds of 145 miles per hour in Florida, caused $7.4 billion in damages and killed 27 people. For many areas in the U.S., droughts in 1998 were among the worst ever. Currently, the western part of North America is in the midst of one of the worst droughts in 500 years. While no single weather event can be attributed to global climate change, the pattern of increasing extreme weather can, say climatologists.

The world's foremost authority on climate change, the International Panel on Climate Change (IPCC), involves thousands of scientists worldwide who study atmospheric changes, their potential impacts, and appropriate policy responses. Having verified the increase in greenhouse gas, the rise in temperatures, and the impacts on Earth's living systems, these scientists concluded that global climate change imperils life on Earth. In 1995, the IPCC specified that stabilizing the concentration of carbon dioxide required an immediate reduction in CO_2 emissions of 50 to 70 percent, and required further reductions thereafter until the year 2100.[3]

[3] IPCC second assessment synthesis of scientific-technical information relevant to interpreting article 2 of the UN Framework Convention on Climate Change, 1995, the summary for policymakers, page 9, http://www.ipcc.ch/pub/sa(E).pdf See also "Climate Change Research - Facts, uncertainties and responses," Astrid Zwick, Antonio Soria http://www.jrc.es/pages/iptsreport/vol05/english/art-en1.doc

Types and strengths of greenhouse gases[4]

Processes that generate, absorb, and destroy greenhouse gases determine its concentration in the atmosphere, currently less than 1 percent. Major greenhouse gases besides carbon dioxide and methane are nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and ozone (O_3).[5] Water vapor (H_2O) also contributes to the greenhouse effect, but human activity has little impact on it, according to scientists.

The IPCC identified the strength of each type of GHG based on its ability to trap heat, defined as cumulative radiative forcing.[6] Global warming potential also takes into account the atmospheric lifetimes of GHGs.

Global Warming Potential of major greenhouse gases [7]

	Greenhouse gas	Estimated Lifetime (years)	Global Warming Potential		
			20 years	100 years	500 years
	Carbon Dioxide (CO_2)	50-200[8]	1	1	1
	Methane (CH_4)	12.0	62	23	7
	Nitrous Oxide (N_2O)	114	275	296	156
Chlorofluorocarbons (CFCs)	$CFCl_3$ (CFC-11)	45	6300	4600	1600
	CF_2Cl_2 (CFC-12)	100	10200	10600	5200
	$CClF_3$ (CFC-13)	640	10000	14000	16300
	$C_2F_3Cl_3$ (CFC-113)	85	6100	6000	2700
	$C_2F_4Cl_2$ (CFC-114)	300	7500	9800	8700
	C_2F_5Cl (CFC-115)	1700	4900	7200	9900

[4] Reference: Hong Kong Observatory: http://www.hko.gov.hk/wxinfo/climat/greenhs/e_grnhse.htm Please note that these figures are from the IPCC's Third Assessment Report. The protocol followed for this report follows the U.S. inventory as well as the recommendation of the IPCC, i.e., to continue to use the GWPs from the IPCC's Second Assessment report through the end of the first reporting period when inventories will shift over to the Third Assessment Report.

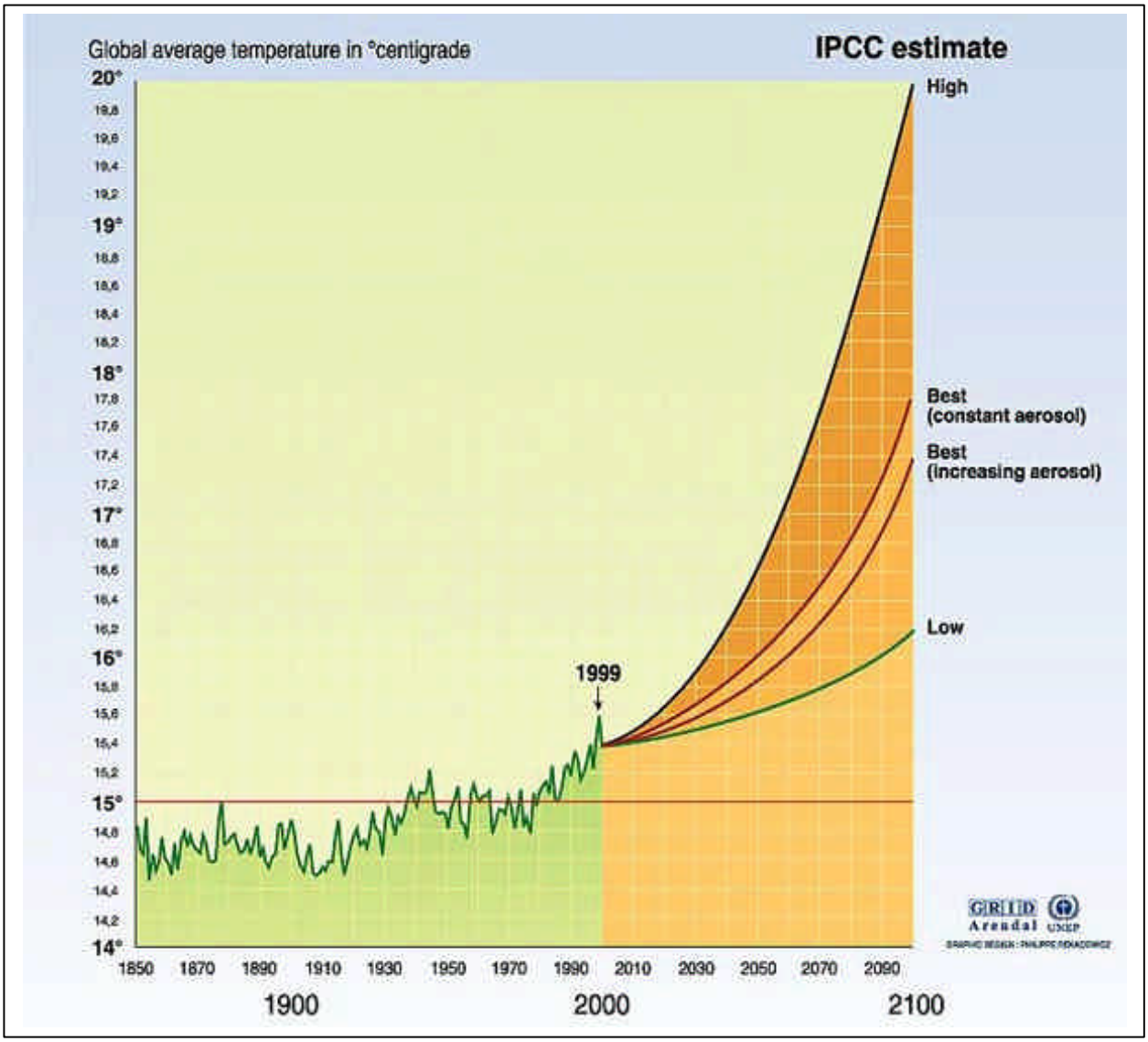
[5] Tropospheric ozone concentrations in the Northern Hemisphere may have increased since preindustrial times because of human activity, resulting in positive radiative forcing. Although not yet well characterized, this forcing is estimated to be about 0.4 Wm2 (15% of that from the long-lived greenhouse gases). However, the observations of the most recent decade show that the upward trend has slowed significantly or stopped. IPCC Summary for Policy Makers http://www.ipcc.ch/pub/sarsum1.htm

[6] Radiative forcing considers the difference between the present and some future time caused by a unit mass of greenhouse gas emitted now, expressed relative to CO_2. Radiative forcing is defined as a change in average net radiation at the top of the troposphere (tropopause) due to a change in either solar or infrared radiation. A radiative forcing perturbs the balance between incoming and outgoing radiation. A positive radiative forcing tends on average to warm the Earth's surface; a negative radiative forcing tends on average to cool the Earth's surface.

[7] Global warming potential following the instantaneous injection of 1 Kg of each GHG, relative to 1 Kg of CO_2. Table is based on information found in the IPCC Third Assessment Report, 2001. Derivations of global warming potentials require knowledge of the fate of the emitted gas (typically not well understood) and the radiative forcing due to the amount remaining in the atmosphere (reasonably well understood). GWPs typically encompass $\pm$ 35% uncertainty relative to CO_2 reference.

[8] Different removal processes result in a varying CO_2 lifetime, U.S. Environmental Protection Agency, April 2002, http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUM9T/$File/ghg_gwp.pdf

Projected changes in global temperature:
Global average 1856-1999 and projection estimates to 2100



Source: Temperatures 1856-1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projection: IPCC report 95.

World Scientists' Warning to Humanity

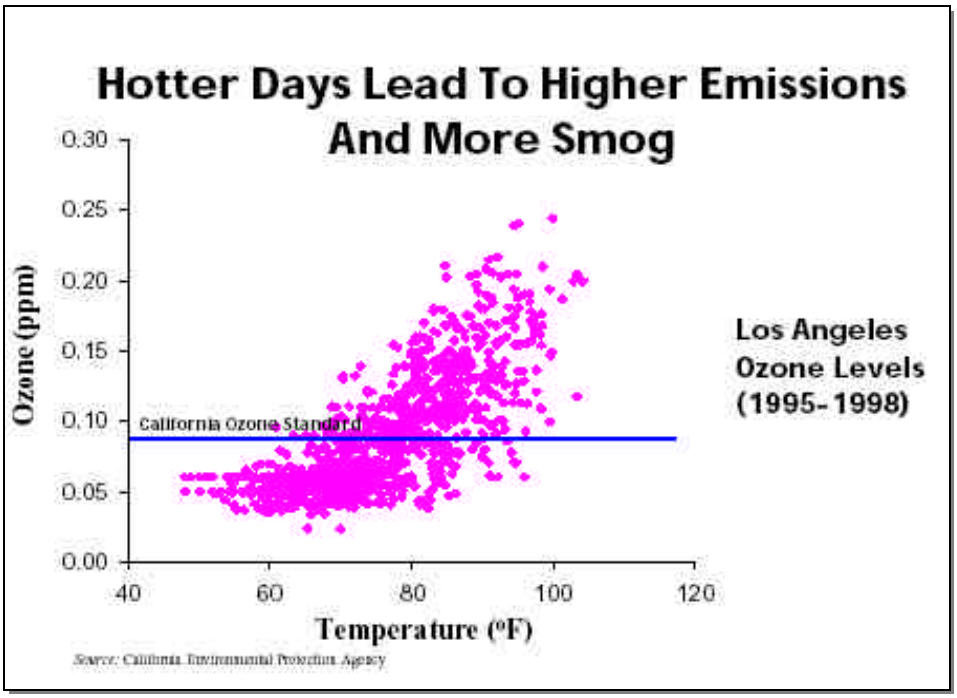
Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about."

--Signed in 1992 by more than 1,600 scientists, including 102 Nobel laureates, from 70 countries
http://www.ucsusa.org/ucs/about/page.cfm:pageID=1009

Relationship between global climate change and air quality

The higher temperatures forecast by scientists will worsen air quality in several ways. Ozone formation tends to increase with higher temperatures, strong sunlight, and a stable air mass, as shown in the following graph. Higher temperatures also increase air pollution by causing vegetation to emit more natural hydrocarbon, harder working engines, increases in fuel evaporation, and greater demands on power plants.[9]

Recent research confirms that global climate change will likely trigger increases in smog and health problems even if the level of man-made smog-causing pollutants remains the same. The research predicts that by 2050 the number of smog-alert days in selected U.S. cities will increase by about 60%, accompanied by more lung diseases including asthma, more hospital admissions, and more premature deaths.[10]



Just as climate change exacerbates air pollution, air pollution also exacerbates climate change. Incomplete combustion of fossil fuels, biofuels, and biomass produces black carbon, also called soot or particulate matter. The impact of these air pollutants on global temperature is very complex.[11] Some climate scientists assert that their overall impact is to heat the atmosphere.[12]

---

[9] "Global Warming and Greenhouse Gas Emissions from Motor Vehicles," AB 1493 (Pavley) Briefing Package, prepared by the California Environmental Protection Agency, http://www.energy.ca.gov/global_climate_change/documents/AB1493_PRESENTATION.PDF

[10] "Heat Advisory: How Global Warming causes More Bad Air Days, July 2004, http://www.nrdc.org/globalWarming/heatadvisory/heatadvisory.pdf

[11] "Climate Change Overview: Technical support document for staff proposal regarding reduction of greenhouse gas emissions from motor vehicles," California Environmental Protection Agency, Air Resources Board, August 6, 2004, http://www.arb.ca.gov/cc/factsheets/august_tsd/overview_august.pdf

Air pollution and climate change share causes and solutions. Reduction in fossil fuel consumption reduces both criteria pollutants and GHG emissions. Many criteria pollutants, specifically the various oxides of nitrogen (NOx) produced during combustion originate from fossil fuel combustion, as does carbon dioxide (CO_2), the primary greenhouse gas. Volatile organic compounds (VOCs) are ozone precursors, and will under certain circumstances, produce methane. Reducing VOCs improves air quality and helps protect the climate.

Electricity, transportation, and industrial sectors account for most of the U.S. anthropogenic emissions of criteria pollutants and GHG emissions. Electric and transportation sectors are the largest aggregate producers of GHG emissions, with each accounting for about 35 percent to 40 percent of total emissions.[13] For all sectors, the two essential steps to both clean the air and protect the climate are improving energy efficiency and switching to lower-carbon or zero-net-carbon fuels, i.e., renewables.

Enormous opportunities exist worldwide for taking these essential steps, usually with significant positive economic benefits as well. For example, estimates from the Centre for Integrated Assessment Modelling indicate that Kyoto-level cuts in CO_2 emissions would reduce the cost of reaching European countries' 2010 air pollution objectives by at least €5 billion.[14]

> In continuing to address criteria pollutant nonattainment challenges, state and local officials have the opportunity to capture significant GHG emission reductions. The most effective path for achieving this goal is to ensure that, in obtaining emission reductions needed for criteria pollutant attainment, the applied strategies are ones that also provide GHG reduction benefits, rather than measures that are ineffective or counterproductive from a GHG perspective.
>
> "Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options," STAPPA /ALAPCO

Clean air solutions do not necessarily translate to climate protection. Smog-creating air pollution decreased substantially in the U.S. following the Clean Air Act of 1970. By contrast, CO_2 emissions rose during the same period because air quality tactics such as "tailpipe" controls and smokestack scrubbers have little or no impact on carbon dioxide. In fact, some clean air technologies actually increase CO_2 by lowering plant efficiency, thus requiring more energy to be used. Some alternative fuels that are good for air quality either have no effect or increase GHG emissions. Congestion management measures like signal synchronization often reduce emissions only temporarily. Emissions may actually increase in the long run because short-term traffic relief encourages people to drive more. Although strategies that cut standard air pollution often miss GHG emissions, strategies that reduce GHG emissions almost always improve air quality as well.[15]

---

[12] See, for example, "Defusing the Global Warming Time Bomb," James Hansen, Scientific American, March 2004.
[13] "Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options," October 1999, STAPPA/ALAPCO, http://www.4cleanair.org/comments/execsum.PDF
[14] UNECE Convention's IIASA, http://www.unece.org/env/emep/pr03_env02e_h.pdf
[15] "Converging solutions: Clean air and climate protection," ICLEI fact sheet by Chris Giovinazzo, undated.

Many initiatives that aim to both clean the air and protect the climate are emerging. One recent development with potentially far-reaching impacts is the suit filed in July 2004 against five major utilities by attorneys general from eight states including California, and officials from New York City. The suit charges that greenhouses gas emissions from the utility companies are creating a public nuisance. The suit seeks a court order to require the utilities to reduce these emissions. Attorneys general contend that they must act because normal regulatory approaches such as action from the E.P.A., Congress, and the administration, have failed to adequately address the threat posed by utilities' GHG emissions.[16]

Passage of AB1493 in 2002, California's law to regulate greenhouse gas emissions, represents the first-ever mandatory reduction of greenhouse gas pollutants from vehicles in the U.S. The legislation directed the Air Resources Board to develop regulations for automobile manufacturers to achieve maximum feasible reductions in GHG emissions. In September 2004, the California Air Resources Board voted unanimously to adopt standards that cut carbon dioxide emissions by 25 percent starting with the 2009 model year.[17]

The two major national associations of air pollution control agencies, State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) in 1999 issued a substantial education resource guide to help state and local officials identify and assess harmonized strategies and policies to reduce air pollution and address climate change simultaneously.[18] Also, STAPPA/ALAPCO together with ICLEI in 2003 released software called CACPS – Clean Air and Climate Protection Software – to help state and local governments track criterion air pollution and GHG emissions.[19] CACPS was used for this Sonoma County GHG emissions inventory.

