

Appendix C: Greenhouse Gas Reduction Calculations

This document provides a summary of the calculations of potential greenhouse gas emission reductions resulting from implementation of the various programs included in the Climate Change Action Plan (CCAP). The data and assumptions provided below were utilized in running the Climate and Air Pollution Planning Assistant (CCAPA) software prepared by ICLEI – Local Governments for Sustainability. Programs for which assumptions of effectiveness could not be made (for example, the GHG reductions that might occur from various public education efforts) did not yield GHG reduction calculations, are not included in this summary and indicated as “n/a” in the Implementation Matrix, Appendix B.

Summary

The sections with measures with quantifiable GHG reduction potentials are Our Lifestyles and Our Buildings. This document is organized by the order in which the measures appear in the CCAP.

Section	GHG Reduction Potential
Our Lifestyles	26,090
Our Buildings	40,920
Our Environment	n/a
Our Economy	n/a

Within each section, the impacts of some measures may target the same set of emissions. For example, calculations about recycling and reducing waste may include waste reduction of the same piece of paper. In such cases, the emissions reduction potentials may be greater than what will be yielded in actuality.

## Our Lifestyles

### Decrease miles travelled in single-occupant vehicles

LF1: Continue to encourage greater residential and commercial densities within walking distance of high frequency transit centers and corridors.

LF2: Consider land use and transportation alternatives (better bicycle and pedestrian access and increased transit feeder service) to best use the future Civic Center SMART station.

1,000	Number of people near Transit Orient Development	A	City of San Rafael %
4.00	Price of Gasoline (\$ per gallon)	B	Price 10-01-08
4,770	Annual Reduction in VM Person in TOD	C	CAPPA
12,306,600	Annual Vehicle Mile Reduction	D	$C \times A \times 2.58$
624,701	Annual Gasoline Savings (gallons)	E	$D/E$
2,498,802	Annual Cost Savings	F	$B \times E$
0.009413	Tons CO <sub>2</sub> e per gallon gasoline	G	ICLEI CAPPA
6,775	Total CO <sub>2</sub> e reduction		$E \times G$

LF4: Facilitate creation of a bike share program, particularly in the Downtown area.

150	Units (bicycles)	A	CAPPA
\$4.00	Price of Gasoline (\$ per gallon)	B	Price of Gasoline 10-01-08
20	Avg. trip per bicycle per day	C	Average use of each bike
2.0	Avg. trip length	D	Downtown area only
50	% of trips replacing car trips	E	CAPPA
1,095,000	% VMT reduced by participants	F	$A \times C \times D \times 365 \times E / 100$
55,584	Annual Gasoline Savings (gallons)	G	$F / 19.7$
0.009413	Tons CO <sub>2</sub> e per gallon gasoline	G	ICLEI CAPPA
525	CO <sub>2</sub> E Metric tons per community	H	$G \times .009413$

LF5: Coordinate with Marin Transit and the Transportation Authority of Marin to pursue funding opportunities to increase transit service and improve convenience to encourage greater ridership.

250	# New daily transit passengers	A	MCTD Report for 23 and 45 lanes
\$4.00	Price of gasoline	B	Price of Gasoline 10-01-08
9.4	Passengers per vehicle	C	MCTD
2.7	Leverage Factor	D	CAPPA
9.8	Average Trip Length (mile per trip)	E	CAPPA
894,250	Average Trip Length (mile x passengers)	F	$A \times E \times 365$
2,414,475	Annual Vehicle Mile Reduction	G	$F \times D$
122,562	Annual Gasoline Savings	H	$G / 19.7$
30,135	Increase Diesel Use (gallons)	I	$F \times 413388 / (C \times 130500)$
0.009413	Tons CO <sub>2</sub> e per gallon gasoline	J	ICLEI CAPPA
0.009531	Tons CO <sub>2</sub> e per gallon diesel	K	ICLEI CAPPA
870	CO <sub>2</sub> e Metric tons Reductions		$H \times J - I \times K$

LF7: Provide transit and carpool incentives to City employees, including alternate work schedules and telecommuting opportunities.

