APPENDIX D. Assumptions and Calculations

1. Sample Measures for Climate Action Plan Template[1]

1.1 Transportation Measures

1.1.1 Discourage Unnecessary Idling

- Estimated annual CO_2e reduction: 6 tons
- Assumptions:
  - School buses burn a half gallon of fuel per hour of idling
  - 600 gallons of fuel would be saved if 100 buses each reduced idling by 1 hour per month
  - The fuel efficiency of a diesel bus is: 5.4 mpg
- Emission Factor:
  - The GHG Emission Factor for a diesel bus is: 21.166 lbs. of CO_2e per U.S. gallon (CACP software)

1.1.2 Increase Bicycling as an Alternative to Driving

- Estimated annual CO_2e reduction: 6 tons
- Assumptions:
  - Commuters can cumulatively shift 10,000 VMT by passenger vehicle to bicycle if this policy is implemented.
  - Fuel efficiency of passenger vehicles ("passenger vehicle" is a composite of a range of motor vehicles including cars, trucks, and SUVs): 18 mpg
- Emission Factor:
  - The GHG Emission Factor for a gasoline passenger vehicle is: 21.501 lbs. of CO_2e per U.S. gallon (CACP software)

1.1.3 Convert the Municipal Fleet to Biodiesel

- Estimated annual CO_2e reduction: 190 tons
- Assumptions:
  - 10 city-owned, diesel-powered heavy trucks are converted to B100 as a result of this measure
  - Fuel efficiency of diesel heavy trucks: 5.6 mpg
  - Each heavy truck is responsible for 10,000 VMT per year, so collectively the trucks are responsible for 100,000 VMT per year.
- Emission Factor:
  - The GHG Emission Factor for a diesel – heavy truck is: 21.166 lbs. of CO_2e per U.S. gallon (CACP software)
  - B100 Biodiesel is a carbon neutral fuel (CACP software)

1.2 Energy Efficiency Measures

1.2.1 Promote the Purchase of Energy Star light Fixtures and Compact Fluorescent Light Bulbs CFL's

- Estimated annual CO_2e reduction: 225 tons
- Assumptions:

[1] All values are presented in short tons

- According to the ENERGY STAR website (www.energystar.gov) a qualified bulb can reduce emissions by 450 lbs. of CO_2e over its lifetime.
- The measure will get 1,000 community members to change one bulb to an energy efficient one.

▪ Conversion Factor:
- 450 lbs. x 1,000 = 450,000 lbs. or 225 tons of CO_2e

1.2.2 Conduct Energy Efficiency Retrofits of Municipal Buildings

▪ Estimated annual CO_2e reduction: 245 tons
▪ Assumption:
- Savings of 1 million kWh of Electricity

▪ Emission Factor:
- Electricity: 0.49 lbs of CO_2e per kWh (PG&E)

▪ Estimated annual CO_2e reduction: 6 tons
▪ Assumption:
- Savings of 1,000 therms of Natural Gas

▪ Emission Factor:
- Natural gas: 12.36 lbs. of CO_2e per therm (CACP software)

1.3 Renewable Energy Measures

1.3.1 Offer Incentives and Financing Information for Residential Solar PV Projects or Install a Solar PV System on the roof of the City Hall

▪ Estimated annual CO_2e reduction: 0.5 ton per kW of installed solar capacity
▪ Assumptions:
- For every kW of installed capacity, PV-generated electricity savings translate to an annual reduction of 1 ton CO_2e
- For every kW of installed capacity, PV panels can generate approximately 2,000 kWh of electricity per year.
- Using solar power results in zero emissions

▪ Emission Factor:
- The GHG emission factor for average grid electricity delivered by PG&E in 2005 is: 0.49 lbs. of CO_2e per kWh (PG&E)

2. Solid Waste Management Practices

2.1 Business Recycling Practices

2.1.1 Increase the reuse of cardboard boxes

▪ Estimated annual CO_2e reduction: 81,200 tons
▪ Assumptions:
- 50 percent of Alameda County's cardboard would be reused when this measure is implemented, or 21,000 tons
- National average methane recovery rate at the landfill is ~50%