In Europe, the European Environmental Agency has issued a report that analyzes the linkages between climate protection and air quality.[20]

The integration of air quality management and climate protection is the subject of Phase Two of this project where the relationship between global climate change and air quality from an implementation and policy perspective will be taken up in more depth.

[16] "New environmental cops: state attorneys general," Christian Science Monitor, July 22, 2004, http://www.csmonitor.com/2004/0722/p03s01-usju.html
[17] "California Goes Ahead With Disputed Smog Plan," UPI, September 24, 2004, http://www.spacedaily.com/news/pollution-04c.html
[18] "Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options," October 1999, STAPPA/ALAPCO, http://www.4cleanair.org/comments/execsum.PDF
[19] http://www.cacpsoftware.org
[20] http://reports.eea.eu.int/technical_report_2004_5/en/tab_content_RLR

Summary of findings

This study found that from 1990 to 2000, overall GHG emissions produced in Sonoma County increased by 28 percent. Two critical factors in this rise are increases in emissions from vehicle transportation of about 43 percent, and in population of 18 percent during this same period. For comparison, GHG emissions nationwide increased by 14.2 percent between 1990 and 2000, according to the U.S. Environmental Protection Agency.[21]

Greenhouse gas emissions[22] (GHG), Sonoma County

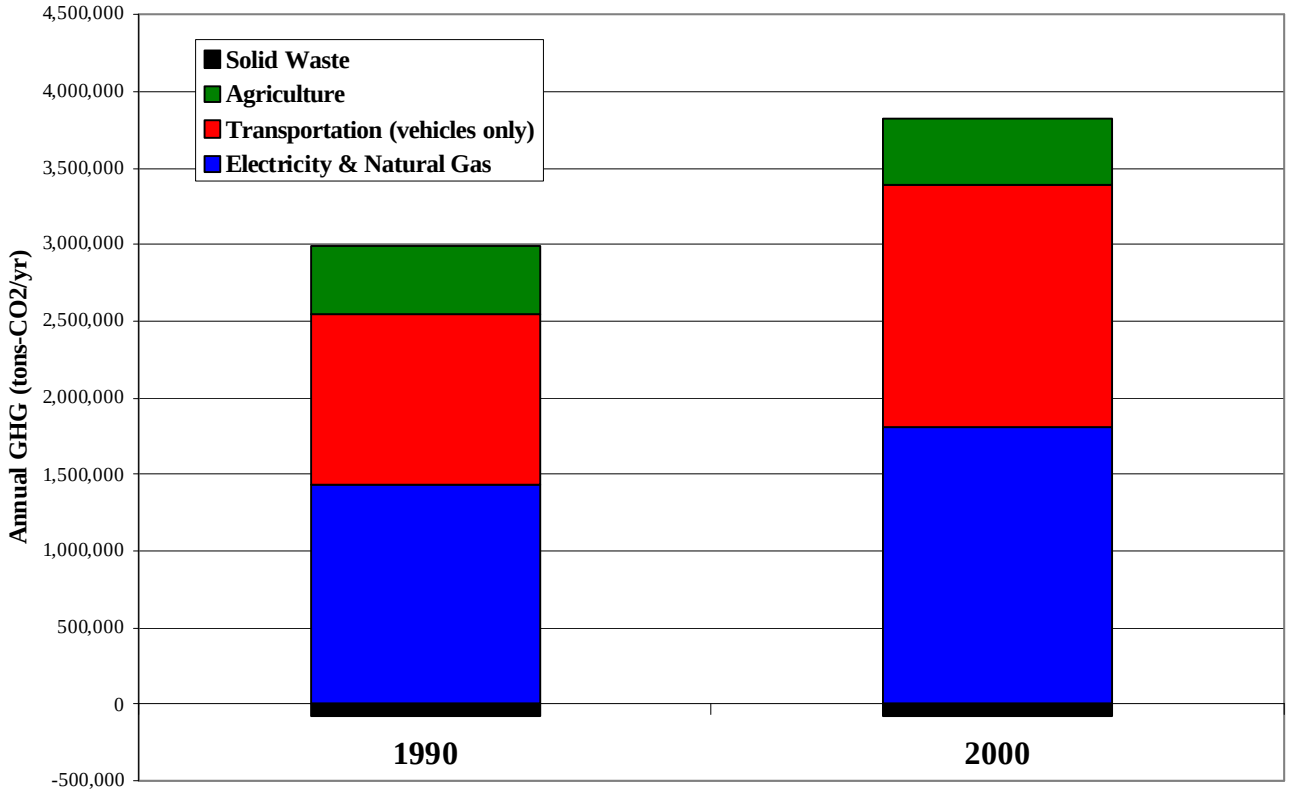
	1990		2000		% change
	GHG (tons)	**% of total**	**GHG (tons)**	**% of total**	
Electricity & natural gas	1,430,996	48	1,804,158	47	**+26**
Transportation (vehicles only)	1,115,000	37	1,589,000	42	**+43**
Agriculture	444,690[23]	15	425,040	11	**-4**
Sub-total	2,990,686	100	3,818,198	100	
Solid Waste[24]	-80,332		-78,818		**+2**
Total Net GHG	**2,910,354**		**3,739,380**		**+28**
Population		**388,222**		**458,614**	**+18**
GHG per person in Sonoma		**7.5**		**8.2**	**+9**

[21] "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 –2000" U.S. Environmental Protection Agency, 2002, http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUKBK/$File/executive_summary.pdf

[22] Greenhouse gas (GHG) is expressed throughout this report, except where otherwise noted, in tons equivalent carbon dioxide (tons eCO2)

[23] Data is for 1992; data for 1990 not available.

[24] Solid waste is negative because solid waste's overall impact is to take GHG out of the atmosphere, following the protocol used for this inventory. Please see page 27 for an explanation.


Solid Waste
Agriculture
Transportation (vehicles only)
Electricity & Natural Gas
Annual GHG (tons-CO2/yr)
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
1990
2000

Greenhouse gas emission accounting

Accounting for greenhouse gas emissions, although a relatively new field, has evolved rapidly over the last ten years as pioneer practitioners worldwide standardize methods and protocols for calculating GHG emissions. ICLEI – Local Governments for Sustainability, through its Cities for Climate Protection campaign, is a leader in developing accounting methodology and setting standards for local communities' GHG emission inventories. ICLEI coordinates its work with the California Climate Action Registry,[25] the U.S. Department of Energy, the U.S. Environmental Protection Agency, Canada-based software developers Torrie Smith Associates, and, more recently, State and Territorial Air Pollution Program Administrators-Association of Local Air Pollution Control Officials (STAPPA/ALAPCO). As noted previously, over 600 local governments worldwide participate in ICLEI's Cities for Climate Protection campaign, suggesting the importance of having a standard GHG emission protocol, as well as the role ICLEI plays in promulgating standards.

All accounting methodologies, even in highly advanced fields such as finances, face new challenges and change over time. GHG accounting is especially challenging, first because of the relative newness of its methodology, and second because GHG data source development is also relatively new.

Accounting never exactly represents reality. What is included and excluded is determined by accounting protocol and by the amount of resources devoted to data collection and analysis. For example, this GHG inventory doesn't include emissions from meat consumed locally but produced elsewhere, nor emissions from residents' air travel; it does include emissions from electricity consumed locally even when the electricity is produced elsewhere.

Communities can obtain a good idea of their GHG emissions relatively easily using ICLEI's GHG emissions accounting method, as we intend to demonstrate in this report. In general, the years to be studied are specified, and data - much of it from government sources – is collected and then converted to greenhouse gas emissions using standard coefficients.

Many communities use software to help organize and convert data into emissions and create reports. ICLEI and STAPPA/ALAPCO developed and released new software, called Clean Air Climate Protection Software (CACPS) in 2003 to enable communities to inventory criterion air pollutants and GHG emissions. CACPS was used for most of the calculations in this study.

Base years chosen for this study, 1990 and 2000, correspond with years for other significant data benchmarking, i.e., the U.S. Census. The year 2000 also corresponds to the base year used by the County of Sonoma and Sonoma's nine cities to inventory GHG emissions of their municipal operations.

[25] The California Climate Action Registry, a non-profit public/private partnership, develops protocols for calculating GHG emissions, and provides GHG emissions software called CARROT to participating organizations. The Registry anticipates a carbon trading market in the future, and is now helping businesses establish "credit for early action." The Registry focuses on emission tracking and certifying, primarily for business, while ICLEI focuses on a comprehensive climate protection program for local governments, from pledging to tracking to implementing GHG reduction measures.

Electricity and natural gas[26]

Electricity originates with some other form of energy - falling water, wind, geothermal steam, nuclear, natural gas, oil, or coal. Electricity from fossil fuels emits relatively more greenhouse gas than electricity from renewable resources, e.g., hydropower, wind, and biomass, as shown in the following table.[27]

GHG emissions	Power plant energy source	
Least	Hydro, wind, solar thermal, biomass	Biomass fuels (such as wood) emit carbon dioxide when burned, but extract carbon dioxide from the atmosphere when they are growing.
| | | | | | | ?	Geothermal, solar photovoltaic (PV), nuclear	Geothermal steam contains carbon dioxide which is usually vented. The production of PV panels is energy intensive; however, if renewable energy sources were used in their manufacture, then GHG emissions would be minimal. Electricity is needed to produce enriched uranium nuclear fuel, often from coal-powered plants. Waste from nuclear energy generation makes this a controversial energy source.
	Natural gas	Carbon/Hydrogen Ratio[28] (C/H) = 1:4
Most	Oil	C/H = ~1:2
	Coal	C/H = ~1:1

Each power plant has its own emissions coefficient that is based on the type of fuel burned and the plant's thermal efficiency. Thermal efficiency is a function of the power plant's design, and indicates how much of the heat created during combustion becomes electricity. The range for this is about 30 to 60 percent, resulting in wide variation in power plants' emissions coefficients.

California's electricity grid receives power from many locations and energy sources. The mix can vary from one hour to the next. It is impractical to determine the exact amount of greenhouse gas emitted by electricity consumption because this would require identifying the exact sources, coefficients, and mix for the electricity. The U.S. Department of Energy annually determines each state's emissions coefficient based on the average amount of power supplied from various sources. The coefficient used for this report is 0.73 lbs of equivalent carbon dioxide emitted for every kilowatt hour consumed.[29]

The impact of "green" power generation is demonstrated by the following two examples. If California's electricity came exclusively from coal, the state's GHG emissions for electricity would be about three times higher. If California's electricity were as green as that used in the City of Healdsburg - supplied by the Northern California Power Authority rather than PG&E - the state would cut its GHG emissions for electricity by more than half.

[26] Although Sonoma County relies almost solely on natural gas, other jurisdictions following Sonoma County's inventory model should count in this section any oil and coal combusted for stationary consumption.
[27] Harnessing power from hydro, wind, solar thermal, and biomass sources currently relies on some use of fossil fuel, for example, in the manufacture of photovoltaic panels, and the fuel used in transporting firewood.
[28] Differences among fossil fuels are caused primarily by the fuel's ratio of carbon and hydrogen: the more carbon, the more carbon dioxide.
[29] Coefficient used in CACP software; it is derived from the Department of Energy, and based on the grid region.

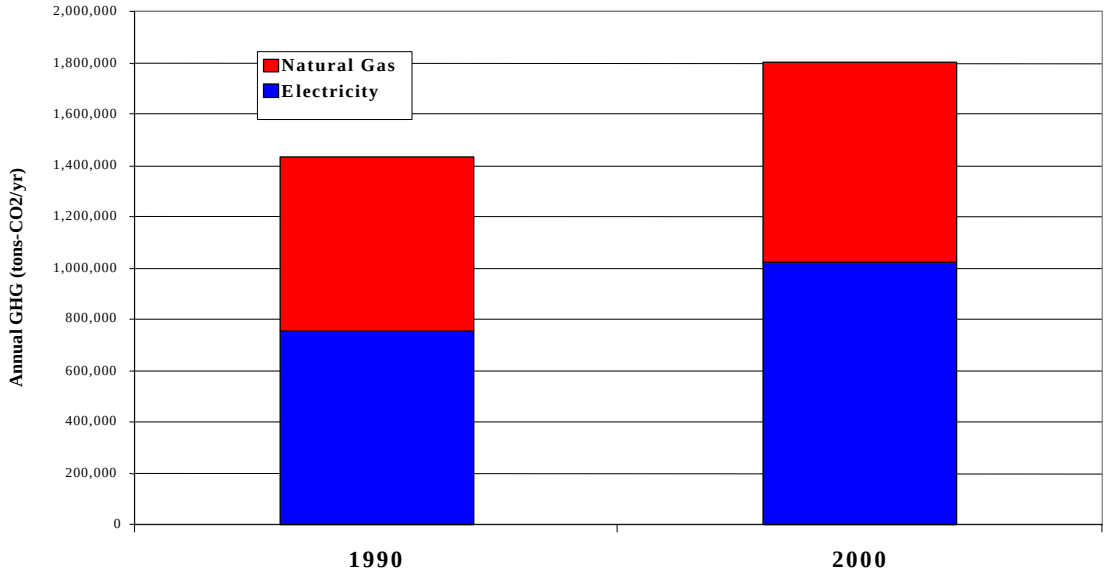
Converting natural gas usage to GHG emissions requires no coefficient specific to time or place. Natural gas is almost entirely methane. Each molecule of methane becomes one molecule of carbon dioxide upon combustion, equal to about 12 pounds of carbon dioxide released for each therm of natural gas consumed.[30]

Steps for calculating GHG emissions from electricity and natural gas:

1. Obtain electricity (kilowatt-hours) and natural gas (therms) data from the California Energy Commission. This data is organized by the following SIC sectors: residential, commercial, industrial, agricultural and water pumping, and other. The SIC sector definitions for these categories are based on SIC code classifications of economic activity within the county.
2. Enter this data into the CACP software to compute GHG emissions.
3. Obtain the following data from the U.S. Census using SIC codes:
    a. Total population
    b. Number of commercial establishments
    c. Number of employees
    d. Number of industrial establishments, including agriculture and water pumping, non-agricultural and other (includes airports, postal service, sewer, street lighting, communication, and military)
4. Enter these census figures into the software to compute per capita, per employee, and per establishment emissions.

Results for Sonoma County

From 1990 to 2000, total electricity use in Sonoma County increased by 29 percent, and natural gas use increased by 14 percent. GHG emissions from electricity and natural gas use combined increased 26 percent. Electricity and natural gas account for 47 percent of Sonoma County's total GHG emissions in 2000. These emissions are associated primarily with energy use in buildings, and are from all sectors - residential, commercial, and industrial.



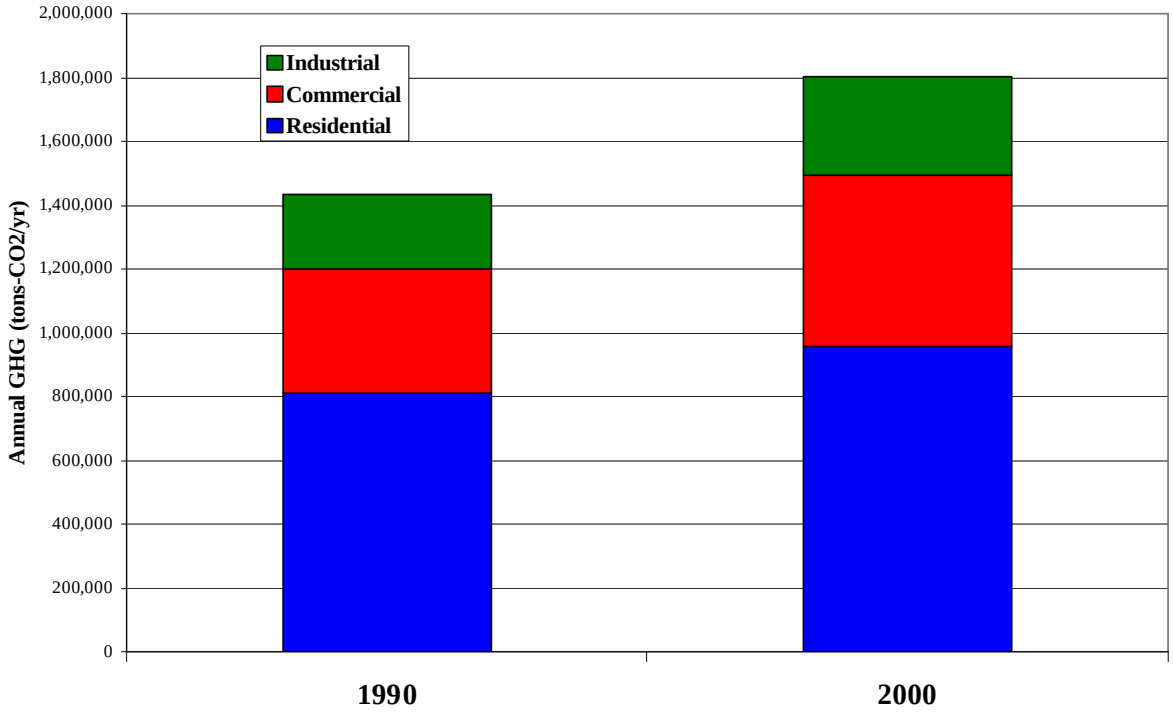
[30] Please note that regional variations exist for fossil fuels other than natural gas.

