Employee Commutes:

Baseline information to enable cities to reduce GHG emissions and save money

GHG Inventory Project, Sonoma County, California

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Overview

Sonoma County cities and the County inventoried the greenhouse gas emissions (GHG) associated with their internal municipal operations as the first step of their pledge to reduce emissions and protect the climate. These municipalities participate in the Cities for Climate Protection® program of the International Council of Local Environmental Initiatives (ICLEI)[1].

ICLEI Corporate Analysis software computes greenhouse gas emissions from each local government's operations based on information provided about energy use and solid waste generation. The municipal operations portion of the emissions analysis covers all buildings, facilities, operations, lands, programs, and vehicles owned and/or operated directly by the local government. The exception is public transit, which is included in the community-wide emissions analysis to facilitate comparisons with emission reduction measures, some of which likely include the encouragement of transit use. The software also allows for the inclusion in the corporate inventory the emissions associated with the local government's employees' commute to and from work.

Commuting to and from work has an immense impact on both the environment and on people's quality of life. Finding ways to reduce the impact defies easy answers. Quantifying the problem is one place to begin when seeking solutions.

Our study calculated the greenhouse gas produced annually by employees' commutes for eight Sonoma cities - Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Sebastopol, Sonoma, and Windsor.

Employee commutes for the eight cities produced 1777 tons of GHG emissions for the last year, representing 15 percent of the total annual emissions produced by the cities' internal operations during FY 2001-02.

Methodology

The Corporate Analysis module in the Cities for Climate Protection Greenhouse Gas Emissions software includes a section for estimating GHG emissions due to the employee commute.

The inputs for this section are totals for annual fuel use for each GHG-producing fuel type used by the employees in their commute. Finding this number is not completely

[1] For more information about the International Council of Local Environmental Initiatives, please visit www.iclei.org

straightforward, since any given employee may carpool, use mass transit, walk or use a non-traditionally fueled vehicle. Any of these "modes" may be used in any combination and proportion. Additionally, different GHG-producing fuel types can be used such as gasoline, diesel and natural gas.

Ideally, each city employee would submit the total number of days worked in the baseline years, the percentage of days each year commuted using each transportation mode, the fuel type and efficiency of each of the modes used and the distance commuted using each of the modes.

For the purposes of this project, due to the large number of employees in some cities, it was impractical to gather this information from all city employees in all eight cities. Therefore, the team employed an online survey created for this project, to a randomly selected group of employees in each city. This randomly selected sample of employees was sized for each city to provide statistically accurate results that could be generalized for the employee population of that city.

The survey enabled the team to determine a mean annual fuel use per employee for each city. The mean fuel use was then used to calculate total fuel use in the two base years for the employee population of each city. The total employee fuel use for commuting to work for each base year was calculated using total employee population during the base years. The mean fuel use was determined using employee data from the current year because of we had no practical way of obtaining accurate commute data fro past years. Population means for the commute parameters were assumed not to have significantly changed year over year from the base years.

Process

The Climate Protection Campaign hired Ned Orrett to design the protocol for the employee commute survey, and Kendra Markle to design web-based survey administration and analysis tools.

Protocol

This protocol covers four steps:

A. City/Project Preparations
    - Obtain lists of city employees and contact information for study years
    - Select Representative Groups of Employees for Survey Purposes
B. Employee Survey Questions (commuting details)
C. Administering the Survey
D. Analyzing the Survey Data: estimate mean fuel consumption per employee per year due to the city employee commute for each city and year

Use of simple random sample

The city liaison for each city provided complete employee lists for the current year. The employee lists were compiled into Excel spreadsheets. After the sample size for each city was calculated, a random number generator was used to select a set of random names that were drawn from the employee list. Excel spreadsheet functions were used for this process.

The sample size calculation is shown in the appendix. Sample sizes for each city were computed to give a margin of error for each of the parameters shown in the following table:

C.L. = 95%	Miles per gallon	Commute Distance	Commute Days
E	±2 mpg	±1.5 mi	±1.5 days

Use of a survey administered via the Internet

The employee commute survey was administered using a Web-based tool accessed via the Internet using a standard browser such as Internet Explorer or Netscape. The survey web pages were designed and implemented by Kendra Markle. City employees selected to participate in the survey received unique identification numbers to ensure that the survey was only taken once, and to guarantee the privacy of the survey respondent.