▪ Emission Factor:

- The GHG emission reduction factor for reuse of cardboard is: 3.87 tons CO_2 e per ton of cardboard recycled (WARM Model http://epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html)

2.1.2 Increase the recycling of plastic film (LDPE)

- Estimated annual CO_2e reduction: 1.9 tons
- Assumptions:
  - Recycling plastic film reduces upstream energy use.
  - Majority of plastic film is Low Density Polyethylene LDPE
- Emission Factor:
  - The GHG emission reduction factor for recycling LDPE is: 1.9 tons CO_2e per ton of LDPE (plastic film) recycled (WARM Model)

2.1.3 Increase the recycling of paper

- Estimated annual CO_2e reduction: 4.3 tons
- Assumptions:
  - Recycling paper reduces upstream energy use and methane emissions at the landfill.
  - National average methane recovery rate at the landfill is ~50%

- Emission Factor:
  - The GHG emission reduction factor for recycling mixed general paper is 4.3 tons CO_2 e per ton of general paper recycled (WARM Model)

2.1.4 Increase the reutilization of reusable transportation package

- Estimated annual CO_2e reduction: 830 lbs.
- Assumptions:
  - The average wooden pallet weighs about 55 lbs. (http://www.osha.gov/SLTC/etools/woodworking/packship_ergonomics.html)
  - The average plastic pallet can be used 50 times longer than a wooden pallet
  - No sequestration factor at the landfill has been take into account
  - National average methane recovery rate at the landfill is ~50%

- Emission Factor:
  - Gross methane emissions factor for wood at landfill is 0.605 tons CO_2e per ton of wood (CACP software)

2.1.5 Duplex Copying

- Estimated annual CO_2e reduction: 1.9 tons
- Assumptions:
  - By printing double sided, the municipal government can save 1,000,000 sheets of paper in a year
  - 1,000,000 sheets = 0.45 tons
  - National average methane recovery rate at the landfill is ~50%

- Emission Factor
  - The GHG emission factor for reducing paper is 4.28 tons CO_2 e avoided per ton of office paper saved (WARM Model)

2.1.6 Separating Commercial Food Waste for composting instead of landfilling

- Estimated annual CO_2e reduction: 1.09 tons
- Assumption
  - National average methane recovery rate at the landfill is ~50%

- Emission factor:
  - The GHG emission factor for composting food scraps instead of landfilling is 1.09 tons of CO_2e per ton of food waste (WARM Model)

2.2 Bay Friendly Landscaping Practices

2.2.1 Select plants that require less shearing, reduce lawn size, and grasscycle

- Estimated annual CO_2e gross reduction: 2.5 tons per acre
- Assumptions:
  - Approximately 8 tons of yard waste per acre, per year can be avoided by implementing this group of measures http://www.ciwmb.ca.gov/organics/Landscaping/KeepGreen/Manage.htm
  - National average methane recovery rate at the landfill is ~50%
  - No sequestration factor at the landfill has been take into account
- Emission Factor :
  - Gross methane emissions factor of yard waste at landfill is 0.686 tons CO_2e per ton of yard waste (CACP software)

2.2.2 Keep green waste on-site to reduce transport to the landfill

- Estimated annual CO_2e reduction: 1.15 tons (2,300 lbs)
- Assumptions:
  - Approximately 8 tons of yard waste per acre, per year can be avoided
  - This measure eliminates twelve, 50-mile trips by heavy, diesel-fuelled trucks to get the yard waste to the landfill, which equals 600 VMT annually
  - Fuel efficiency Diesel Heavy truck = 5.6 mpg
- Emission Factor:
  - The GHG Emission Factor for a diesel heavy truck is: 21.166 lbs. of CO_2e per U.S. gallon (CACP software)