Electricity, natural gas, and GHG emissions, Sonoma County [31]

	1990			2000			% change GHG
	kWh (millions)	**therms** (millions)	**Total GHGs** (tons)	**kWh** (millions)	**therms** (millions)	**Total GHGs** (tons)	
Residential - total	**988**	**76**	**810,123**	**1,213**	**83.6**	**958,627**	**+18**
Per capita[32]			*2.1*			*2.1*	*0*
Per household[33]			*5.4*			*5.6*	*+4*
Commercial - total	**743**	**22**	**392,423**	**997**	**27.8**	**535,368**	**+36**
Per capita			*1.0*			*1.1*	*+10*
Per commercial employee[34]			*4.2*			*4.7*	*+12*
Per commercial establishment[35]			*43.1*			*54.7*	*+27*
Industrial - total	**455**	**11.5**	**228,450**	**606**	**14**	**310,163**	**+36**
Agriculture & water pumping	86	2	42,134	94	2.3	48,388	+14
Per employee[36]			*324.1*			*806.5*	*+149*
Per establishment[37]			*2340.8*			*3,225.9*	*+38*
Non-agriculture industrial	298	9	158,786	383	10	203,970	+12
Per employee[38]			*5.4*			*4.8*	-11
Per establishment[39]			*63.4*			*72.4*	+14
Other[40]	71	0.5	27,531	129	1.7	57,804	+101
Per employee[41]			*4.8*			*8.1*	*+69*
Per establishment[42]			*64.0*			*137.6*	*+115*
Total energy use - all sectors	**2,186**	**109.5**		**2,816**	**125**		
Total tons GHGs - all sectors	**756,896**	**674,100**	**1,430,996**	**1,026,493**	**777,665**	**1,804,158**	**+26**

[31] Energy use data supplied by Andrea Gough, California Energy Commission, 1516 9th Street, MS-22, Sacramento, CA 95814, (916) 654-4928, fax (916) 654-4901, agough@energy.state.ca.us**.** Figures do not include fuel such as heating oil, propane, and diesel for powering individual generators. Please note that Cities for Climate Protection protocol specifies that emissions from water and waste pumping, and from street and traffic lighting be counted as part of government operations.
[32] Population – 1990:388,222; 2000:458,614. 18% increase in population.
[33] Households – 1990:149,011; 2000:172,403. 16% increase in households.
[34] 1990: 92,936 employees; 2000: 114,922 employees. 24% increase in commercial employees.
[35] 1990: 9,096 establishments; 2000: 9,792 establishments. 8% increase in commercial establishments.
[36] 1990: 130 employees; 2000: 60 employees. 54% decrease in Ag & Water Pumping employees
[37] 1990: 18 establishments; 2000: 15 establishments. 17% decrease in Ag & Water Pumping employees.
[38] 1990: 29,324 employees; 2000: 42,505 employees. 45% increase in Non-Ag Industrial employees.
[39] 1990: 2,503 establishments; 2000: 2,819 establishments. 13% increase in Non-Ag Industrial establishments.
[40] Airports, postal service, sewer, street lighting, communication, and military
[41] 1990: 5,777 employees; 2000: 7,109 employees. 23% increase in Other Industrial employees.
[42] 1990: 430 establishments; 2000: 420 establishments. 2% decrease in Other Industrial establishments.

Sonoma County Greenhouse gas emissions, electricity and natural gas: Industrial, commercial, residential



Energy efficient aeration blowers at the Laguna Wastewater Treatment Plant

The City of Santa Rosa installed new efficient aeration blowers at their wastewater treatment plant. The new blowers are estimated to use 50 percent less energy than the previous blowers, reduce over 1,200 tons of greenhouse gas emissions per year, and save more than $400,000 per year. This GHG reduction is equivalent to the electricity use of 600 single family homes, or 13 trips to the moon in a 25 mpg car. Through this project, the city saves $125 for every ton of GHG reduced.

From “Standing Together for the Future.” Find reference in Resources page 47.

Transportation

Vehicles on Sonoma County roads were the only source of GHG emissions considered for this study's transportation sector. Air travel was beyond the study's scope, and is not generally part of the Cities for Climate Protection or other GHG emissions inventory protocol.

Most vehicles on Sonoma County roads are powered by fossil fuel, primarily gasoline and diesel, which are major GHG contributors. Therefore, as the amount of driving increases, so does the amount of greenhouse gas emitted. According to the Sonoma County Transportation Authority, population growth in the county combined with greatly increased number of vehicles per person is leading to more vehicle miles traveled, more congestion, longer trips and poorer air quality.[43] Reflecting this finding, vehicle miles traveled in Sonoma County increased a dramatic 42.5 percent between 1990 and 2000, more than twice the rate of the county's 18 percent population increase.[44] The future will bring even more vehicle miles and congestion in Sonoma County, according to a study from the Association of Bay Area Governments that projects increases in the number of jobs, residents, and commuters.[45]

One major factor in Sonoma County's vehicle miles traveled is the number of commuters who drive alone. In the Bay Area, Sonoma is second only to Napa for the number of residents who drive alone to work. The reasons for driving alone given most frequently by Sonoma commuters are difficulty finding carpool partners, a lack of direct transit service, and irregular work hours. Compared with the rest of the Bay Area, Sonoma's carpool and bicycle rates are slightly above average, while use of transit modes is lower.[46]

Sonoma County Primary Commute Mode

Drive Alone	72%
Carpool	19%
Bus	3%
Walk	3%
Bicycle	2%
Motorcycle	1%
Telecommute	1%
Vanpool	<1%

The importance of the relationship between city-centered living and climate protection is shown in the map on page 21. On average, those who live in urban parts of Sonoma County travel fewer miles and produce fewer greenhouse gas emissions.

[43] "Keeping Sonoma County Moving," Comprehensive Transportation Plan, Sonoma County Transportation Authority, June 2004, http://www.sonoma-county.org/scta/CTP2004.htm

[44] Metropolitan Transportation Commission data is available on the following sites:
http://www.mtc.ca.gov/datamart/stats/vmt.htm for average daily VMT
http://www.mtc.ca.gov/datamart/stats/vmt9095.htm for select annual VMT totals

[45] Smart Growth Strategy/Regional Livability Footprint Project, Policy-based projections 2003, Association of Bay Area Governments, http://www.abag.ca.gov/planning/smartgrowth/projections.html

[46] "Commute Profile, October 2003," Rideshare.511, http://rideshare.511.org/research/pdfs/cp_sonoma_cp03.pdf

Steps for calculating GHG emissions from transportation:

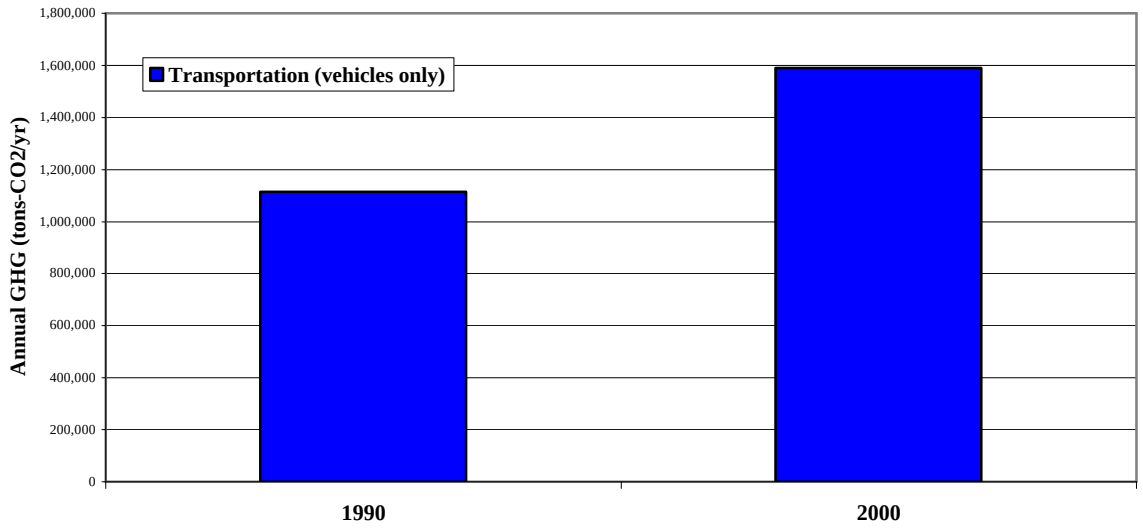
1. Obtain the number of total daily vehicle miles traveled (VMT) from the Metropolitan Transportation Commission (MTC), and multiply by 365 to calculate annual VMT.[47]
2. Using state averages available from the MTC, break down VMT figures using a complex breakdown based on vehicle type and size class. CACP software performs this step.
3. Calculate the number of gallons of fuel used given average fuel efficiency of each type of vehicle.[48] CACP software performs this step.
4. Convert estimated gallons of gasoline and diesel combusted in Sonoma County vehicles into GHG emissions. CACP software also performs this step.

Results for Sonoma County

Transportation from vehicles was responsible for 42 percent of total greenhouse gas emissions in Sonoma County in 2000. From 1990 to 2000, GHG emissions from vehicle transportation increased by 42.5%.

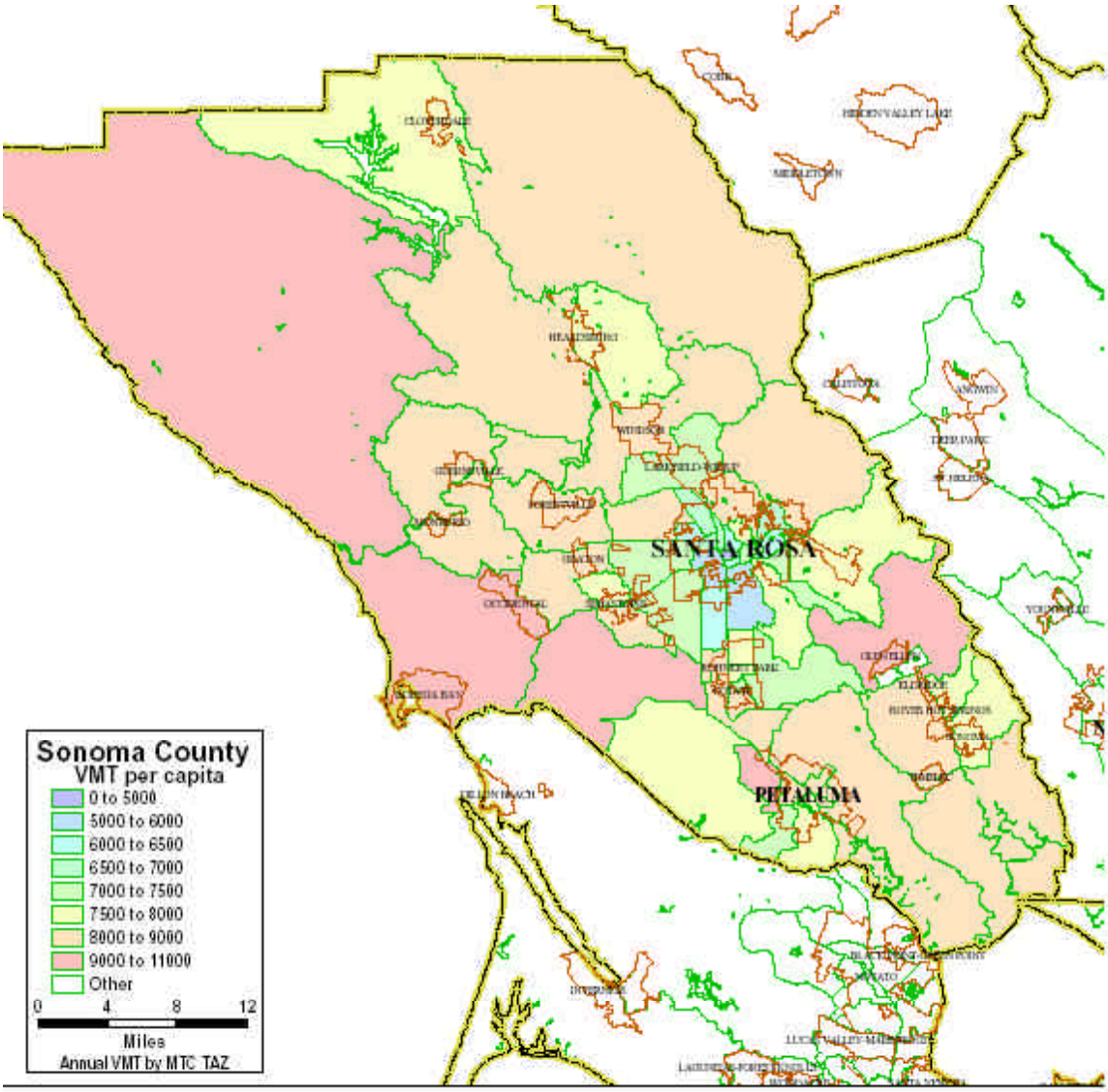
Transportation and GHG emissions, Sonoma County

	1990	2000	% change
Daily Average vehicle miles traveled (VMT)[49]	5,873,500	8,368,000	
Annual VMT	2,144,000,000	3,054,000,000	
GHG from transportation	1,115,000	1,589,000	**+42.5%**



[47] To account for decreases in driving on the weekend, many analysts recommend using 320 instead of 365 as the multiplier for converting daily to annual VMT. In the Bay Area, driving increases on the weekend; for this reason we used 365 for this report.
[48] State averages include gasoline and diesel but not alternatives such as biodiesel. It is assumed that such alternatives represent an insignificant amount of overall transportation fuel. Note: State averages for fuel efficiency may not accurately reflect average fuel efficiency for Sonoma vehicles.
[49] Metropolitan Transportation Commission data is available on the following sites:
http://www.mtc.ca.gov/datamart/stats/vmt.htm for average daily VMT
http://www.mtc.ca.gov/datamart/stats/vmt9095.htm for select annual VMT totals

Location of residence is correlated to miles traveled



This map shows the relationship between residence location and vehicle miles traveled. In general, the farther from the urban core, the more miles traveled and the more greenhouse gas produced through transportation.[50]

[50] Joel Woodhull created the map using data from an analysis conducted by John Holtzclaw who used smog check records from the mid 1990's to obtain vehicle miles traveled per registered vehicle. The areas defined by various colors are traffic analysis zones used by the Metropolitan Transportation Commission. For more information: www.sonomatlc.org

Agriculture

Agricultural activities such as livestock management, use of agricultural equipment, fertilizer application, and conversion of land for agricultural purposes produce greenhouse gas. Calculating the GHG emissions from these agricultural activities is more demanding than for other sectors in this study. In fact, after considerable research, it was determined that data unavailability and the complexity of calculations would prevent inclusion of agricultural activities other than livestock in this study.[51] It is worth noting that CACP software does not include an agriculture section, likely because of the difficulties cited above, and because most communities that conduct GHG inventories are urban.[52]

Regarding the potential for climate protection through increased sequestration of carbon dioxide, some estimates calculate that terrestrial ecosystems now absorb approximately 10 percent of the annual GHG emissions from fossil fuel combustion.[53] While terrestrial ecosystems are expected to continue absorbing carbon from the atmosphere, their capacity to do so is unknown.[54]

Emissions from livestock include methane from flatulence and manure, followed by nitrous oxide from nitrogen compounds that are released as manure decomposes. GHG from livestock is considered human-caused for two reasons. People control the animal population to provide human food and other services, and the practice of keeping animals in high concentrations causes their manure to produce more gas as it decays than it would under unmanaged conditions. Manure concentrated in waste lagoon undergoes anaerobic digestion, resulting in significant methane production. When manure is allowed to decompose naturally in the field, aerobic digestion of the manure produces little or no methane.