The structure of the Survey questions and the user interface allowed respondents flexibility in answering in order to obtain maximum accuracy of responses. The survey data had to be able to accurately represent four basic parameters for each respondent in order to compute annual fuel use patterns.

Survey Design

Four basic parameters

The calculation of the amount of fuel used by a survey respondent requires four basic parameters:

- Commute mode (transportation mode/fuel type)
- Days commuted using this mode
- Distance commuted using this mode
- Passenger miles per gallon (fuel efficiency x number of passengers)

Commute Mode

In order to accurately represent the commute pattern of a respondent, the notion of *commute mode* was used. A commute mode is a transportation mode combined with a fuel type. A *transportation mode* is defined in our survey as:

- Drive Alone
- Carpool
- Motorcycle/Scooter

- Bus
- Walk
- Bicycle
- Other non-fuel-using (e.g., roller blade or work-at-home)

Each mode has a fuel type associated with it, which can be:

- Gasoline
- Diesel
- Electric
- Natural gas
- Other
- None

The transportation mode/fuel type combinations specify a commute mode. Respondents were asked to specify a percentage of their total days worked they used each commute mode.

- **Number of days commuting to work by various commute modes**

The respondent was first asked how many total days were worked in the past year. The respondent was then asked to select a commute mode (transportation mode/fuel type) and to enter the percentage of total days worked this commute mode was used. The respondent was allowed to specify as many commute modes and percentages as necessary to cover all the days worked in the past year.

- **Commute distance**

The respondent was asked for the total roundtrip commute distance in miles. For a mass transit mode such as a bus, this would be an estimate of the total route distance between embarkation and debarkation. This would also be true for a carpool.

- **Fuel efficiency**

Fuel efficiency of the commute mode was expressed as "passenger miles per gallon." Any multiple rider commute modes used an effective fuel efficiency number that is the product of the basic fuel efficiency of the vehicle, multiplied by the number of riders.

Sample size

The sample size was calculated using the method shown in the appendix. The sample size was calculated to be large enough to give an acceptable margin of error for sample means at the 95% confidence level.

- **Response rate assumption**

An assumption was made that, because of the nature of the city employee population, and the fact that many if not most city employees have Internet access, response rate on the survey would be close to 100%. This assumption turned out to be unrealistic. In most

cases, response rate was closer to 80-90%. The effect of this on our study results is to make the margin of error on the mean fuel use larger. Although sample n was calculated, then increased by 10% to allow for less than 100% response, in one case, the response rate was less than 80%.

- **Employee Population**

Employee population to be surveyed included all full and part-time employees. Volunteer workers and elected officials were not included.

Employee Survey Questions

The following set of questions is designed for administration to samples of employees selected for each city and for each specific year for which emission estimates are being assembled.

The primary goal of this set of questions is to determine the amount of fossil fuels used by employees of each city each year as they commute to and from work. The Team's analysts may then determine the average emissions per responding employee, and with that, the commute-related emissions for all employees for that city and year.[2] This fulfills the input requirement for this segment of the municipal GHG inventories. A secondary goal is to quantify the use of different of commute modes across time.

[2] Total Commute Fuel use = Average Fuel Use per Employee * ? Total Number of City Employees

Sonoma County Municipal Employee Commute Survey

Approximately how many days did you work during the last year? _____

How did you get to work? Please enter your best estimate of the *percentage* of days during the year spent commuting to and from work by the following methods:

- ❑ Drive Alone
- ❑ Carpool
- ❑ Bus
- ❑ Motorcycle
- ❑ Bicycle
- ❑ Walk
- ❑ No Commute (Worked at Home)

Please provide fuel usage information for each of the commute methods indicated above:

Drive Alone

Miles commuted *per day*: _____

Vehicle fuel efficiency (miles per gallon or kWh): _____

Vehicle Fuel

Gasoline (this applies to regular and hybrid electric vehicles)

- ❑ Diesel
- ❑ Electricity (100% electric only)

Carpool

Average persons per vehicle: _____

Miles commuted *per day*: _____

Vehicle fuel efficiency (miles per gallon or kWh): _____

Vehicle Fuel

- ❑ Gasoline (this applies to regular and hybrid electric vehicles)
- ❑ Diesel
- ❑ Electricity (100% electric only)

Bus

Average # bus passengers: _____

Miles commuted *per day*: _____

Bus Fuel

- ❑ Natural Gas
- ❑ Diesel

❑ Do not know

Motorcycle

Miles commuted *per day*: _____

Vehicle fuel efficiency (miles per gallon): _____

Average Persons Transported: _____

Bicycle

Miles commuted *per day*: _____

Walk

Miles commuted *per day*: _____

Any comments?