2.2.3 Avoid fuel consumption due to avoided trimming and mowing

- Estimated annual CO_2e reduction: 315 lbs. per acre
- Assumptions:
  - On average, 15 gallons of gas are consumed per acre of lawn
- Emission Factor:

- The GHG Emission Factor for a gasoline is: 21.501 lbs. of CO_2e per U.S. gallon (CACP software)

2.2.4 Avoid irrigation by choosing appropriately sized lawns, choosing appropriate plant species, and using compost and mulch

- Estimated annual CO_2e reduction: 54 lbs. per year per single family lawn or 9,450 tons for the whole Alameda County (assuming all households have single lawns)
- Assumptions:
  - Sustainable landscaping practices can reduce water consumption by 50 percent
  - In Costal areas of California, an average home–single family lawn consumes 55,395 gal of water/year (0.17 acre-feet of water/year) http://www.ppic.org/content/pubs/cep/EP_706EHEP.pdf
  - There are about 350,000 households in Alameda County
  - For every million gallons of water, 3,950 kWh are consumed in Northern California (California Energy Commission) http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF
  -
- Emission Factor:
  - The GHG emission factor for average grid electricity delivered by PG&E in 2005 is: 0.49 lbs. of CO_2e per kWh (PG&E)

2.2.5 Plant trees strategically around a building/site

- Estimated annual CO_2e reduction: 147 lbs.
- Assumptions:
  - A single tree can reduce air conditioning use by 300 kWh
- Conversion Factor/Calculation:
  - The GHG emission factor for average grid electricity delivered by PG&E in 2005 is: 0.49 lbs. of CO_2e per kWh (PG&E)

2.3 Green Buildings

2.3.1. Adopt an Ordinance that Increases the Recycling of Construction and Demolitions (C&D) Debris

- Estimated CO_2e reduction: 1200 lbs per average home
- Assumptions:
  - A typical new home in Alameda County produces 8.5 pounds of waste per square foot of finished building.[2] Assuming a house size of 2,000 square feet, that equals 17,000 lbs. of debris sent to the landfill.
  - Achieving 50 percent diversion would result in 8,500 lbs. less C&D debris entering the landfill.

[2] Based on waste generation studies for three residential developments in Alameda County. Compiled by Matthew J. Southworth, P.E.

- The composition of the C&D is around 47% organic material which majority is wood. Source: StopWaste.org
- National average methane recovery rate at the landfill is ~50%
- No sequestration factor at the landfill has been take into account

- Emission Factors:
  - Gross methane emissions for wood at landfill is 0.605 tons CO_2e per ton of wood (CACP software)

2.3.2. New Single Family Home: Build GreenPoint Rated

- Estimated CO_2e reduction: 4,971 lbs per average home
- Assumptions
  - The home is new
  - The home is 2,000 square feet[i]
  - The home uses 8,602 kWh of electricity per year[ii]
  - The home uses 489 therms of natural gas per year[iii]
  - The home has electric air conditioning
  - The home's C&D debris is 17,000 pounds (8.5 pounds per square foot)[iv]
  - The landscape area is 1,000 square feet, or 2.3% of one acre

- Emission Factors:
  - The GHG emission factor for Natural gas: 12.36 lbs. of CO_2e per therm (CACP software)
  - The GHG emission factor for average grid electricity delivered by PG&E in 2005 is: 0.49 lbs. of CO_2e per kWh (PG&E)

Emissions Reduction Measure	**Assumptions: Annual Electricity savings**	**Assumptions: Annual Natural Gas savings**	**Approximate GHG Reduction (annual)**
Energy Efficient Design	kWh	Terms	Lbs of CO_2e
Apply optimal value engineering (to reduce cooling and heating space)[v]	43	11	157
Design energy heels on trusses(to reduce cooling and heating space)[vi]	17	2	33
Efficient ductwork installation in conditioned space (to reduce cooling and heating space)[vii]	69	17	243.9
Install deep overhangs to reduce space cooling[viii]	17		8.3
Install insulation effectively (to reduce cooling and heating space) [ix]	43	11	157
Efficient DHW delivery system – reduce water heating[x]		4	49.4
Total	**189**	**45**	**648.6**
Energy Efficient Appliances	**kWh**	**Terms**	**Lbs of CO_2e**