Methane and other biogas are untapped sources of renewable energy. Innovative ventures have demonstrated how this waste can become fuel, as shown in the inset box shown on page 24.

[51] Examples of resources that address GHG emissions from agricultural activities include: US EPA, Greenhouse Gas Mitigation Assessment: A Guidebook, Chapter 7: Agricultural Sector, and "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories," Chap. 4, IPCC, 2000.
[52] A USEPA spreadsheet tool supplied by Ryan Bell, ICLEI, was used for this report.
[53] Watson, R. T., M. C. Zinyowera, et al., eds. 1996. *Climate Change 1995—Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses.* New York: Cambridge University Press.
[54] "The Institutional Dimensions of Carbon Management," from Institutional Dimensions of Global Environmental Change (IDGEC), 2000. http://dlc.dlib.indiana.edu/archive/00000342/00/canadellp041300.pdf

Steps for calculating GHG emissions from livestock.

1. Determine the number of livestock.[55]
2. Calculate the methane and nitrous oxide emitted by livestock and their manure.[56]
3. Convert the methane and nitrous oxide to equivalent tons of carbon dioxide using standard conversion factors.[57]

The simplicity of these three steps belies the intricacies of performing such calculations, as detailed in the footnotes below.

---

[55] Livestock population data for this study were taken from the Census of Agriculture produced by the National Agriculture Statistics Service (NASS) and the U.S. Department of Agriculture, and from the Sonoma County Agricultural Crop Report. Supplemental data was obtained from Stephanie Larson, Livestock Range Advisor, Sonoma County Agriculture Extension Office, University of California, Davis. This data was especially important for cattle populations. For example, the census provides the population counts for mature cows and the total cattle population, but not for the subpopulations of bulls and calves. Thus, a method for estimating these subpopulations was required. Because census data populations did not perfectly match the populations for which counts were needed, assumptions, e.g., 1 bull for every 100 cows, had to be made which may have introduced a small source of error. To estimate bull populations, it was assumed that for every 100 cows, beef farms kept 4 bulls and cattle farms kept 1 bull. To estimate calf populations, every adult cow was assumed to have one calf. Of these, 20% become "replacement calves." For every 100 cattle, there are thus 20 replacement calves 0-12 months of age and 20 replacements 12-24 months of age (the 12-24 month replacements should actually be 20% of last year's population, but the census does not occur annually). The other 80% of the calves are typically sold when they're six months old. Thus, in addition to the 20 calves (per 100 adults) that are replacement calves 0-12 months old, there are 80 calves kept for one-half of the year, or approximately 40 additional calves 0-12 months old (per 100 adults). Thus, the population of replacement calves 0-12 months old was 60% of the adult cow population, while the population of replacement calves 12-24 months old was 20% of the adult cow population. The appropriateness of this population estimation method was confirmed by observing that it yielded total cattle populations very close to the actual county total as counted by the census. For the three years considered, percentage error ranged from was 1.3%, 0.4%, and 8.9%. (Because calves are born in different seasons, it is reasonable to assume that at any given time, half of that year's calves will be present for counting.) When calculating emissions, however, this estimation method may slightly overestimate emissions because a calf kept until 6 months of age will produce less than half of the emissions of a calf kept from birth to age 1, because emissions increase with size. However, a more appropriate scalar for calf emissions could not be found.

[56] Calculations follow the process prescribed by the U. S. Environmental Protection Agency, Emission Inventory Improvement Program (EIIP) handbook, volume 8, October 1999, Chapters 6 and 7. Equations, conversion factors, and national averages used for typical animal mass and other similar values were found in this report. To calculate the amount of methane released directly by livestock, the population of that animal was multiplied by the pounds of methane typically released annually by that animal. To calculate the amount of methane released from manure decomposition, the number of livestock was multiplied by the typical animal mass, the typical weight of solids produced per animal mass and the amount of methane produced per unit of solids. The latter value was calculated using a weighted average of the different manure management methods used in the county and these methods' methane conversion rates. To calculate the amount of N_2O released from manure decomposition, the number of each type of livestock was multiplied by the typical animal mass for that type, the Kjeldahl N/year/animal mass, the percentage of manure managed (as opposed to being deposited on the range or paddock), and a conversion factor of 80% which represents the amount of elemental nitrogen that is not volatized to NH_3 or NOx and thus remains to potentially become N_2O. This calculation determines the amount of elemental nitrogen annually present in Sonoma County's managed manure. To calculate the amount of elemental nitrogen becomes N_2O, the kg/year of unvolatized N was multiplied by a conversion factor for each type of manure management system weighted by the percentage of manure managed in that system. Because fewer manure management conversion factors were provided, these calculations were less precise than those for methane, reducing the calculation's accuracy slightly. In calculating the releases of nitrogen and methane as manure decomposes, for dairy cattle, the EPA calculation method only offers nitrogen and methane conversion values for "heifers," (female cattle that have not calved over 500 pounds). It gives no value for calves under 500 pounds. Nor did the subpopulation categories already calculated (determined by age) line up with these new categories (determined by weight). Therefore, it was assumed that all calves 12-24 months represented a heifer, while all calves 0-12 months of age (a figure that includes those 80 calves kept for one-half the year) represented one-half of a heifer. To calculate the amount of nitrogen and methane released from manure decomposition, assumptions had to be made about the proportion of farms using particular manure management techniques. Percentages of farms employing particular manure management practices, such as deep pit, pasture, and anaerobic lagoon, were estimated by Stephanie Larson, UC Davis, for cattle and sheep, by Michael Murphy, UC Davis, for horses, and by individual animal raisers for turkeys. Where not specified, values (e.g. typical animal mass, methane conversion rates) are national or state averages supplied by the U.S. EPA EIIP handbook. For beef farms, it was assumed that 100% of the manure was deposited on the range. For dairy farms, it was assumed that 70% of the manure was managed in anaerobic lagoons, 15% was managed in drylots, and 15% was deposited on the range. We assumed that manure management methods have been relatively constant over time.

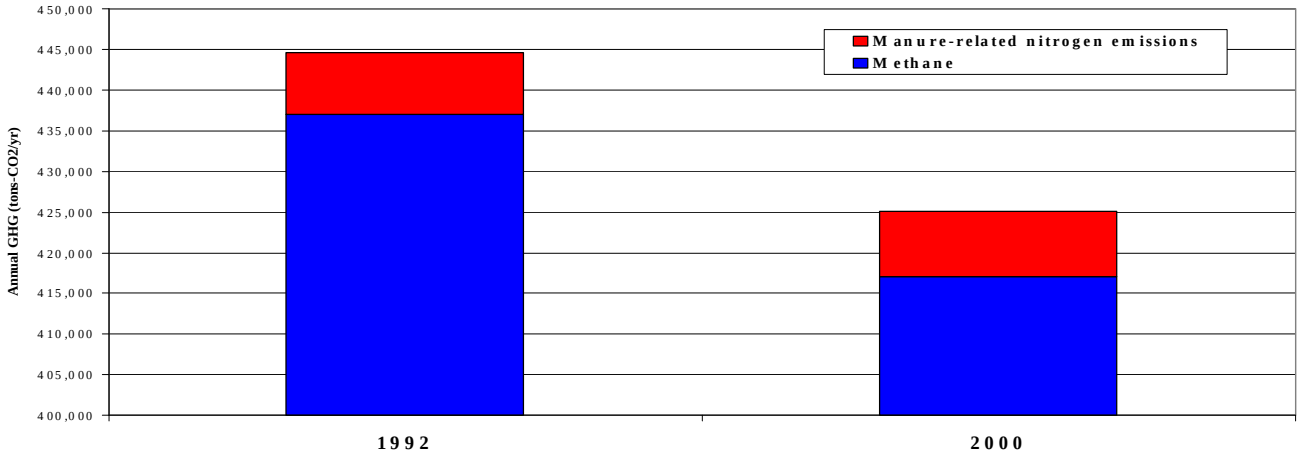
[57] Restating what was previously noted: Various types of GHG, e.g., CH_4 and N_2O, are converted to measures of equivalent carbon dioxide (eCO_2) to enable calculations with and comparisons among the various types of GHG.

Results for Sonoma County

Livestock account for 11 percent of Sonoma County's GHG emissions in 2000. Decreases in GHG emissions for the study period correspond to decreases in the number of livestock.

GHG emissions from livestock

	1992[58]		2000		% change
Methane (CH_4) - tons	20,813		19,863		-5
Methane converted to equivalent CO_2- tons		437,066		417,115	-5
Manure-related nitrogen emissions (nitrous oxide) converted to equivalent CO_2 - tons		7,624		7,925	+4
Total GHG (equivalent CO_2 - tons)		**444,690**		**425,040**	**-4**



Cows generate electricity - Methane digester also breaks down waste

Marin County rancher Albert Straus runs his family's dairy farm, organic creamery, and electric car from manure generated by his 270 cows. On Thursday, Straus switched on a 75- kilowatt generator. His electricity meter began running backward, indicating that power originating from a nearby poop-filled lagoon was feeding PG&E's power grid. The farm's new $280,000 system signaled a breakthrough for the state's dairy industry.

The Straus Farms' methane generator is expected to save between $5,000 and $6,000 per month in energy costs. Straus estimates he will pay back his investment in two to three years. Straus' new methane digester will also eliminate tons of greenhouse gases and strip 80 to 99 percent of organic pollutants from wastewater. Heat from the generator warms thousands of gallons of water that may be used to clean farm facilities and to heat the manure lagoon. Wastewater left over after the methane is extracted is used for fertilizing the farm's fields.

Taken from an article by Maria Alicia Gaura, **San Francisco Chronicle**, Friday, May 14, 2004. Full text of the article posted at: http://sfgate.com/cgi-bin/article.cgi?file=/c/a/2004/05/14/BAGJG6LG3R15.DTL

[58] Data for 1990 unavailable.

Fetzer Vineyards: GHG Emission Case Study for Agriculture

Fetzer Vineyards, headquartered in Hopland, California, is the sixth largest vineyard by total sales in the United States. The California Climate Action Registry selected Fetzer as a case study to demonstrate how an agricultural producer can calculate its impact on the climate. The prominence of wine renders this study relevant to Sonoma County as well as to California.

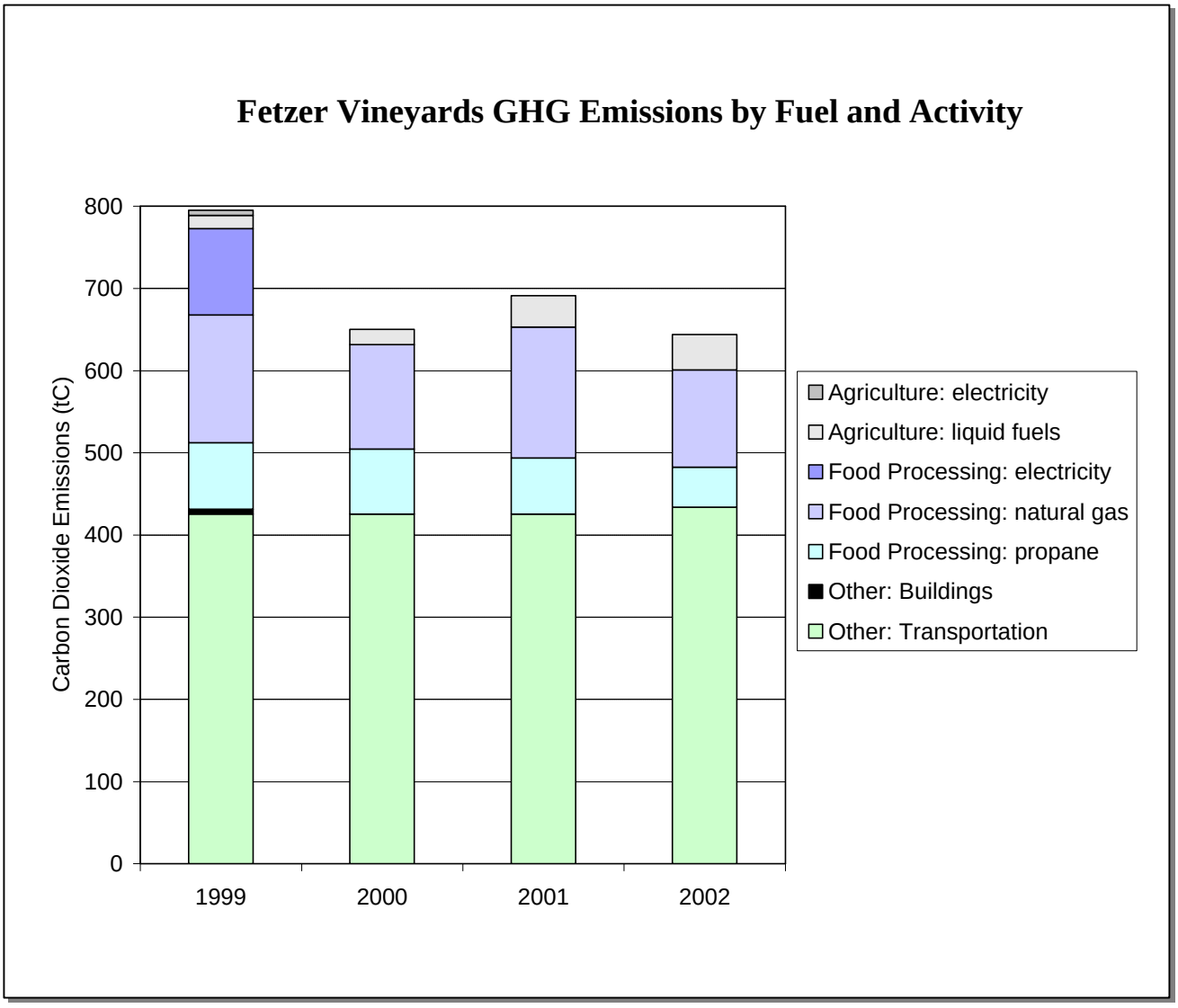
Fetzer, a recognized industry leader in the area of energy and environment, has taken several actions to reduce its GHG emissions. With the advent of competition for retail electricity in 1998, Fetzer became the first winery to purchase 100% renewable power. In addition to numerous projects to reduce electricity consumption, roughly 50,000 kWh are produced on site by solar photovoltaic panels. In 2002, Fetzer also substituted approximately 9,000 gallons of diesel with 100% biodiesel from soybean oil. Recently, Fetzer has also undertaken energy efficiency measures that have significantly reduced its consumption of natural gas.

To inventory Fetzer's GHG emissions, Fetzer's electricity consumption for 1999 were converted to eCO_2 emissions using an emissions coefficient factor specific to Pacific Gas and Electric Company, the utility serving Fetzer Vineyards. Emissions for 2000 through 2002 were assumed to be zero because Fetzer purchased renewable electricity beginning in May 1999.

The following figure shows Fetzer's GHG emissions by economic activity and fuel. As can be seen, GHG emissions at Fetzer, which are dominated by the transportation-related consumption of liquid fuels, dropped significantly after 1999 due to the change to renewable electricity in 2000. Overall, GHG emissions dropped an average of 2.2% per year between 1999 and 2002. Of the fuel-consuming activities, emissions dropped 8.7% per year on average from natural gas used for food processing, and propane emissions dropped 15.5% per year. Liquid fuel consumption for agricultural crop production grew an average of 39.2% per year during this period.

Note: This study took into account only GHG emissions resulting from company activity, e.g., building energy use and transportation fuel. Another significant source of GHG emissions may be the CO2 emitted by fermentation of grapes. Wineries may be able to capture this CO2, preventing it from being released into the atmosphere; there may also be commercial applications for such CO2. In general, GHG inventories look at anthropogenic sources, i.e., combustion of fossil fuels, and are not concerned with CO2 that is part of the "natural" carbon cycle, for example vines that take in CO2 as they grow, and release CO2 when they and grapes are composted/fermented.