450	# of employees offered cash out	A	Current # employees: 450
4.00	Price of gasoline	B	Price of Gasoline 10-01-08
11	Percent of employees participating	C	Marin Co. Commute Program
33	Average round trip commute length PER DAY	D	GHG Inventory Survey
3.2	Number of days per week carpooling	E	Marin Co. Commute Program
5,491	AVMT reduction per participant	F	$D \times E \times 52$
271,814	Annual Vehicle Mile Reduction	H	$F \times A \times C / 100$
13,798	Annual Gasoline Savings (gallons)	I	$H / 19.7$
55,191	Annual Cost savings on Energy	J	$B \times I$
0.009413	Tons CO <sub>2</sub> e per gallon gasoline	K	ICLEI CAPPA
155	CO <sub>2</sub> e Metric Tons		$I \times K$

**Promote energy savings from transportation**

LF8: Encourage ownership of plug-in electric vehicles, as they become available and in use, by providing charging stations in City garages and parking lots and consider requirements in newly constructed private parking facilities.

110	Number of Charging Spaces	A	Available parking spaces
\$4.00	Price of Gasoline (\$ per gallon)	B	Price of Gasoline 10-01-08
0.114	Price of Electricity (\$ per kWh)	C	P G & E 10-01-08
20	Miles per Gallon of Vehicle Replaced	D	CAPPA
4,704	Average Annual Vehicle Miles per Charging Space	E	CAPPA
25,872	Annual Gasoline Savings (gallons)	F	A x E / D
287,179	Annual Electricity Use (kWh)	G	F x 11.1
\$70,750	Annual Cost Savings	H	B x F - C x H
0.009413	Tons CO <sub>2</sub> e per gallon gasoline	I	ICLEI CAPPA
0.00039947	Tons CO <sub>2</sub> e per kWh	J	ICLEI CAPPA
130	CO <sub>2</sub> e Metric Tons		F x I - G x J

LF9: Adopt a policy to limit City vehicle idling where practical. Evaluate equipping trucks with an auxiliary electrical system for illumination and warning signs.

165	Number of vehicles in fleet	A	City of San Rafael - 2008
\$4.00	Cost of Diesel	B	Price 10-01-08
1.0	Daily Hours Vehicles Idled	C	CAPPA
0.5	Diesel Use per Hour of Idling (gallons)	D	CAPPA
240	Days of Operation per Year	E	CAPPA
19,800	Annual Diesel Savings (gallons)	F	A x C x D x E
79,200	Annual Cost Savings	G	F x B
0.009531	Tons CO <sub>2</sub> e per gallon diesel	K	ICLEI CAPPA
190	Total CO <sub>2</sub> e reduction	H	F x Diesel Emissions

**Reduce material consumption and increase resource re-use**

LF10: Adopt a Zero Waste Goal and develop a Zero Waste Strategic Plan for San Rafael.

26,455	Total emissions from waste in 2020	A	GHG Inventory
50%	Current rate of diversion (assumed by AB939)	B	Assumption (AB939)
70%	"Zero Waste" reduction in waste emissions	C	Assumption
35%	Rate of diversion of currently disposed waste	D	B x C
9,260	Total CO2e reduction		A x B

LF12: Encourage programs to educate and assist homeowners in composting and the creation of facilities to convert organic waste (e.g. vegetative or food waste) to energy to significantly reduce or eliminate landfill disposal.

78,846	Tonnage of waste 2020	A	GHG Inventory
14.6%	Percent of waste stream that is food waste	B	CIWMB 2004 study
11,512	Ton of paper products in 2020	C	A x B
50%	Current rate of diversion (assumed by AB939)	B	Assumption (AB939)
70%	"Zero Waste" reduction in waste emissions	C	Assumption
35%	Rate of diversion of currently disposed waste	D	B x C
4,029	Tons of food waste diverted (recycled/composted)	E	C x D
0.00028	Tons CO2e reduction per pound of paper product diverted	F	CAPPA
2,260	Total CO2e reduction		E x F x 2000 lbs per ton

**Alternate calculation method:**

4613	Emissions from food waste 2005	A	GHG Inventory
9.6%	Percent growth between 2005 - 2020	B	ABAG 2007 projection
5,056	Emissions from food waste 2020	C	A x ( 1 + B )
50%	Percent of currently disposed food waste that is diverted	D	Assumption
2,528	Total CO2e reduction		C x D

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LF13: Work with City's waste franchisee to create additional incentives in the rate structure for waste reduction and recycling and expand the range of recycled products if resale markets exist.