Optional Contact Information

Name: _____

Telephone: _____

e-mail: _____

Thank you!

Discussion of Results

The employee commute survey was one of the most ambitious efforts at data collection undertaken by the inventory team. The Web-based survey administration tool is unique and was developed especially for this project. However, our survey response rate was low (ranging from 49% to 91%) relative to our expectations, and our sample size was in some cases too small to support a highly accurate margin of error from a theoretical standpoint. However, our means compare favorably with countywide studies. We used the data on Sonoma County commute patterns from the RIDES website for comparison with our survey results.[3]

Perhaps not surprisingly, the most common commute mode was driving alone. This was true among all cities. The cities ranged from 88% to 99% of commute days drive alone. This compares to 77% for the Sonoma County mean. There were very small percentages of carpooling and motorcycle use. There were even smaller percentages of walking and biking. There was no public transportation use reported among our survey respondents. The only two fuels used were gasoline and diesel, with gasoline being by far the most used. There were no alternative fuels such as natural gas or electricity. There was no

[3] http://rideshare.511.org/research/

telecommuting or work at home. The data seems to indicate that the carpooling and mass transit transportation modes are less used among the city employees than the countywide average.

Mean per person gasoline use for all cities that participated in the survey was 179 gallons for the survey year, with a range of 115 gallons to 263 gallons. 179 gallons of gasoline burned generates two tons of CO2 emissions. Diesel use ranged from 0.8 gallons per person to 16.7 gallons per person, with several cities reporting no diesel use.

The mean number of days commuted to work was 209 days across all the cities with a range of 192 days to 232 days. A 50-week work year represents 250 potential days for commuting.

Mean commute distance reported was 17 miles for all participating cities. This compares to a mean commute distance of 19 miles for Sonoma County as reported in on the RIDES website. The range was a low of 10 miles to a high of 25 miles.

Mean fuel efficiency reported was 19 miles per gallon, which compares to 24 miles per gallon nationwide.

Recommendations

The most obvious, and possibly the easiest way to reduce greenhouse gas emissions from commuting is to encourage carpooling and mass transit use. The most common reasons (cited in both the RIDES data and in comments we received) for not carpooling are lack of flexibility with hours and difficulty in finding ride sharing partners. Cities could use the Internet to post ridesharing opportunities, as well as using a ride board where individuals could post their contact information for ridesharing.

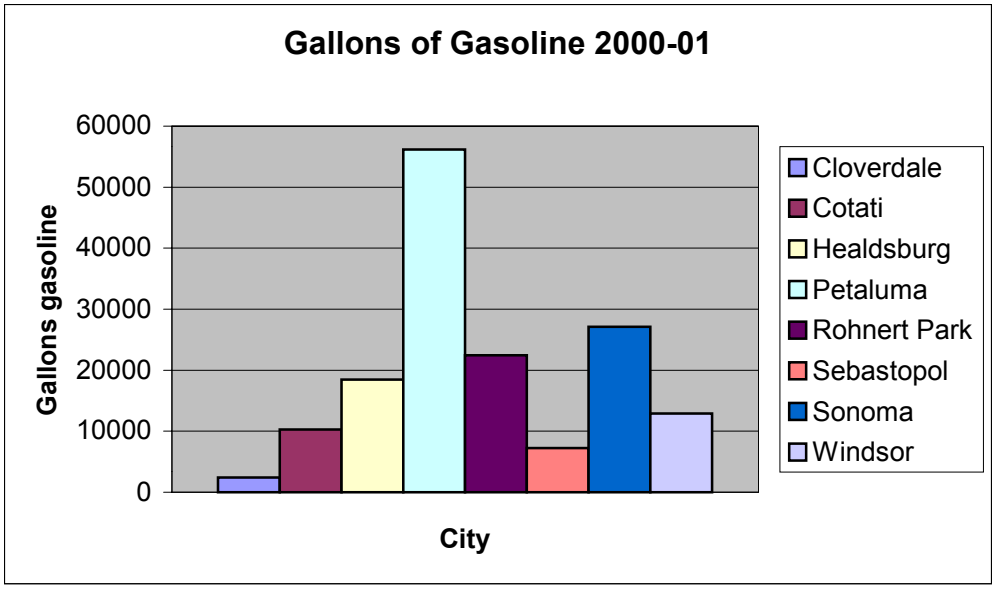
There might also be a system of financial incentives put in place, such as subsidized mass transit fares and cash prizes for such things as “Most Days Not Driving Alone”, etc. Cities might also consider providing a natural gas powered van to shuttle employees from park-and-ride lots or residential areas.