From "Evaluation of Metrics and Baselines for Tracking Greenhouse Gas Emission Trends: Recommendations for the California Climate Action Registry," By Lynn Price, Scott Murtishaw, and Ernest Worrell of the Lawrence Berkeley Laboratory, June 2003, http://eetd.lbl.gov/ea/ies/iespubs/53027.pdf


Fetzer Vineyards GHG Emissions by Fuel and Activity
Carbon Dioxide Emissions (tC)
800
700
600
500
400
300
200
100
0
1999
2000
2001
2002
Agriculture: electricity
Agriculture: liquid fuels
Food Processing: electricity
Food Processing: natural gas
Food Processing: propane
Other: Buildings
Other: Transportation

Solid Waste

This study counts only GHG emissions from landfilled solid waste, not the emissions released when the materials were manufactured. An explanation for this is offered below.

Landfilling can result in a positive or negative contribution to a city's GHG emissions, depending on the type of waste and on the management of the waste in the landfill. When carbonaceous material such as paper is buried in a landfill, part of its carbon is sequestered. This means it can no longer enter the atmosphere as greenhouse gas. The remainder of the carbon decomposes to methane, a potent greenhouse gas, and carbon dioxide.

When methane is allowed to escape to the atmosphere, net GHG emissions from solid waste is positive and substantial. However, an estimated 70 percent of the Sonoma County landfill's methane is captured and used to generate electricity that is sold to PG&E. More information about the County's landfill energy generation is offered in the inset box on the following page.

The net effect of landfilling solid waste when employing this accounting method is to offset, or reduce, a community's overall GHG emissions. However, the amount of GHG sequestered when solids are landfilled offsets only a fraction of the amount of GHG produced when those same materials were manufactured. For instance, manufacturing a ton of office paper generates 3 tons of GHG. Landfilling that ton of office paper will only offset about 0.5 tons of the emissions from manufacture, depending on the landfill operation.

To prevent double counting, manufacturing emissions are not part of a community's GHG inventory; instead they accrue to the manufacturer. The complete picture of solid waste's GHG impact emerges through an economy-wide inventory. Communities are given credit in ICLEI's accounting protocol later when they reduce and recycle solid waste, measures that result in carbon sequestration in forests and avoided emissions from manufacturing.

The methodology for calculating solid waste GHG emissions differs from that used in other sectors where emissions actually released during a given year are calculated. For solid waste the calculation is based on the total amount of emissions produced over time by the solid waste generated in a given year. This approach is preferable because it more accurately reflects the atmospheric pollution occurring due to a community's actions in a given year, and because interventions such as recycling will more readily appear when tracking reduction measures.

Because of the many types of solid waste and the various ways to process them, including methane recapture, calculating their corresponding GHG emissions is complex. CACP software includes custom emissions coefficients to facilitate making these calculations.

Steps for calculating GHG emissions from solid waste:

1. Determine the tons of solid waste produced in the subject year(s) by residential and commercial sectors[59].
2. Estimate, by percentages, the composition of both residential and commercial waste using the Solid Waste Characterization Database produced by the California Integrated Waste Management Board (CIWMB).[60]
3. Convert CIWMB solid waste characterization categories and percentages to CACP software categories and percentages for both residential and commercial sectors.[61]
4. Enter the landfill type in the software by choosing from the available menu, and enter the methane recovery factor.[62]
5. Convert solid waste tonnage into GHG emissions using the CACP software.

Sonoma County turns trash into power and cash

By capturing methane and converting it to electricity, the County of Sonoma reduced 103,046 tons of greenhouse gas and generated 51,045 MWh of power at its landfill in 2001, according to a study done by Edwin Orrett for the County of Sonoma. Among various GHG reduction measures, such as photovoltaics, hybrid cars, and natural gas buses, methane capture and use for electricity at the landfill produced the greatest amount of greenhouse gas savings per dollar spent, according to Orrett's study.

By July 2004, Sonoma's landfill power plant is expected to have ten generators producing 7.5 megawatts of electricity, enough to power 7,500 homes, or a town about the size of Windsor. Revenue from the sale of the electricity will be about $600,000 per year. With the new generators, Sonoma County's landfill power plant will be the tenth largest in California. Only 57 of the State's 172 active landfills operate power plants.

Orrett's study is listed under Resources, page 47. The Sonoma County Waste Management Agency provided the 2004 data cited above. Please note that the GHG accounting methodology used in this report represents a refinement of the methodology used by Orrett for Sonoma County's GHG emissions inventory. Therefore, solid waste GHG figures found in these two studies are not comparable.

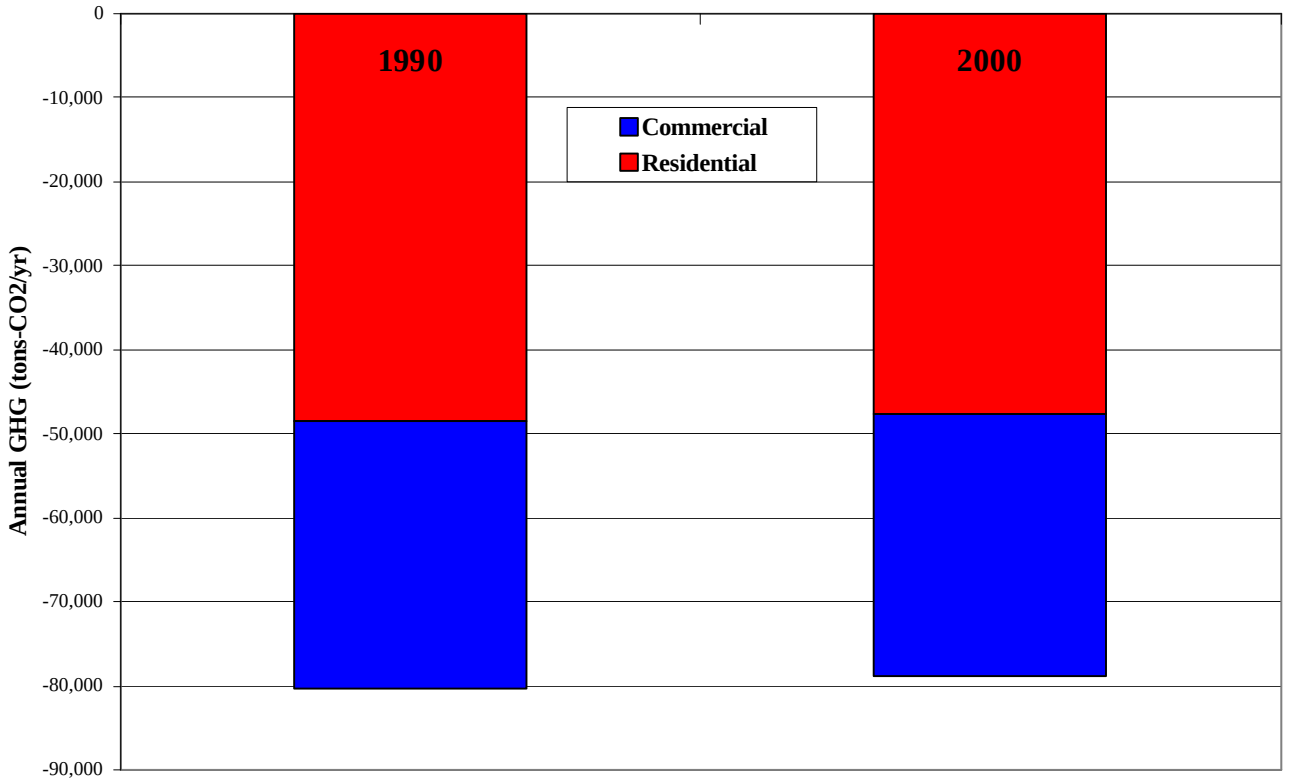
[59] Solid waste data is available from local waste management agencies and from the California Integrated Waste Management Board (CIWMB).
[60] The CIWMB database estimates the composition of waste typically disposed by single family and multifamily residences and by businesses in California.
[61] CACP software categories are Paper Products, Food, Plant Debris, Wood/Textiles, and All Other Waste. The CIWMB characterization has significantly more categories; these are combined to determine the percentages used in the CACP software.
[62] The 70% methane recovery factor for Sonoma County was provided by Ken Wells, Director of the Sonoma County Waste Management Agency.

Results for Sonoma County

Solid waste landfilled in Sonoma County resulted in an overall reduction in GHG emissions. GHG sequestered by landfilling and methane conversion offset about 2 percent of Sonoma County's total GHG emissions in 2000.

Solid waste and GHG emissions [63]

	1990		2000		% change
	Solid waste - tons	GHG - tons	Solid waste - tons	GHG - tons	GHG - tons
Residential	297,828	-48,446	292,285	-47,545	2%
Commercial	243,677	-31,886	239,142	-31,273	2%
Total	**541,505**	**-80,332**	**531,427**	**-78,818**	**2%**



[63] Data supplied by Donna Caldwell, Sonoma County Waste Management Agency, (707) 565-3587.

Solid Waste Characterization, Sonoma County[64]

Solid waste, CACPS categories	Residential	Commercial
Paper	27.5%	32.4%
Food	17.0%	18.1%
Plant	16.1%	6.0%
Wood, textiles	4.3%	7.6%
All other	35.1%	35.9%
Total	100%	100%

Paper vs. electronic news: Small choices add up to big differences

Researchers studied the environmental impacts of the industrial processes needed to supply the ***New York Times*** to a Berkeley resident for one year. They found that the newsprint version produces about 54 times more carbon dioxide than does receiving the same information electronically. Other air pollutants were also significantly higher for newsprint, as reflected in the table that follows.

Annual emissions - kilograms	CO_2	NOx	SOx
Newsprint - per reader, assuming 2.6 readers per issue	270	0.9	1.4
Newsprint - 1.2 million readers	324 million	1.08 million	1.68 million
Electronic - per reader	5	.004	.004
Electronic - 1.2 million readers	6 million	4,800	4,800
Newsprint: Electronic	**54:1**	**225:1**	**350:1**

Environmental Science and Technology, June 1, 2004, as reported in **Science News**, June 12, 2004.

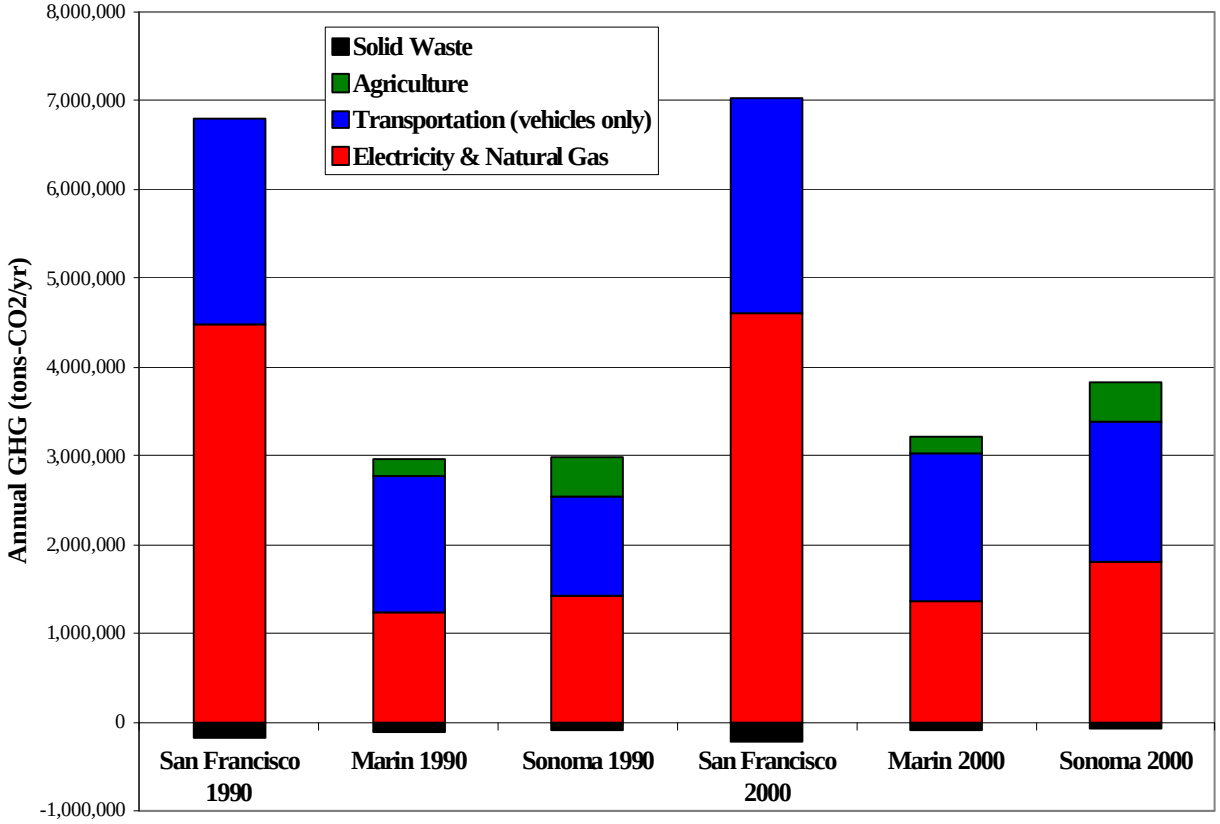
[64] Data from the California Integrated Waste Management Board. Total tonnage for each jurisdiction is computed using regional per capita disposal rates obtained in the 1999 Statewide Waste Characterization Study. http://www.ciwmb.ca.gov/wastechar/rescomp.asp?J=639&SortBy=Disposal

Marin, San Francisco, Sonoma comparison

	1990			2000			% change		
	Marin [65]	**San Francisco**[66]	**Sonoma**	**Marin**	**San Francisco**	**Sonoma**	**Marin**	**San Francisco**	**Sonoma**
Electricity & natural gas									
Residential	*724,835*	*1,717,488*	*810,123*	*797,499*	NA	*958,627*	*+10*	NA	*+18*
Commercial	*469,933*	*1,878,814*[67]	*392,423*	*562,434*	NA	*535,368*	*+20*	NA	*+36*
Industrial	*36,609*	*893,764*	*228,450*	*15,145*	NA	*310,163*	*-59*	NA	*+36*
Total	1,231,377	4,490,066	1,430,996	1,375,078	4,612,505	1,804,158	+25	+3	+26
Transportation[68]	1,542,175	2,320,000	1,115,000	1,649,116	2,420,000	1,589,000	+7	+4	+43
Ag. & water pumping	197,376	NA	444,690[69]	183,462	NA	425,040	-7	NA	-4
Solid Waste	-116,204	-185,490	-80,332	-94,091	-217,087	-78,818	+13	+2	+2
Total GHG	2,854,724	6,624,576	2,910,354	3,113,565	6,815,418	3,739,380	+9	+3	+28
Population[70]	230,096	723,959	388,222	247,289	776,733	458,614	+7	+7	+18
Tons GHG per person	12.4	9.2	7.5	12.6	8.8	8.2	+2	-4	+9

[65] Marin figures from County of Marin Greenhouse Gas Emissions Analysis Report, June 2003.
[66] San Francisco figures from San Francisco Community Action Plan, http://temp.sfgov.org/sfenvironment/aboutus/energy/cap.pdf or www.sfenergy.org. Additional information from Danielle Dowers, Utility Specialist, San Francisco Public Utilities Commission, Nov. 2004.
[67] Includes municipal operations.
[68] In San Francisco's Community Action Plan report, transportation figures include intraregional trips. However, Marin and Sonoma's transportation figures do not include intraregional trips; therefore, we subtracted San Francisco's intraregional trips from their transportation figures above for comparison purposes.
[69] Data is for 1992; data for 1990 not available.
[70] Population data from U.S. Census, http://census.abag.ca.gov/counties/counties.htm

Marin, San Francisco, Sonoma greenhouse gas emissions, 1990, 2000



California Context[71]

California uses less fossil energy to generate electricity than the rest of the United States. California's lower reliance on fossil fuel is due to the availability of hydroelectric and nuclear power, and to the State's continuing and growing use of renewable energy.