78,846	Tonnage of waste 2020	A	GHG Inventory
21.0%	Percent of waste stream that is paper products	B	CIWMB 2004 study
16,558	Ton of paper products in 2020	C	A x B
50%	Current rate of diversion (assumed by AB939)	B	Assumption (AB939)
70%	"Zero Waste" reduction in waste emissions	C	Assumption
35%	Rate of diversion of currently disposed waste	D	B x C
5,795	Tons of paper products diverted (recycled/composted)	E	C x D
0.00041	Tons CO <sub>2</sub> e reduction per pound of paper product diverted	F	CAPPA
4,750	Total CO <sub>2</sub> e reduction		E x F x 2000 lbs per ton

LF14: Adopt a construction debris recycling and reuse ordinance.

5221	Emissions from lumber, textile, construction organics 2005	A	GHG Inventory
9.6%	Percent growth between 2005 - 2020	B	ABAG 2007 projection
5,722	Emissions from lumber, textile, construction organics 2020	C	A x ( 1 + B )
44%	Percent of the lumber, textile, etc. category that is C&D	D	CIWMB study 9.6% out of the 21.9% of the waste stream categorized in lumber & textile is recorded under C&D
2,508	Emissions from C&D lumber/organics	E	C x D
50%	Percent of C&D lumber diverted through C & D ordinance	F	Assumption
1,255	Total CO <sub>2</sub> e reduction		E x F

LF15: Assist in the establishment of additional reuse facilities (resale shops, refilling stations, repair shops and resource recovery yards).

5221	Emissions from lumber, textile, bulky items 2005	A	GHG Inventory
9.6%	Percent growth between 2005 - 2020	B	ABAG 2007 projection
5,722	Emissions from lumber, textile, construction organics 2020	C	A x ( 1 + B )
10%	Percent of C&D lumber diverted through Resource Recovery Park(s) and C&D Yards	D	Assumption
570	Total CO <sub>2</sub> e reduction		C x D

LF17: Modify the City's purchasing practices and policies to become a model for other businesses and organizations.

275	Total emissions from waste in 2020	A	GHG Inventory
100%	"Zero Waste" reduction in waste emissions	B	Assumption
275	Total CO <sub>2</sub> e reduction		A x B

Summary: Our Lifestyles Measures:			26,090
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## Our Buildings

### Increase the supply of renewable energy sources

BU1: Support efforts of Marin Energy Authority to increase the proportion of renewable power offered to residents and businesses and to provide financial and technical assistance for energy efficiency upgrades.

Calculations of GHG reductions were based on the Marin Energy Authority's 2008 Business Plan which estimated GHG reductions of between 133,592 and 75,582 annual metric tons of CO<sub>2</sub>e.

BU2: Consider creation of or participation in a bond financing program to fund installation of renewable energy systems and energy efficiency upgrades more affordable to property owners with no up-front costs and annual energy savings exceeding financing costs.

12600	Single-family residences (proxy for "property owners")	A	<a href="http://www.cityofsanrafael.org">www.cityofsanrafael.org</a>
25%	Percent of single-family residences that will participate	B	Berkeley estimate for "property owners"
3,150	Single-family residences participating in program	C	A x b
5844	KWH of electricity used by average residence	D	PG&E
100%	Energy use supplied by solar PV	E	Assumption
0.000234	Tons CO <sub>2</sub> e per KWH	F	GHG Inventory
1.37	Tons CO <sub>2</sub> e reduction per participating residence	G	D x E x F
4,810	Tons CO <sub>2</sub> e reduction per participating residence		A x G

BU3: Adopt zoning allowances for residential wind power generators and for location of solar collectors.