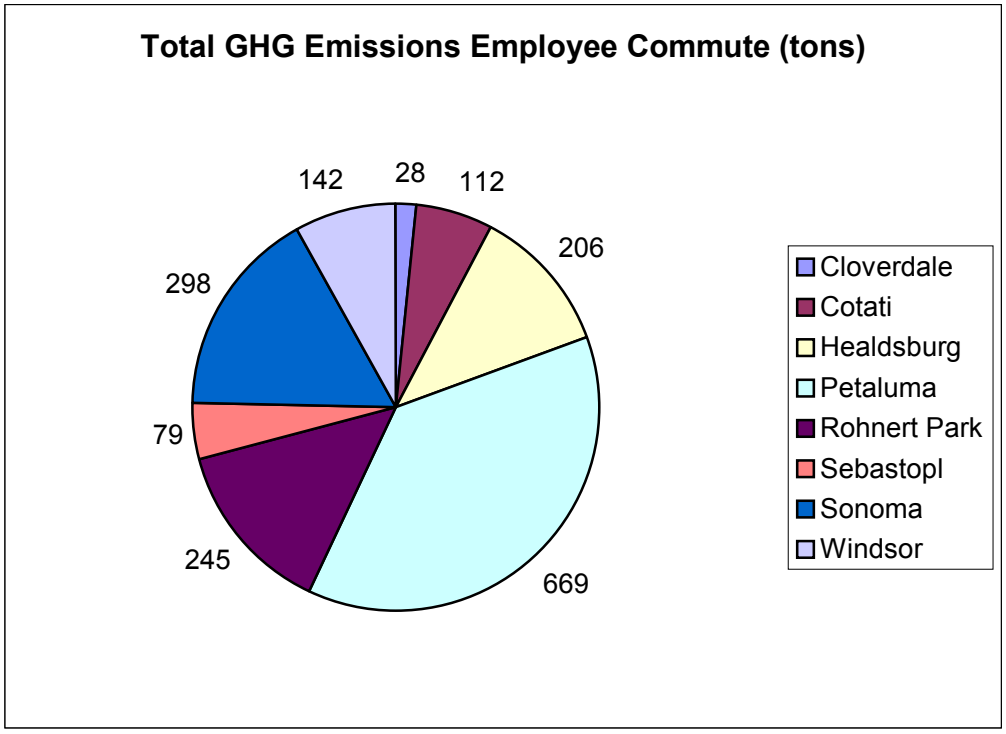
More flexibility in hours might encourage people to walk or take mass transit. Another avenue to reduce commuting is to encourage working at home. This might also result in productivity gains.

Data Summaries

Fuel Consumption base years	Cloverdale	Cotati	Healdsburg	Petaluma	Rohnert Park	Sebastopol	Sonoma	Windsor
Gasoline per person(gal)	**57.3**	**263**	**158**	**177**	**180**	**136**	**224**	**115**
City Total 2000-2001	**2408**	**10263**	**18436**	**56167**	**22449**	**7229**	**27099**	**12923**
City Total 2001-2002	**2293**	**10789**	**18436**	**54572**	**22808**	**7229**	**27547**	**13500**
Diesel per person(gal)	**3.7**	**0.0**	**4.1**	**16.7**	**0.0**	**0.0**	**1.5**	**0.8**
City Total 2000-2001	**154.6**	**0.0**	**475.7**	**5306.3**	**0.0**	**0.0**	**184.1**	**89.9**
City Total 2001-2002	**147.3**	**0.0**	**475.7**	**5155.7**	**0.0**	**0.0**	**187.1**	**93.9**
Commute Mode Percentage								
Drive Alone	**74**	**90**	**92**	**99**	**97**	**88**	**97**	**99**
Carpool	**10**	**8**	**7**	**0**	**0**	**0**	**0**	**0**
Motorcycle	**0**	**2**	**0**	**1**	**2**	**0**	**0**	**0**
Mass Transit	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Non-fuel using	**16**	**0**	**1**	**0**	**1**	**12**	**3**	**0**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