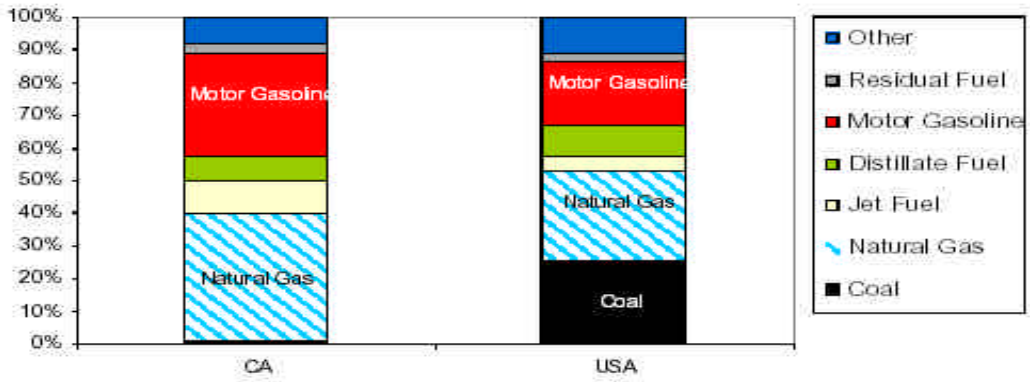
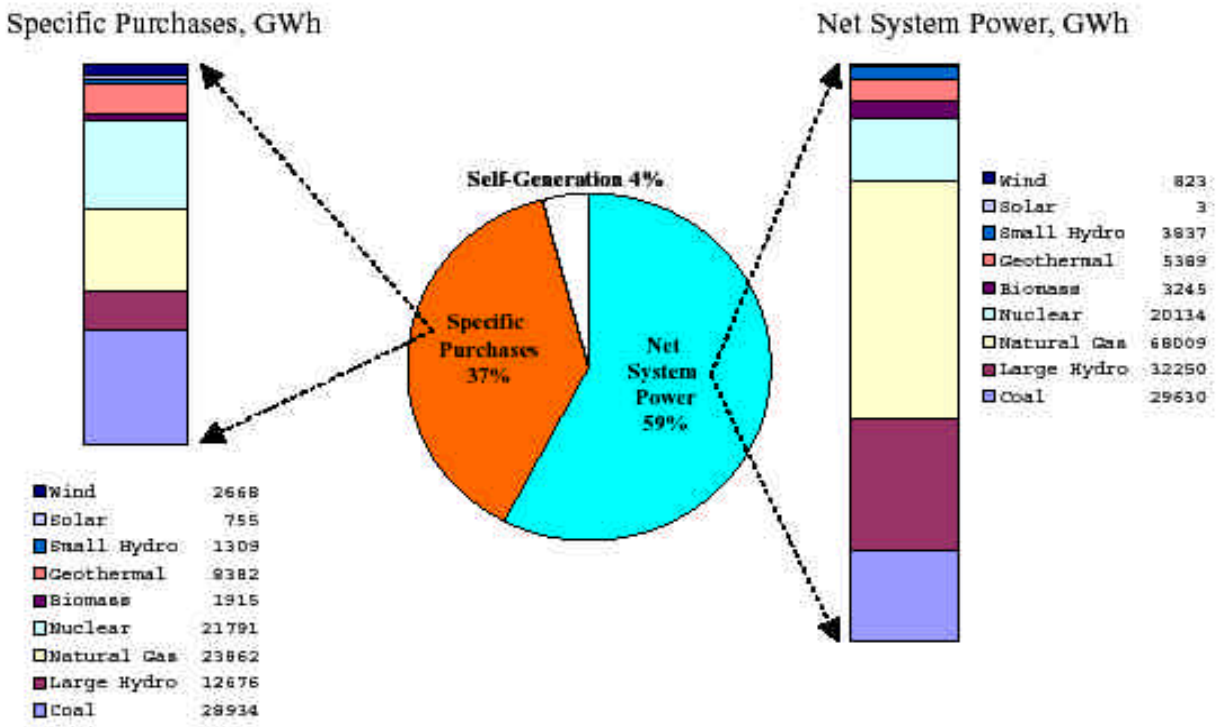


Figure ES-1: Distribution of Fossil Fuel Consumption in California and United States in 1999

California's power mix, 2003[72]



[71] Excerpts for California Context, including graphs except as noted, taken from "Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999," pages 2-13, California Energy Commission, November 2002, Publication #600-02-001F, http://www.energy.ca.gov/reports/600-02-001F/

[72] "2003 Net System Power Calculation," California Energy Commission, http://www.energy.ca.gov/reports/2004-05-05_300-04-001R.PDF; GWh is an abbreviation for gigawatt hours.

From 1990 to 1999, California's gross state product increased 28 percent, its population grew by 10 percent, and its total greenhouse gas emissions increased 3.5 percent. California has been able to reduce its per capita carbon dioxide emission rate by 8.6 percent, from 13.2 tons of carbon dioxide equivalent per person in 1990 down to 12.4 tons of carbon dioxide equivalent per person in 1999. In terms of per dollar of gross state product, the state lowered its "greenhouse gas intensity" by 19 percent, from 0.96 lbs. of carbon dioxide equivalent per dollar of gross state product in 1990 down to 0.77 lbs. of carbon dioxide equivalent per dollar of gross state product in 1999. [73]

Carbon dioxide emissions from the combustion of fossil fuels have remained more or less constant for combined electricity generation and industrial use, primarily due to fuel switching and abundant non-fossil fuel choices (renewable, hydro, and nuclear) for electricity generation. These modest increases throughout the 1990s are also due to aggressive state control of criteria air pollutants, which can lead to a reduction of carbon dioxide emissions.

Trends in California GHG emissions

	1990	**1999**	**% change**
Carbon Dioxide	363.8	362.8	
Fossil Fuel Combustion	358.2	356.3	
Other	5.6	6.5	
Methane	34.6	31.6	
Nitrous Oxide	24.6	23.5	
HFCs, PFCs, SF6	2.1	9.7	
Gross Emissions	425.1	427.7	0.6%
Soils and Forest (Sink)	-25.6	-18.8	
Net Emissions	**399.5**	**408.9**	**2.4%**
Marine Bunker Fuels[74]	22.0	10.7	
Gross Emissions Minus Marine Bunkers	403.1	417.0	3.5%
Net Emissions Minus Marine Bunkers	377.5	398.2	5.5%

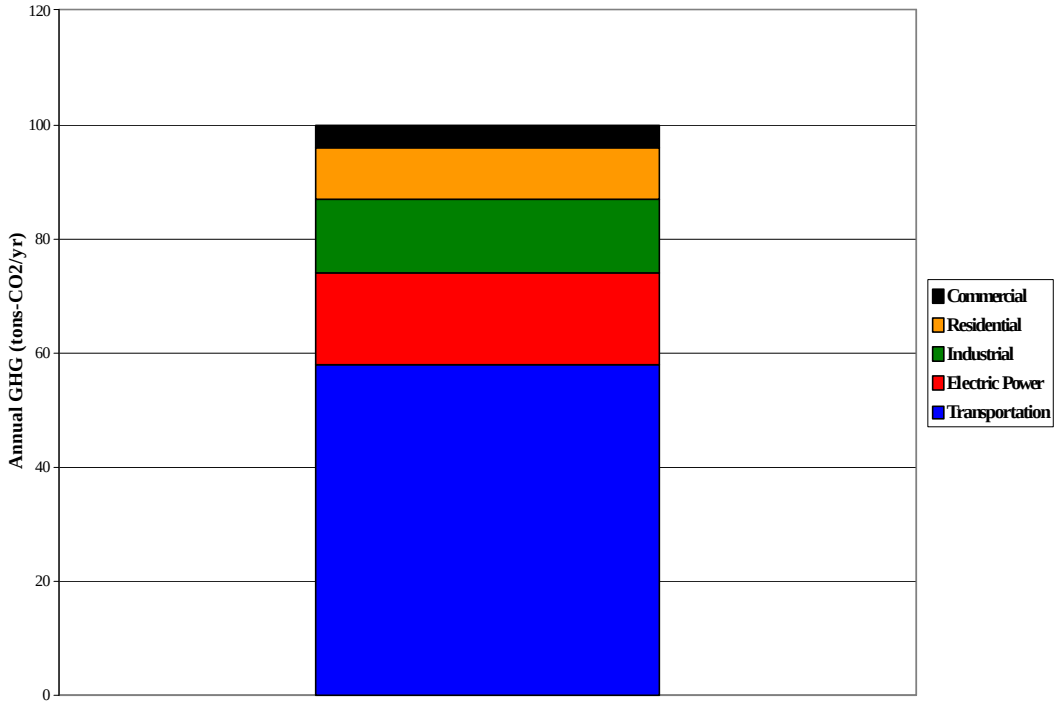
Figures expressed in MMT eCO2

Carbon dioxide emissions have grown substantially in the transportation sector, which more closely mirrors national growth trends. This growth is especially true for gasoline-based emissions in the transportation sector, which have increased by 9.4 percent over the decade.

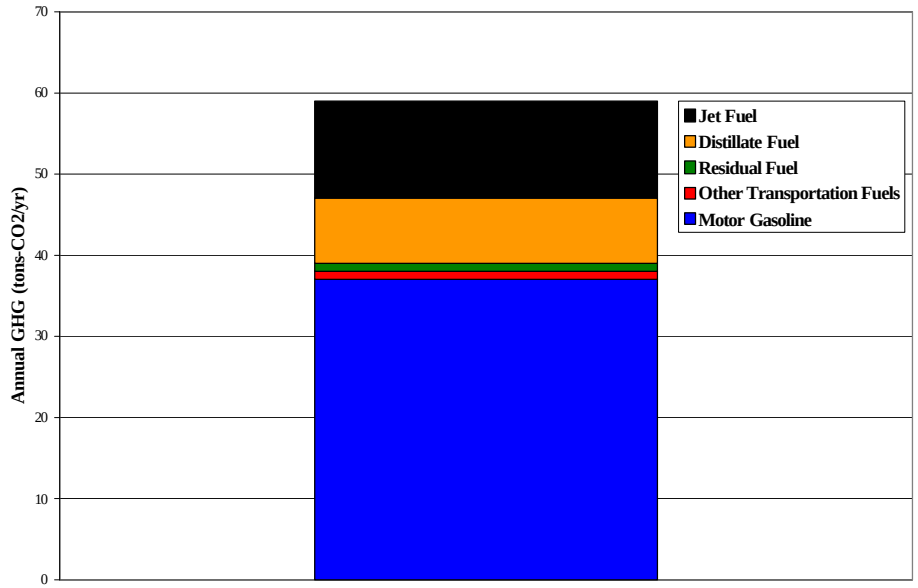
[73] Many factors contribute to improving the State's energy intensity, including changes in the composition of the industrial sector, increases in the price of energy, new technologies, and California's building energy code. "The Public Benefit of California's Investments in Energy Efficiency, RAND, 2000, http://www.rand.org/publications/MR/MR1212.0/MR1212.0.pdf

[74] Marine bunker fuels, defined as fuel sold to ships moving in international trade, are excluded from national emissions. When the IPCC began developing its guidelines for national emissions inventories in the early 1990s, the practice of excluding marine bunker fuels was extended to international aviation fuels, defined as fuel consumed by aircraft moving between international destinations. International bunker emissions account for about 2 percent of U.S. carbon dioxide emissions. National Energy Information Center, Emissions of Greenhouse Gas Emissions in the United States, 1998, http://www.eia.doe.gov/oiaf/1605/gg99rpt/carbon.html

Greenhouse gas emissions from all fuels, California 1999[1]



Breakdown of transportation sector by fuel type, California 1999



[1] Total equals 345.7 million metric tons; excludes marine bunker fuels.

B. Recommendations for a GHG emission reduction target for Sonoma County

With completion of this community-wide GHG emissions inventory, Sonoma County fulfills Milestone One of the Cities for Climate Protection five milestone program.

Milestone Two involves setting a GHG emissions reduction target. Three reference points help determine the target:

- the base year and its corresponding amount of GHG emissions
- the target year by which those reductions will be achieved
- the percent by which the emissions of the base year are to be reduced

In deciding how bold a target to set, some points to consider are:

- As previously noted, scientists in 1995 said that stabilizing the concentration of carbon dioxide required an immediate reduction in CO_2 emissions of 50 to 70 percent, and required further reductions thereafter until the year 2100.
- Cities for Climate Protection encourages municipalities to consider a 20 percent reduction target.[75]
- The Kyoto Protocol set a 7 percent U.S. emission reduction target from 1990 levels by 2012.
- The County of Santa Clara, led by the Silicon Valley Manufacturers Group, in March 2004 set an emissions reduction target of 20 percent below 1990 levels by 2010. This is about three times the level of the Kyoto Protocol. (Please see article about Silicon Valley on page 39.) Other communities have also set bold targets, as shown below.

Examples of community targets municipalities have adopted[76]

Municipality	Base year	Target year	Community GHG reduction target	Year target adopted
Berkeley	1990	2010	15%	1998
Chula Vista	1990	2010	20%	2000
County of Marin	1990	2015	15-20%	2002
Oakland	1990	2010	15%	1999
San Diego	1990	2010	15%	2000
San Francisco	1990	2012	20%	2002

Those responsible for implementing an emissions reduction target often ask, “How will we achieve reductions when our community is still growing?” This is the dilemma humankind must successfully address to meet the global climate crisis. Fortunately, solutions exist.

[75] In 1989 Toronto became the first city worldwide to adopt a GHG reduction target. It pledged to achieve a reduction of 20 percent below 1989 levels by 2005. The city’s action is known as the "Toronto target," and has helped set the standard for local action for emission reductions. www.epa.gov/globalwarming/greenhouse/greenhouse2/cities.html

[76] From a survey conducted by the Climate Protection Campaign in Fall 2004.

Another question that may arise regarding GHG emission targets is, why are the goals set by Cities for Climate Protection and the Kyoto Protocol so small when the scientific imperative is much greater. ICLEI's literature states, "Adopting the 20 percent reduction target is a substantial beginning." Faced with political, economic, and cultural realities, ICLEI representatives and Kyoto signatories accept a more modest target than science dictates.

Sonoma County must also recognize political, economic, and cultural realities. Moreover, Sonoma's challenge is greater than most other areas because our GHG emission growth rate was about double that of the rest of the nation. Nonetheless, timidity and inaction cannot be justified given the dire forecasts for humanity if we ignore scientists' warnings. Silicon Valley business and community leaders adopted a "stretch goal" when faced with the same choice, according to Margaret Bruce of the Silicon Valley Manufacturers Group. Although achievement of their ambitious target was uncertain, they still felt compelled to be bold.

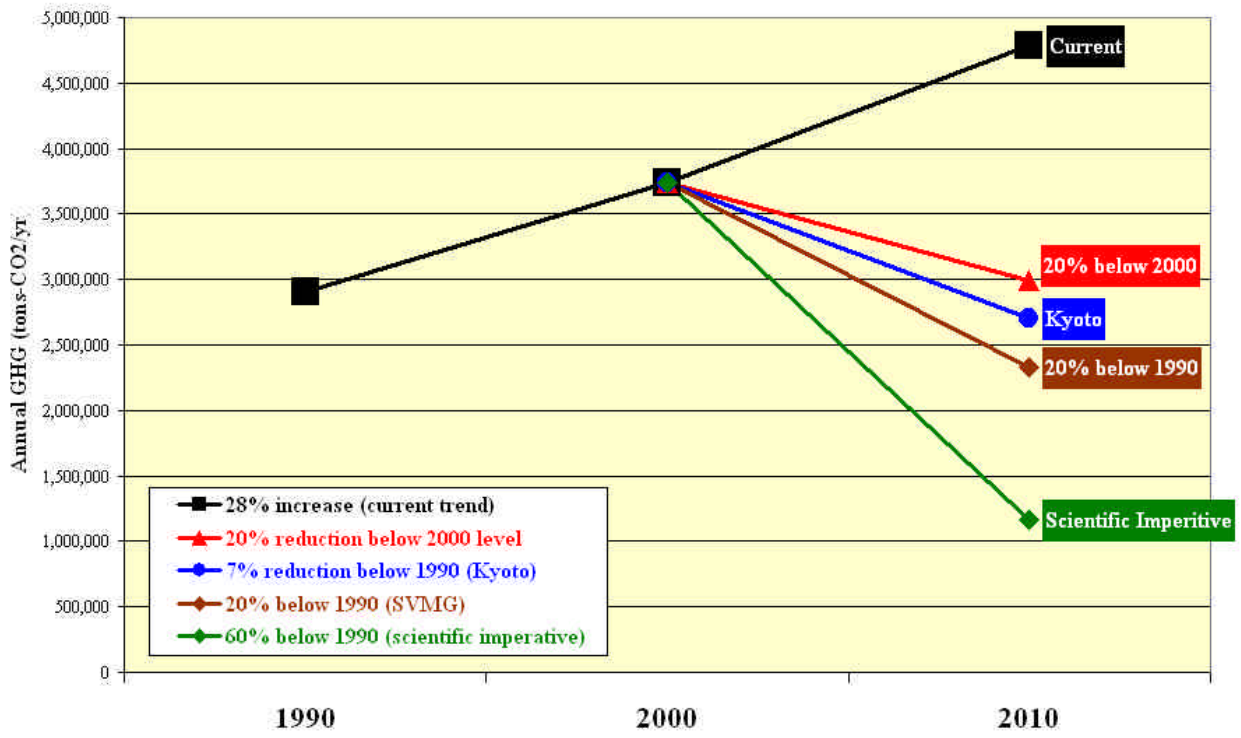
People in Sonoma County take pride in their love of nature and their responsibility toward others. This is a community with a knowledge-based economy that thrives on innovation and maximizing opportunities. It is therefore recommended that Sonoma County rise to the test, make a choice for the future, and take on a climate protection challenge that may at first seem impossible.