14,175	Residential buildings, see assumptions below	A	City of San Rafael, assumption
1%	Percent of residential buildings installing small wind turbines	B	Marin Clean Energy, Appendix F
142	Small wind turbines installed	C	A x B
80%	ACDC capacity factor	D	Marin Clean Energy
22%	Generation capacity factor	E	Marin Clean Energy
2,185,445	KWH electricity generated	F	C x D x E x 24 hours x 365 days
0.000234	Tons CO <sub>2</sub> e per KWH	G	GHG Inventory, PG&E
510	Tons CO <sub>2</sub> e		GHG Inventory, PG&E

**Increase resource conservation and energy efficiency**

BU4: Apply green building requirements to residential, commercial and civic remodeling projects as well as new construction.

660,000	Square Foot of facilities	A	City of San Rafael x 10 years
0.135	Price of Electricity (\$ per kWh)	B	Energy Information
1.615	Price of Natural Gas (\$ per therm)	C	Energy Information
17.3	Typical New Const Annual Energy Use per SF (kWh)	D	CAPPA
0.33	Typical New Const Annual Energy Use per SF (therms)	E	CAPPA
20	Percent Electricity Savings	F	LEED Data Sheet
20	Percent Natural Gas Savings	G	LEED Data Sheet
1.5	Retrofit Cost (\$ per square foot)	H	CAPPA
2,283,600	Total Annual Electricity Savings (kWh)	I	A x D x F/100
43,560	Total Annual Natural Gas Savings (therms)	J	A x E x G/100
378,635	Annual Cost Savings	K	B x I + C x J
7.3	Simple Payback (years)	L	CAPPA
0.00039947	Tons CO <sub>2</sub> e per kWh	M	GHG Inventory
0.005602187	Tons CO <sub>2</sub> e per therm	N	GHG Inventory
1,150	CO <sub>2</sub> Emission Reduction		I x M + J x N

480	Units New housing construction	A	San Rafael Ave. X 10 years
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0.135	Price of Electricity (\$ per kWh)	B	Energy Information Admin.
1.615	Price of Natural Gas (\$ per therm)	C	Energy Information Admin.
5844	Typical Household Electricity Use (kWh)	D	CAPPA
600	Typical Household Natural Gas Use (therms)	E	CAPPA
20	Percent Electricity Savings Compared to Existing Code	F	LEED Data Sheet
20	Percent Natural Gas Savings Compared to Existing Code	G	LEED Data Sheet
\$5,000	Increased Building Cost (\$ per household)	H	CAPPA
561,024	Total Annual Electricity Savings (kWh)	I	$A \times D \times F / 100$
57,600	Total Annual Natural Gas Savings (therms)	J	$A \times E \times G / 100$
351.59	Cost Savings per Household	K	$L / A$
168,762	Annual Cost Savings	L	$B \times I + C \times J$
31.9	Simple Payback (years)	M	CAPPA
0.00039947	Tons CO <sub>2</sub> e per kWh	N	GHG Inventory
0.005602187	Tons CO <sub>2</sub> e per therm	O	GHG Inventory
550	CO <sub>2</sub> Emission Reduction		$I \times N + J \times O$

1,700	Total CO <sub>2</sub> e Reduction		Sum of above
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BU5: Develop a program to achieve energy savings in existing buildings, with a goal of decreasing energy use by 20% as of the year 2020.

### Single Family Resale

4330	Single family units projected to be resold over 10 years	A	County Assessor's Website
2390	Multi family units projected to be resold over 10 years	B	County Assessor's Website
6720	Total projected resold residential units	C	$A + B$
20%	Average energy savings per unit audited	D	Bob Brown
5844	Electricity use per unit, baseline	E	PG&E
600	Natural gas use per unit, baseline	F	PG&E
1168	Electricity savings per unit	G	$C \times E$
120	Natural gas savings per unit	H	$C \times F$
0.000234	Tons CO <sub>2</sub> e per kWh	I	GHG Inventory
0.00535	Tons CO <sub>2</sub> e per therm	J	GHG Inventory
0.92	Total CO <sub>2</sub> e reduction per unit	K	$G \times I + H \times J$
6,182	Total CO <sub>2</sub> e reduction		$C \times K$