	YEAR	Cloverdale	Cotati	Healdsburg	Petaluma	Rohnert Park	Sebastopol	Sonoma	Windsor	TOTAL
Number of employees	00-01 01-02	42 40	39 41	117 117	317 308	125 127	53 53	121 123	112 117	926 926
Ave. # days commuting per year per employee – all modes		221	210	212	206	232	202	210	192	211 average
Percent commute days – driving alone		74	90	92	99	97	88	97	99	92 average
Length commute in mi. roundtrip - drive alone		5	26	15	16	16	13	23	10	16 average
Ave. vehicle fuel efficiency – MPG, gasoline		18	21	17	17	21	18	20	19	19 average
TOTAL tons GHG per year – all modes, all fuels	00-01 01-02	**28** 27	**112** **118**	**206** **206**	**669** **650**	**245** **245**	**79** **79**	**298** **302**	**142** **148**	**1777** **1774**


Gallons of Gasoline 2000-01
60000
50000
40000
30000
20000
10000
0
Gallons gasoline
City
Cloverdale
Cotati
Healdsburg
Petaluma
Rohnert Park
Sebastopol
Sonoma
Windsor


Total GHG Emissions Employee Commute (tons)
142
28
112
206
298
79
245
669
Cloverdale
Cotati
Healdsburg
Petaluma
Rohnert Park
Sebastopl
Sonoma
Windsor

Appendix

Employee Commute Sample Size Calculation

Formula to compute sample size *n* with a *finite population correction factor* (small *N*)

$$n = \frac{N\sigma^2\left(z_{\alpha/2}\right)^2}{(N-1)E^2 + \sigma^2\left(z_{\alpha/2}\right)^2}$$

$$\bar{x} - E \le \mu \le \bar{x} + E$$

For a 95% degree of confidence: $z_{\alpha/2} = 1.96$

Use range rule of thumb to estimate σ:

$$\frac{\max - \min}{4}$$

N = 55 employees (Sebastopol)

1. Sample size calculation for Miles Per Gallon estimate

$MPG_{max} = 40$
$MPG_{min} = 10$

$\sigma_{est} = 7.5$ MPG

n required to estimate μ for miles per gallon:
$n = (55 * (7.5)^2 * (1.96)^2)/((55-1)*E^2 + (7.5)^2*(1.96)^2)$
$= (9.94^e3)/(54*E^2 + 216)$

E	5	4	3	2	1
n	8	11	17	28	44

Interpretation : With a sample size of 17, we will have a 95% confidence level that our population mean will be within the range of the sample mean plus or minus 3 miles per gallon.

2. Sample size calculation for commute distance estimate

$Distance_{max}$= 20
$Distance_{min}$ = 0

σ_{est} = 5 miles

n required to estimate μ for miles per gallon:
$n = (55 * (5.0)^2 * (1.96)^2)/((46-1)*E^2 + (5.0)^2*(1.96)^2)$
$= (4.42^e3)/(54*E^2 + 96)$

E	3	2.5	2	1.5	1
n	9	12	17	25	35

Interpretation : With a sample size of 17, we will have a 95% confidence level that our population mean will be within the range of the sample mean plus or minus 2 miles total commute distance.

3. Sample size calculation for commute days per year estimate

Assume full time = 200 days
$Work\ Days_{max}$= 210
$Work\ Days_{min}$ = 190

σ_{est} = 5 days

n required to estimate μ for commute days per year:
$n = (55 * (5.0)^2 * (1.96)^2)/((46-1)*E^2 + (5.0)^2*(1.96)^2)$
$= (4.42^e3)/(54*E^2 + 96)$

E	3	2.5	2	1.5	1
n	9	12	17	25	35

Interpretation : With a sample size of 17, we will have a 95% confidence level that our population mean will be within the range of the sample mean plus or minus 2 days total workdays in a year.

4. Conclusion

Using a degree of confidence of 95%, a margin of error of 2 or 3 mpg for miles per gallon and 1.5 or 2 for both commute distance and commute days will give adequate accuracy of our final yearly fuel use, with an acceptable sample size.[4]

Report author, John David Erickson, is a telecom escapee and currently a student in Sonoma State University's Energy Management and Design program. He can be reached at dave@skymetrics.us. This report is posted at www.skymetrics.us

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