"Yes it is impossible, therefore it will take a little longer."

Paolo Lugari, Founder of Gaviotas

Recommendation: Sonoma County residents, businesses, and governments adopt a community-wide GHG emission reduction target of 20% below 1990 levels by 2010.

Choices for the future



Choices		**2010 Target** (tons GHG)
Current trend	28% continued growth rate in GHG emissions in Sonoma County	**4,786,406**
20% reduction	20% reduction in GHG emissions from 2000 by 2010	**2,991,504**
Kyoto	7% reduction in GHG emissions from 1990 by 2010, the target set for the U.S. through the Kyoto Protocol	**2,706,629**
SVMG	20% reduction in GHG emissions from 1990 by 2010, the target set by the Silicon Valley Manufacturers Group in March, 2004	**2,328,283**
Scientific imperative	50 - 70% reduction in carbon dioxide emissions from 1995 to stabilize levels in the atmosphere, amounts specified by the International Panel on Climate Change[77]	**1,164,142**

[77] IPCC second assessment synthesis of scientific-technical information relevant to interpreting article 2 of the UN Framework Convention on Climate Change, 1995, the summary for policymakers, page 9, http://www.ipcc.ch/pub/sa(E).pdf See also "Climate Change Research - Facts, uncertainties and responses," Astrid Zwick, Antonio Soria http://www.jrc.es/pages/iptsreport/vol05/english/art-en1.doc

Valley firms to fight global warming

Coalition hopes innovation will entice other regions

In one of the first programs of its kind in the United States, a coalition of major Silicon Valley companies is set to announce today a plan to reduce greenhouse gas emissions to collectively combat global warming.

The companies -- Hewlett-Packard, Oracle, Calpine, Lockheed, ALZA, Life Scan and PG&E -- along with the city of San Jose, NASA Ames Research Center and the Santa Clara Valley Water District, will set a goal of cutting Santa Clara County's carbon dioxide emissions to 20 percent below 1990 levels by 2010.

If successful, such a reduction would be more than triple the goal set by the still-stalled Kyoto agreement on global warming. It would be as effective as removing 1.1 million cars from Silicon Valley roads…

Organizers of the Silicon Valley plan estimate that Santa Clara County emitted 15.7 million tons of carbon dioxide in 2000, up from 13.4 million tons in 1990. The estimates are based on consumption of gasoline, diesel fuel, electricity and natural gas.

Article by Paul Rogers, **San Jose Mercury News**, March 29, 2004. Full text of the article is available at: http://www.mercurynews.com/mld/mercurynews/news/local/8302706.htm

C. Recommendations for next steps for reducing GHG emissions in Sonoma County

For Milestone Three, developing a plan for achieving the emissions reduction target, many communities worldwide have produced comprehensive, practical plans to reduce their GHG emissions. Examples include Brookline, Massachusetts; Portland/Multnomah County, Oregon; Missoula, Montana, Marin County, and San Francisco.[78]

Broad community involvement and commitment from residents, business, and government is the key for success in setting targets, developing plans, and implementing programs for community-wide greenhouse gas reduction efforts. This level of undertaking is similar to the development and adoption of communities' general plans for which communities usually make significant investments. Logically, general plans and greenhouse gas emission reduction plans should align and integrate.

Two recommendations from "Standing Together for the Future," the GHG emission inventory report for eight cities in Sonoma County, September 2003, bear on this point:

"All Sonoma County jurisdictions direct staff to evaluate actions necessary to ensure their general plan reflect their commitment to climate protection, and target September 30, 2004, to report to the government bodies the results of these evaluations."

"All Sonoma County jurisdictions cooperate to identify a process and actions necessary to establish community-wide targets, plans, and programs, and target September 30, 2004, as the date by which the approach for doing so is identified."

No Sonoma County jurisdictions have implemented these recommendations. We reaffirm the importance of doing so. They support this report's second recommendation:

Recommendation: Sonoma County residents, businesses, and governments develop a plan that will enable the achievement of its GHG reduction target.

These recommendations should be implemented as soon as possible. The earlier we begin, the easier it will be in the future.

Examples of GHG emission reduction measures are provided on page 42. Many of the energy-saving examples have already been implemented by Sonoma residents, businesses, and municipalities, e.g., changing incandescent bulbs to efficient compact fluorescents, installing solar panels for a renewable energy supply, buying gas-saving hybrid vehicles, curbing sprawl through development that follows new urban design principles. Such measures help eliminate our dependency on fossil fuel as well as protect the climate. They provide a springboard for accelerated efforts in the future.

[78] Websites where these plans are posted are given in the resources and references section of this report.

We encourage those who disseminate information to the community to familiarize themselves with the recommendations found in "Talking Global Warming" about how to frame and deliver compelling messages regarding the climate crisis and solutions. The research upon which "Talking Global Warming" is based shows that information alone, no matter how accurate, is not sufficient to inspire people to take action.[79]

Tamminen on Air Quality and Climate Protection in California

"With air quality, for years we had been making good, steady progress. Now, in the last four or five years, we're going backwards: to stage-one smog alerts, to non-attainment of federal ozone standards and particulate matter. So there are very troubling signs on the horizon, especially as we try to accommodate the state's growth...[We have] 36 million people and our population is growing by almost 600,000 every year. We have 30 million motorized vehicles in the state, almost one per person. And the vehicles in showrooms today have worse fuel economy than in 1987. So if you have more vehicles that are less fuel-efficient, that results in more consumption and more air pollution."

Grist: The greenhouse-gas law would establish a 30 percent reduction in CO2 emissions. Will the governor stand behind that number?

"Absolutely. Of course we're waiting for the final report to come out and there will be opportunity for public comment. But whatever gets adopted by the [California Air Resources] Board as technologically feasible, the governor has stated he will defend." [Grist editor's note: The CARB staff's final report, released after this interview was conducted, proposed giving the auto industry eight rather than six years, starting in the 2009 model year, to meet the 30 percent target. The CARB will decide in September whether to endorse the staff's recommendation.]

"In terms of California's role as a trendsetter, the governor has mentioned AB 1493. That is our greenhouse-gas bill with respect to cars, which he intends to defend in court if need be, because there've been some rumblings about challenges [from auto companies]. We're doing our best to work with the stakeholders to avoid that, so we get implementation and actual CO2 reductions rather than just go to battle. His friend [New York Gov. George Pataki] has literally told him they are waiting to see how it plays out so they can adopt it in New York. Other states are looking to do the same. I just got back from Australia and England, where they're also looking to copy what we're doing."

Excerpted from "Terry Firma," an interview with Terry Tamminen, secretary of California's Environmental Protection Agency, by Mark Hertsgaard, **Grist Magazine**, Aug. 19, 2004, http://www.gristmagazine.com/maindish/tamminen081904.asp

[79] Reference to "Talking Global Warming" is given in the Resource section, page 47.

Examples of emission reduction measures

Although it is beyond the scope of this project to supply a comprehensive, ranked list of actions for reducing GHG emissions, the following measures exemplify the plethora of possibilities. Community measures are identified by voluntary, incentive-based, and regulatory to reflect the various strategies available to municipalities for implementing these measures. Most measures can be approached using more than one strategy. See Resources, page 47, for references.

Measures for the whole community that local government can take

Homes, buildings and facilities

Increase energy efficiency and conservation, and increase the use of renewable energy

	Voluntary	Incentive-based	Regulatory
Distribute compact fluorescent bulbs, lighting occupancy sensors, and other energy saving devices	**X**	**X**	
Offer small business energy audits and technical assistance	**X**	**X**	
Distribute water saving devices such as low flow showerheads and faucet aerators	**X**	**X**	
Promote "cool communities" through landscaping, for example, planting trees to shade buildings	**X**	**X**	**X**
Develop and adopt building codes that set energy efficiency standards for construction, and promote energy efficient retrofits in existing buildings at time of sale	**X**	**X**	**X**
Promote building insulation and weatherization	**X**	**X**	**X**
Reward businesses that develop and implement energy conservation programs including energy efficiency improvements and fuel switching (including use of solar energy), heat recovery/co-generation systems	**X**	**X**	
Require light colored, high albedo rooftops and pavement	**X**	**X**	**X**
Offer financial incentives, for example, fee and tax reductions, rebates, and loans, to builders who construct energy-efficient homes and buildings		**X**	
Encourage the use of energy efficient appliances and HVAC systems	**X**	**X**	
Encourage passive solar design and solar orientation incentives, guidelines, and ordinances	**X**	**X**	
Encourage the use of photovoltaics and other renewable energy applications	**X**	**X**	
Facilitate cooperative or aggregate purchase or buyer program for lighting, and energy efficient equipment	**X**	**X**	**X**
Establish financing program for efficiency improvements in the community, for example, revolving loan funds through bonds, energy taxes, etc.	**X**	**X**	

Transportation

Decrease the use of single occupancy vehicle travel by increasing the use of public transit, vans, carpooling, cycling, and walking

	Voluntary	Incentive-based	Regulatory
Adopt land use and zoning policies that discourage sprawl and that promote infill high-density development, including density bonuses and incentives for high-density, infill, and transit-oriented Impact, facility, mitigation, and permit fee	**X**	**X**	**X**
Implement policies that shift funds from roads and highways to alternative transit		**X**	**X**
Use parking fees to fund transit use, bicycle and pedestrian improvements		**X**	**X**
Reward drivers of fuel efficient vehicles, for example, through priority parking		**X**	
Engage community stakeholders to build their support for alternative transit	**X**	**X**	
Fund infrastructure improvements, for example, install bike racks and showers	**X**	**X**	
Encourage employers to provide carpool incentives, for example, free or priority parking for carpoolers	**X**	**X**	
Implement a free bike share program	**X**	**X**	
Reduce fares on public transit	**X**	**X**	
Offer shuttle service that connects neighborhoods to commuter lines	**X**	**X**	
Guarantee emergency rides home for pedestrians and bicyclists	**X**	**X**	
Establish a service center for transit passes, route information, schedules, maps, car and van pool information and coordination	**X**	**X**	
Create an alternative working schedule program for non-motorized commuters, for example, flextime, compressed work week, and work from home	**X**	**X**	
Implement programs to remove public parking		**X**	**X**
Adopt zoning ordinances that reduce minimum parking space requirements and allowances		**X**	**X**
Ensure that children's routes to school are safe	**X**	**X**	**X**

Solid Waste

Source reduction: Reduce the amount of waste being generated and going to landfills; use the methane coming from landfills to generate electricity

Two basic strategies exist to reduce GHG emissions associated with solid waste: 1) use less, and 2) recycle more. The first strategy, also called "source reduction" avoids the GHG emissions of manufacture, and it also saves the purchase cost of supplies. One example of source reduction is promoting double sided photocopying, and saving paper costs as well as solid waste. Electronic documents can replace paper documents. The recycling strategy reduces the overall GHG emissions over landfilling since manufacturing products from recycled materials generally requires substantially less processing and energy.

The effect of reducing the GHG emissions of manufacture is accounted for later with ICLEI's protocol, when measures are taken to reduce their landfilled solid waste by either using less, or diverting more to recycling. Either action will yield GHG credit for reducing the emissions of manufacture, and reduce their overall GHG emissions accordingly.

PRIUS VS. EXPEDITION

	TOYOTA PRIUS	FORD EXPEDITION	HUMMER
Fuel costs per year*	$565	$2,070	
Smog-forming pollutants per 15,000 miles	2.8 - 4.1 lbs.	27.4 - 36.3 lbs.	39 – 40 lbs.
If every vehicle in Sonoma County were a Prius (Expedition), the amount of GHG emitted per year would be **	1,133,755 tons	4,146,304 tons	
If every vehicle in Sonoma County were a Prius (Expedition), the amount of smog-forming pollution emitted per year would be	1,328,113 lbs.	11,758,659 lbs.	
The total difference would be 3,012,549 tons CO2 and 10,430,546 lbs. of smog forming pollutants.			

* Assuming gas prices of $2.07 for regular and $2.25 for premium, and assuming 15,000 miles driven per
** Assuming each of Sonoma's 223,930 vehicles is driven 15,000 miles per year

Benefits: Prius vs. Expedition

- **1/4 cost for gas**
- **1/4 GHG production**
- **1/9 smog-forming pollutants**

References: US EPA's Green Vehicle Guide www.fueleconomy.gov, http://www.fueleconomy.gov/feg/sbs.ht, http://www.mtc.ca.gov/datamart/stats/regveh.ht

	Voluntary	Incentive-based	Regulatory
Conduct home composting education programs	**X**	**X**	
Establish a center for reusing salvageable goods	**X**	**X**	
Distribute compost bins	**X**	**X**	
Collect curbside yard debris	**X**	**X**	
Implement or expand residential and commercial recycling collection	**X**	**X**	
Establish community recycling drop-off sites	**X**	**X**	
Offer incentives to reduce waste such as pay-as-you-throw or unit pricing, special taxes and tipping fees		**X**	
Implement a landfill methane collection and conversion program			**X**

Using prices to curb greenhouse gas emissions

A powerful, underutilized strategy available to governments is market-based measures. Intelligently applied, price signals can help reverse the incentives that now encourage people to use fossil fuels. Many governments are not fully aware of the powerful set of tools at their disposal. These can be extremely effective and are often less expensive to implement than traditional regulatory approaches. Economic instruments can also generate substantial revenues for government. By rewarding desired practices using funds levied on undesired practices, price signals can help shift our energy use towards efficiency and renewables, and away from fossil fuels.

Many compelling examples are offered in ICLEI's booklet "Changing the Price Signal: How local governments can use economic instruments to cut traffic and pollution."

Natural gas powered County buses

Sonoma County's 62-bus fleet includes 34 Compressed Natural Gas buses. These 34 buses reduce the GHG emissions from the County bus fleet by approximately 15% from a standard diesel fleet. According to the County's GHG inventory, one CNG bus driving 34,200 miles per year will save 22 tons eCO2/year, and $6,660/ year.