High efficiency furnace[xi]		21	259.5
High efficiency air conditioner[xii]	85		41.7
ENERGY STAR dishwasher[xiii]	97	4	100.7
ENERGY STAR refrigerator[xiv]	65		32
ENERGY STAR clothes washer[xv]	100	11	181.9
ENERGY STAR ceiling fan with CFLs[xvi]	200		41.7
ENERGY STAR bathroom fan[xvii]	9		4.4
Subtotals:	**556**	**36**	**718.2**

Renewable Energy	**kWh**	**Therms**	**Lbs of CO_2e**
Install solar PV system (2.4 kW)	3,500		1,717
Install solar hot water system		43	531.7
Subtotals:			**2,248.7**

Water Energy Savings	**Gallons**	**Lbs of CO_2e**
Landscape Water Use	27,000	53.6
Indoor Water Use	12,500	24.2
Subtotal:		**77.81**

a. Assumptions for water and energy savings calculations are described in 2.2.4 section

Other Savings	**Lbs**	**Lbs of CO_2e**
C&D debris recycling	8,500 lbs C&D debris recycled	1,200 (one time)
Bay Friendly Landscaping Practices	370 of yard waste	127
Subtotal:		**1,227**

b. Assumptions for calculating the savings from Bay Friendly Landscaping practices are described in 2.2.1 and for C&D recycling they are described in 2.3.1

The total emissions savings from this measure is **4,971 lbs of CO_2e per year**

2.3.3 Local Fire Station: Achieve LEED certification

- Estimated CO_2e reduction: 33 tons
- Assumptions
  - The Fire Station is 8,500 sq ft building
  - 75% of the C&D waste was diverted
  - The building is equipped with efficient lighting, heating and cooling equipment
  - Indoor water conservation measures save over 60,000 gallons of water

per year,
- Landscape area is 2.25 acre

Emissions Reduction Measure	Annual energy savings kWh	Approximate Reduction (annual) Tons CO_2 e
Building commissioning	7,400	1.8
Optimized design and equipment selection	32,000 kWh	7.8
On-site renewable energy generation	16,070 kWh	3.9
Subtotal		**13.6**

Water Energy Savings	**Gallons**	**Tons of CO_2e**
Landscape Water Use	1,380,000	1.3
Indoor Water Use	60,000	0.06
Subtotal		**77.8**

Other Savings	**Tons**	**Tons of CO_2e**
C&D debris recycling	73.8 tons C&D debris recycled	12.42 (one time)
Bay Friendly Landscaping Practices	18 tons of yard waste	6.17
TOTAL :		**33.8**

a. Assumptions for water and energy savings calculations are described in 2.2.4 section
b. Assumptions for calculating the savings from Bay Friendly Landscaping practices are described in 2.2.1 and for C&D recycling they are described in 2.3.1

References

[i] The national average size for new single family homes is over 2,400 square feet according to the National Association of Home Builders (www.nahb.org). We used 2,000 square feet to be conservative and because of the variety of housing sizes and types in Alameda County.

[ii] *California Statewide Residential Appliance Saturation Study Update to Air Conditioning Unit Energy Consumption Estimates Using 2004 Billing Data*, California Energy Commission, page 25 (new home UEC for SF PG&E), June 2006, CEC Report Number CEC-400-2006-009, found online at: http://energy.ca.gov/2006publications/CEC-400-2006-009/CEC-400-2006-009.PDF

[iii] *California Statewide Residential Appliance Saturation Study Volume 2 Study Results*, California Energy Commission, page 24 (new home UEC for SF PG&E), June 2004, CEC Report Number 300-00-004, found online at: http://energy.ca.gov/reports/400-04-009/2004-08-17_400-04-009VOL2B.PDF

[iv] Based on findings of waste generation studies for three residential developments in Alameda County 1999-2004 by Matthew J. Southorth, PE.