**Single Family through Neighborhood Audits**

7670	Single family units not resold over 10 years	A	All rental multi-family units
20%	Average energy savings per unit audited	B	Berkeley RECO program
5844	Electricity use per unit	C	PG&E
600	Natural gas use per unit	D	PG&E
1168	Electricity savings per unit	E	B x C
120	Natural gas savings per unit	F	B x D
0.000234	Tons CO <sub>2</sub> e per kWh	G	GHG Inventory
0.00535	Tons CO <sub>2</sub> e per therm	H	GHG Inventory
0.92	Total CO <sub>2</sub> e reduction per unit	I	E x G + F x H
7,056	Total CO <sub>2</sub> e reduction		A x I

**Multi Family through Inspection Audit**

5150	Apartments to be audited by 2020	A	All rental multi-family units
100%	Percent of audited apartments that will retrofit	B	Assumption
22%	Average energy savings per unit retrofitted	C	Flex Your Power
5844	Electricity use per unit	D	PG&E
600	Natural gas use per unit	E	PG&E
1286	Electricity savings per unit	F	C x D
132	Natural gas savings per unit	G	C x E
0.000234	Tons CO <sub>2</sub> e per kWh	H	GHG Inventory
0.00535	Tons CO <sub>2</sub> e per therm	I	GHG Inventory
1.01	Total CO <sub>2</sub> e reduction per unit	J	F x H + G x I
5,202	Total CO <sub>2</sub> e reduction		A x B x J

**Commercial at Resale**

1000	Commercial units projected to be resold over 10 years	A	Bob Brown estimate
20%	Average energy savings per unit audited	B	Berkeley CECO program
40836	Electricity use per unit	C	PG&E
2736	Natural gas use per unit	D	PG&E
8166	Electricity savings per unit	E	B x C
546	Natural gas savings per unit	F	B x D
0.000234	Tons CO <sub>2</sub> e per kWh	G	GHG Inventory
0.00535	Tons CO <sub>2</sub> e per therm	H	GHG Inventory
4.84	Total CO <sub>2</sub> e reduction per unit	I	E x G + F x H
4,840	Total CO <sub>2</sub> e reduction		A x I

**Commercial through Inspection Audits (less resold properties)**

14,276,000	Total Commercial Square Foot NOT RESOLD	A	Total - resold
100%	Success rate of retrofit action over audits performed	B	Assumption
20%	Average energy savings per square foot audited	C	Bob Brown
10.79	Electricity use per square foot, baseline	D	PG&E (Total commercial use / A)
0.28	Natural gas use per unit, baseline	E	PG&E (Total commercial use / A)
2157	Electricity savings per 1,000 square feet	F	$C \times D / 1,000$
56	Natural gas savings per 1,000 square feet	G	$C \times E / 1,000$
0.000234	Tons CO <sub>2</sub> e per kWh	H	GHG Inventory
0.00535	Tons CO <sub>2</sub> e per therm	I	GHG Inventory
0.8	Total CO <sub>2</sub> e reduction per 1,000 square feet	J	$D \times F + E \times G$
11,421	Total CO <sub>2</sub> e reduction		$A \times B \times J / 1000$

34,700	Total CO <sub>2</sub> e Reduction		Sum of above
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BU6: Develop a program to achieve water conservation in existing buildings and landscaping, with a goal of decreasing water use by 30% as of the year 2020.

0.0045	Price of Water (\$ per gallon)	A	MMWD
350	Water Used per Household per Day	B	MMWD
56,900	City Population	C	City of San Rafael
0.003	Energy Use per Gallon of Water (kWh)	D	MMWD
30	Percent Population Under ordinance	E	Per EBMUD example
845,229,651	Total Annual Water Savings (gallons)	F	$(C/2.58 \times B \times 365 \times E/100)$
2,535,689	Total Annual Electricity Savings (kWh)	G	$F \times D$
3,803,533	Annual Cost Savings	H	$A \times F$
0.000399	Tons CO <sub>2</sub> e per kWh	I	GHG Inventory
1,010	CO <sub>2</sub> Emission Reduction		$G \times I$

BU7: Complete the energy audit of major City buildings and facilities to identify opportunities for efficiency measures and develop an implementation plan for upgrades.

824	Tons CO2e emissions from City facilities' energy use	A	GHG Inventory
15%	Average energy savings per unit audited	B	Berkeley CECO program
120	Total CO2e reduction		A x B
Summary: Our Buildings Measures:		Total	40,920