"Greenhouse Gas Emission Analysis for the County of Sonoma," Edwin Orrett, P.E., August 2002.
http://www.recyclenow.org/FINAL_RE.PDF

Measures for municipal operations[80]

- Adopt procurement policies that specify energy efficiency standards
- Replace existing lights with energy-efficient and low-wattage lamps and ballast, e.g., use light emitting diodes (LEDs) for traffic signals
- Improve energy efficiency when replacing equipment, renovating or constructing
- Lighten colors of rooftops and street paving to reduce the "heat island" effect
- Use plants to reduce energy use, e.g., with rooftop gardens and shade trees
- Capture “waste” heat through co-generation
- Convert to solar power, e.g. install solar water heating at recreational facilities, and use solar powered street and emergency lights
- Reduce lighting in areas that are overlit
- Switch from a five to a four day work week to reduce energy use in buildings as well as in commuting
- Replace job-related driving with telecommunications, transit, bicycling, and walking
- Provide incentives to reduce municipal employee travel, e.g. trip reduction policies like subsidized transit passes, elimination of free parking, preferred parking for carpools
- Purchase fuel efficient fleet vehicles
- Reduce the fleet size, i.e., the total number of vehicles
- Improve fleet scheduling and route efficiency
- Improve fleet maintenance for increased efficiency, e.g., check tire pressure
- Reduce the amount of energy used to supply and treat water and waste water, e.g., promote water conservation, replace old equipment with energy-efficient models
- Require that energy efficiency be a key criterion for new infrastructure
- Increase office recycling, e.g. paper, cardboard, cans, toner cartridges
- Prevent waste in day-to-day operations, e.g., reduce paper use
- Recover food waste in cafeterias and kitchens of local government buildings for composting or other use
- Adopt procurement policies that give preference to recycled materials
- Compost landscaping debris

Carbon Sequestration Measures

- Implement urban forestry projects
- Encourage the maintenance and restoration of a thick cover of plants and trees to absorb and sequester carbon dioxide
- Encourage the maintenance and restoration of soil tilth, rich with carbonaceous matter, to absorb and sequester carbon dioxide, and to retain water to replenish ground water

[80] Adapted by Climate Change Connection from Cities for Climate Protection

Resources

Sonoma County resources

Climate Protection Campaign: Advances practical, science-based solutions for significant greenhouse gas reductions to create a positive future for our children. www.climateprotectioncampaign.org

"Greenhouse Gas Emission Analysis for the County of Sonoma," Edwin Orrett, P.E., August 2002. http://www.recyclenow.org/FINAL_RE.PDF

"Santa Rosa Milestone One," Greenhouse gas emissions inventory, 2002, http://ci.santa-rosa.ca.us/City_Hall/City_Manager/CCPFinalReport.pdf

"Standing together for the Future: Greenhouse gas emission inventories for eight cities in Sonoma County, California," September 2003, http://www.skymetrics.us/standing-together/standing-together.php#summaryreports

"Report on the Sonoma County Ecological Footprint Project," May 2002. Report shows that much of human impact on earth is related to fossil fuel usage. http://www.sustainablesonoma.org/projects/footprintreport/scfpweb.pdf

Sonoma County Waste Management Agency: Administrator for municipalities' climate protection collaboration. Site also offers green building resources. www.recyclenow.org

Sonoma County Business Environmental Alliance: Promotes economic benefits of responsible environmental practices. www.sonoma-county.org/bea

Community Clean Water Institute: Protects water resources and public health, identifies pollution sources, and prevents water pollution throughout Northern California. www.ccwi.org

Resources from other local governments

"County of Marin Greenhouse Gas Emissions Analysis Report," June 2003 http://www.co.marin.ca.us/depts/CD/Main/pdf/CCP_FinalReport.pdf

"Climate Action Plan for San Francisco: Local Actions to Reduce Greenhouse Gas Emissions, September 2004, http://sfwater.org/detail.cfm/C_ID/2137

Other noteworthy examples of local climate action plans:

- Town of Brookline, Massachusetts: http://www.townofbrooklinemass.com/conservation/climatechange.html
- City of Missoula, Montana: ftp://www.ci.missoula.mt.us/Packets/Council/2003-11-17/Referrals/Missoula%20GHG-Energy%20Efficiency%20Plan%2011-17.htm
- City of Portland & Multnomah County: http://www.sustainableportland.org/Portland%20Global%20Warming%20Plan.pdf

Regional Resources

Bay Area Air Quality Management District: Aims for clean air to protect the public's health and the environment in the San Francisco Bay region. http://www.baaqmd.gov/

Association of Bay Area Governments: A regional planning agency that helps solve problems in areas such as land use, housing, environmental quality, and economic development. http://www.abag.ca.gov/ Includes the Bay Area Green Business Program http://www.abag.ca.gov/bayarea/enviro/gbus/

Metropolitan Transportation Commission: The Bay Area's transportation, planning, financing, and coordinating agency. http://www.mtc.ca.gov/

California Resources

California Air Resources Board: Works to protect the public's health, the economy, and the state's ecological resources through the most cost-effective reduction of air pollution. http://www.arb.ca.gov/homepage.htm

California Climate Registry: State institution for businesses to register their GHG reductions. www.climateregistry.org

California Energy Commission: Climate Change and California. http://www.energy.ca.gov/global_climate_change/index.html

"Climate Change Overview: Technical support document for staff proposal regarding reduction of greenhouse gas emissions from motor vehicles," California Environmental Protection Agency, Air Resources Board, August 6, 2004, http://www.arb.ca.gov/cc/factsheets/august_tsd/overview_august.pdf

"Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999," California Energy Commission, November 2002, Publication #600-02-001F. http://www.energy.ca.gov/reports/600-02-001F/

"Evaluation of Metrics and Baselines for Tracking Greenhouse Gas Emission Trends: Recommendations for the California Climate Action Registry," By Lynn Price, Scott Murtishaw, and Ernest Worrell of the Lawrence Berkeley Laboratory, June 2003. http://eetd.lbl.gov/ea/ies/iespubs/53027.pdf

U.S., international, and other resources

Cities for Climate Protection, a program of ICLEI – Local Governments for Sustainability: Premier resource for local governments involved in climate protection www.iclei.org/us

Clean Air and Climate Protection Software Tool to help state and local governments harmonize greenhouse gas and air pollution emission reductions. www.cacpsoftware.org

U.S. Environmental Protection Agency Global warming resources
http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html

Pew Center on Global Climate Change: www.pewclimate.org

Alliance to Save Energy: Organization that promotes energy efficiency worldwide. www.ase.org

Watergy: Resource for the water –energy efficiency connection www.watergy.org

Clean Air-Cool Planet: Resources for colleges and universities www.cleanair-coolplanet.org

Interfaith Power and Light: Resources for faith-based institutions www.interfaithpower.org

United Nations Environmental Programme, Grid-Arendal: Environmental information, communications, and capacity building services for information management and assessment. Excellent source for information and graphics, including a "CO_2 meter" showing the current estimated annual rate of global anthropogenic emissions of carbon dioxide, based on projections made by the International Energy Agency: www.grida.no/

Intergovernmental Panel on Climate Change: www.ipcc.ch

Summary for Policymakers, Climate Change 2001-Impacts, Adaptation and Vulnerability Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report (TAR), "Climate Change 2001" http://ipcc-ddc.cru.uea.ac.uk/

Calculator to determine individual greenhouse gas emissions www.americanforests.org

"Talking Global Warming" Research and recommendations about effective climate communications www.skymetrics.us/talking-global-warming/talkingglobalwarming.php

D. Highlights of stakeholder meetings

Date: January 5, 2004, 2004
Interview conducted by: Mike Sandler and Ann Hancock
Name: Fred Euphrat, PH.D., Owner
Organization: Soil, Trees, and Water, an environmental consulting firm
Contact information:

Phone: (707) 433-5544
Email: woodrat@monitor.net
Mailing address: P. O. Box 1802, Healdsburg CA 95448

Connection to this project: Fred is an advisor to the Climate Protection Campaign. For this project, he is willing to guide us on the agriculture and biomass section of the GHG Inventory.

Summary of key points: Fred is willing to advise us. Get in touch with Pacific Forest Trust people. We're on the right track.

Discussion Summary: Soils are decomposers. Fertilization – NKP - acts like combustion – it speeds up global temperatures by accelerating decomposers in soil. Soil release of carbon is a huge factor for climate protection. Plants are our blanket of protection against global climate change. Biomass = sequestration. The deeper the biomass, the more life.

Carbon sequestration:

- Growing forests and locking up carbon, e.g., in wood in house, hay in bale construction, cotton in clothing, is good for the climate. If it takes longer to use the wood than to grow the tree, then we're on the plus side of the equation.
- Growing eucalyptus forests and burning the wood is bad for the climate.
- Increasing nitrogen fixation is good for the climate.
- Increasing tilth is good for the climate because it increases the soil's ability to hold water and carbon. Standard soil holds 6-7" of water. Carbon molecules act like little accordions.
- First year of opening soil produces a flush of nutrients allowing vigorous plant growth.
- Methyl bromide impacts many issues: soil, GHG, and ozone depletion.
- Paving takes away sequestration possibilities, even though the soil under the pavement isn't decomposing.
- Food coming into the County that's gathered from around the world is another factor.
- Recommend using SR wastewater to grow forests.

Resources, references, referrals:

- Pacific Forest Trust – Lori Wayburn and Connie Best
- Steve Smit, Vina Farms
- Paul Bernier - no till and dry farming
- Don Frazer of de Lormier winery, Alexander Valley

Date: January 7, 2004
Interview conducted by: Mike Sandler and Ann Hancock
Name: Barbara Lee, Executive Director
(later joined by Ken Wells, Director, Sonoma County Waste Management Agency)
Organization: Northern Sonoma County Air Quality Management District
Contact information
Phone: (707) 433-5911
Email: nsc@sonic.net
Mailing address: 150 Mathieson, Healdsburg 95448

Connection to this project: The GHG Inventory being done for this project includes Northern Sonoma County, an area over which the agency Barbara directs has jurisdiction.

Summary of key points: Barbara remains willing to partially fund this project. She is also has funding for related projects. She is willing to advise us, is well-connected and knowledgeable.

Discussion Summary:
Barbara is interested in this project, and is willing to advise us and partially fund us. She has worked for the BAAQMD, has served on CARB advisory committees, has been a researcher.

N. Sonoma hasn't violated ambient air standards for three years, but they can't meet attainment because they are tied to a larger district. Wood smoke is the biggest air quality challenge.

There are several pots of money her district works with. One is penalty money that can be spent on community projects. Barbara seeks projects to fund. She is willing to help (? design and) fund a community study whereby, for example, students take home a survey for their household to complete.

Recommendations:
- Make GHG Inventory relevant to the community by anticipating reduction strategies. Find community-specific measures, impacts, stories. Population-weighted averages don't motivate people because they don't show impacts of people's efforts (personal efficacy, locus of control). Motivate communities to take on recommendations, set goals, challenge other communities. Offer a menu of ordinance options for municipalities to enact.
- Have model ordinances be "bite-sized chunks" that communities can take on. Spell out next steps clearly for communities. Keep in mind "spectrum of efficiencies"

Resources, references, referrals:
- MTC – CalTrans trip data
- DMV – data on clunkers - "vehicle scrappage"
- SB700, Flores - recent state legislation that makes ag take center stage
- CARB just released an ag emissions inventory - methane
- Bob Fletcher, Chief of Emissions Assessment Branch, CARB (916) 322-5350
- CAPCOA – Technical assistance document re wine production emissions – San Joaquin Valley Planning

Date: January 22, 2004
Interview conducted by: Mike Sandler and Ann Hancock
Name: Michelle Passero, Director of Policy Initiatives. Also present: Wendy from PFT.
Organization: Pacific Forest Trust
Contact information

Phone: (707) 578-9950
Email: mpassero@pacificforest.org
Mailing address: 416 Aviation Blvd. Suite A, Santa Rosa, CA 95403
Website: www.pacificforest.org

Connection to this project: Pacific Forest Trust actively seeks to protect forests nationwide for the express purpose of sequestering carbon to protect the climate.

Summary of key points: PFT is actively involved with California Registry.

Discussion Summary:

- PFT helps create conservation easements for forests.
- They work with World Resources Institute.
- SB812 – amended Climate Registry bill - sets framework for forests
- Representatives from PFT are on the stakeholder working group creating guidelines for forest GHG accounting.
- Proposed guidelines require forests to be like native forests.
- Calculation about conversion of forestland to vineyards.
- Biomass to carbon ration usually about 50%. 3.67 (?)
- They are willing to help us, for example, review and edit written materials for the project.

Recommendations: Watch out for perverse incentives.

Resources, references, referrals:

- Mark Harmon – wrote articles
- Steve Hamburg, Brown University
- Andrea Mackenzie, Amy Chestnut – Sonoma County Agriculture and Open Space District – They know about accounting when land is put into open space.
- They supplied some written literature about their work.

E. Press coverage for the project

From **Sonoma West Times and News**, January 23, 2004

Air quality district funds Sonoma Co. climate study

by Dawn Pillsbury, Sonoma West Staff Writer

SONOMA COUNTY - How much of Earth's global warming is Sonoma County responsible for and what can be done about it? That's the question a $25,000 study hopes to answer.

"This is the first time an air district in California has taken a look at this," said Ann Hancock of the Sonoma County Climate Protection Campaign. "We got somebody to say yes to a commitment to the future."

The Bay Area Air Quality Management District, formed to help keep the air clean in the Bay Area including the southern half of Sonoma County, approved a one-year $25,000 contract with the local climate protection campaign on Jan. 6. The campaign will calculate the amount of greenhouse gasses emitted by the entire county, including residents and businesses. The study, due to be done by the end of the year, will also take a look at the relationship between Bay Area air quality and climate protection.

In the last two years, the campaign persuaded the county and city governments to inventory their emissions and reduce them, but this study will involve everything that happens in the county.

The Earth's atmosphere is a blend of gasses that keeps the planet's surface at about 60 degrees Fahrenheit. But because human activity has released large amounts of some gasses such as carbon dioxide and methane, according to the climate protection campaign, the planet's atmosphere is changing enough to disturb planetary weather patterns.

Sonoma County Supervisor Tim Smith, a member of the air quality board, said Sonoma County is at the front of California environmental responsibility.

"We're trying to do what we can to improve air quality, flying in the face of our current president," said Smith.

He admitted that he and fellow Sonoma County member Pam Torliatt of Sonoma had to do some pushing to get the board to approve the contract.

"Some members of the board were wondering if this is something an air board should get involved in," he said.

But, Smith said, it is clear to him that greenhouse gas emissions are important.

The study will inventory all greenhouse gas emissions produced in the county, study climate protection efforts throughout the Bay Area, conduct a survey of air districts across America to

find effective models that link climate protection and air quality and make recommendations to the air district for integrating climate protection into its air quality efforts.

Smith said he hopes the report will include incremental changes that will be easy to implement.

"We can show that these changes are economical," he said. Smith cited the $770,000 solar panel system installed in 2002 on the county Information Services building that is projected to reduce the building's electricity costs by $25,300 every year, and said making environmentally responsible decisions is also good for the budget in the long run.

"It's important for us to provide leadership and show it can be done, for people today and for future generations," he said.

Hancock said that while the contract is small, the campaign hopes to do a lot with it.

The campaign is looking for volunteers to help. To get involved, contact Hancock at 829-1224.

http://www.sonomawest.com/articles/2004/01/23/sonomawest/news/nws-5.txt

---

Editorial from **Sonoma West Times and News**, January 23, 2004

Global responsibility

The Sonoma County Climate Protection Program has convinced the Bay Area Air Quality Management District to fund a $25,000 study to determine the county's production of greenhouse gases.

The study will take the climate protection program a step further than last year's greenhouse gas studies by the county and its cities and calculate the entire county's greenhouse gas emissions, which are linked to global warming and changes in the Earth's climate. The study will then be used to help air quality officials link climate protection with air quality protection. The BAAQMD is the first district in the state to fund such a study. "We got somebody to say yes to a commitment to the future," said Ann Hancock, leader of the county climate protection group. It is another small step in the right direction: Local leaders taking responsibility for our actions that affect the entire Earth.

- B.W.D.

http://www.sonomawest.com/articles/2004/01/23/sonomawest/letters_opinions/edt-2.txt

Acknowledgments

- The Board of the Bay Area Air Quality Management District for support and funding of this project, with special thanks to Petaluma City Council member Pam Torliatt and County of Sonoma Supervisor Tim Smith, climate protection champions, who brought the proposal for this project forward to the Board of the Bay Area Air Quality Management District
- Sonoma County Mayor and Council members Association for their for their original letter to the Bay Area Air Quality Management District Board expressing their support for climate protection
- The Sonoma County Waste Management Agency Board who oversaw implementation of this project
- Ken Wells, Director, and staff of the Sonoma County Waste Management Agency, for their guidance, partnership and big green light that shone on this project from beginning to end
- Jean Roggenkamp, Planning Director, and Joseph Steinberger, Senior Planner and project liaison, Bay Area Air Quality Management District
- Harold Brazil, Metropolitan Transportation Commission, for data assistance
- Project advisors: Fred Euphrat; Joel Woodhull; Michelle Passero, Director of Policy Initiatives, Pacific Forest Trust; Barbara Lee, Director of the Northern Sonoma County Air Quality Management District
- Ryan Bell, Program Officer, ICLEI – Local Governments for Sustainability, Cities for Climate Protection, for technical assistance
- County of Marin Community Development Agency whose Greenhouse Gas Inventory report we used for reference and inspiration

Project Team

- Ann Hancock, Coordinator, Climate Protection Campaign
- Mike Sandler, Coordinator, Community Clean Water Institute, and Executive Associate, Climate Protection Campaign
- Sonoma State University Interns:
  - Dave Erickson — Electricity and Natural Gas, and overall technical assistance
  - Gary Albright — Transportation
  - Monika Villanueva — Solid Waste
  - David Williard — Agriculture
- Edwin Orrett, engineer and ecologist with Resource Performance Partners: Consultant for conceptual project design

CLIMATE PROTECTION CAMPAIGN

P.O. Box 558, Graton, CA 95444 (707) 237-2696

www.climateprotectioncampaign.org