[v] US Department of Energy, Energy Efficiency and Renewable Energy website, *A Consumer's Guide to Energy Efficiency and Renewable Energy*, "Annual heating and cooling cost savings of up to 5 percent." Online at: http://www.eere.energy.gov/consumer/your_home/designing_remodeling/index.cfm/mytopic=10090.

[vi] Malone, Nancy. *Designing an Affordable Green Housing Project*, Home Energy Magazine, based on the Emeryville reSourceful Building study by Siegel & Strain Architects, March/April 2000 issue, online at: http://homeenergy.org/archive/hem.dis.anl.gov/eehem/00/000314.html.

[vii] *Homeowners Benefits to Ducts in Conditioned Space (Brochure)*, California Energy Commission Technical Report Number 500-03-082-A-17, October 2003. "Ducts in conditioned space saves 8-15% on air conditioning costs." Assumed to have the same savings for heating energy. To be conservative, 8% savings was used.

[viii] No data was available for overhang estimates except for Title 24 building simulation modeling results. Since energy savings in this report are based on actual energy consumption per household, instead of theoretical time dependent energy value, Title 24 was not a useful metric. However, a conservative estimate of 2% energy savings during hot summer days due to 24-inch overhangs seems reasonable.

[ix] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. Pipe wrap in Alameda County can save 750-900 kBtus per year, or roughly 7.5 to 9 therms. This is for uninsulated pipes. A standard house has some insulated pipes, so we assumed 50% of that number (~4 therms or ~2%).

[x] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. Pipe wrap in Alameda County can save 750-900 kBtus per year, or roughly 7.5 to 9 therms. This is for uninsulated pipes. A standard house has some insulated pipes, so we assumed 50% of that number (~4 therms or ~2%).

[xi] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. Using DEER RunID's number RSFm0305RFC90 and RSFm1205RFC90, a 90% Annual Fuel Utilization Efficiency furnace (condensing) will save 1753 kBtuh in climate zone 3 and 2357 kBtuh in climate zone 12. If we take a simple average of these two climate zones as an

estimation of Alameda County, then annual savings are 2056 kBtu, or 20.6 therms. This equates to approximately 10% of the estimated heating energy for our model home, which fits well with the common savings estimate of a high efficiency furnace.

[xii] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. Using DEER RunID's number RSFm0305RSA15 and RSFm1205RSA15, a 15.0 Seasonal Energy Efficnecy Ratio (SEER) split-system air conditioner will save 76 kWh in climate zone 3 and 94 kWh in climate zone 12. If we take a simple average of these two climate zones as an estimation of Alameda County, then annual savings are 85.1 kWh. This equates to approximately 10% of the estimated cooling energy for our model home, which fits well with the common savings estimate of a high efficiency air conditioner.

[xiii] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. ENERGY STAR dishwashers save 97kWh/unit from electricity, and 4 therms from water heating.

[xiv] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. ENERGY STAR refrigerators save between 45 and 76 kWh per year depending on freezer configuration. Average savings are around 65 kWh per year.

[xv] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. ENERGY STAR clothes washers save 11.4 therms and 100 kWh per year.

[xvi] 2004-5 Database for Energy Efficiency Resources, California Public Utilities Commission, online database at: http://eega.cpuc.ca.gov/deer/. Installing one 13-watt compact fluorescent lamp (replacing 60W incandescent) saves 36 kWh per lamp. Assuming that our model home has at least six lamps (or two ceiling fans with light fixture included) this equals an approximate savings of 200 kWh per year, or roughly 10% of lighting energy. The ceiling fan motor is not included in this calculation.

[xvii] No data was available for exhaust fan savings estimates except for Title 24 building simulation modeling results. Since energy savings in this report are based on actual energy consumption per household, instead of theoretical time dependent energy value, Title 24 was not a useful metric. However, a conservative estimate of 1% energy savings due to high efficiency fans exhausting moist air from 2 bathrooms was used.