C.1 Introduction

This Appendix provides a detailed overview of the calculations and assumptions used to quantify greenhouse gas (GHG) reductions and the monetary costs and savings for each of the City of Livermore's (City) GHG reduction measures. A qualitative discussion of benefits is also presented. The following information is provided for each measure.

- **Measure Description**. Details the implementation requirement(s) and reduction goal.
- Assumptions. Includes all assumptions used in calculating emissions reductions and costs. Because the majority of measures utilize the same assumptions, Table C-1 includes a master list of assumptions for reference.
- Analysis Details. Presents the methods for calculating business-as-usual (BAU)¹ and baseline² emissions, as well as a more detailed discussion of calculations performed to quantify emissions reductions. A qualitative summary of benefits is also provided. Note that a reasonable amount of information is provided so that the reader can understand the basic methods and equations used to quantify emissions reductions and costs. However, this section *does not* include an exhaustive list of all calculations and steps performed; doing so would result in hundreds of pages of documentation. For additional information, please refer to the citations provided for each measure.

As an introduction to the measure details, this Appendix begins with an overview of the general GHG quantification methods by emissions sector, followed by a brief description of the approach for the cost analysis.

C.2 Overview of GHG Methods

The quantification of GHG reductions was based primarily on guidance provided by the California Air Pollution Control Officers Association (CAPCOA), other reference sources (such as the U.S. Environmental Protection Agency), and professional experience obtained from preparing climate action plans (CAP) for other jurisdictions in California. The majority of calculations were performed using standard factors and references, rather than performing a specific analysis of individual technologies. The following sections provide an overview of general calculation methods by emissions sector.

¹ BAU emissions are defined as those that would occur without the implementation of state or local action.

² Baseline emissions are defined as those that would occur with the implementation of state action, but no local action.

To avoid double counting emissions savings achieved by state programs, emissions reductions attributed to the candidate measures first subtract reductions achieved through the relevant state measures. Likewise, emissions reductions attributed to certain candidate measures subtract reductions achieved by overlapping local measures. By removing overlapping reductions, one can combine GHG reduction strategies to determine the cumulative effect of several measures without double counting measure effectiveness.

C.2.1 State Measures

The City's CAP includes emissions benefits from nine statewide initiatives. These State measures span multiple emission sectors, but are primarily targeted at the building energy and transportation sectors. Emissions reductions achieved by these measures were apportioned to the City-level using statewide estimates of measure effectiveness and sector-specific information. For example, the California Air Resources Board (CARB) estimates that implementation of Pavley I will reduce statewide emissions from passenger vehicles by 27.7 million metric tons (MT) of CO₂ equivalent (CO₂e), or by approximately 17% (California Air Resources Board 2011). GHG reductions achieved by Pavley I within Livermore were therefore quantified by multiplying City-level 2020 BAU emissions from passenger vehicles by 17%. It is important to note that while Livermore will achieve emissions reductions as a result of State programs, implementation of State measures does not require local action.

C.2.3 Local Measures

The section summarizes local efforts that the City proposes to further reduce community-wide GHG emissions.

Building Energy Use

Reduction measures to address GHG emissions from building energy are designed to improve energy efficiency and to transition consumption towards renewable sources of energy. Consumption data of electricity (kWh) and natural gas (therms) consumed by residential, and commercial and industrial buildings were provided for the existing inventory year (2005) and scaled to 2020 under BAU conditions using the socioeconomic data. (City of Livermore 2005a and ICF International 2010).

Emissions reductions achieved by energy measures were quantified using a general standard and factors. Specifically, percent reductions in energy consumption for various actions, such as exceeding the Title 24 Standard, were obtained from CAPCOA and other literature sources. These reductions were applied to the calculated 2020 energy usage to quantify total reductions in energy consumption. GHG emissions that would have been emitted had the energy been consumed were then calculated using utility-specific emission factors.

Transportation

Measures within the transportation sector seek to both reduce the number of vehicle trips, as well as encourage mode shifts from single occupancy vehicles to alternative transportation. Fehr & Peers calculated the potential reduction in vehicle miles of travel (VMT)³ that are expected to occur by 2020 with implementation of each GHG reduction measure (Fehr & Peers 2011) (Attachment C-1).

ICF estimated GHG emissions reductions from transportation measures using VMT data provided by Fehr & Peers. GHG emissions reductions were quantified by multiplying the reduction in VMT (Fehr & Peers 2011) by an emission per VMT factor, which is simply the quotient of 2020 BAU transportation emissions and 2020 BAU VMT. 2020 BAU transportation emissions and VMT are summarized in the Livermore 2005 GHG Inventory (City of Livermore 2005a).

Waste Generation

The City's waste reduction strategy aims to reduce the amount of waste produced by the community and sent to landfills by increasing the waste diversion rate. Waste generation volumes from 2005 were obtained from the City's existing inventory, and the City's baseline diversion rate was obtained from CalRecycle (n.d.). Future year waste generation volumes were determined by scaling to 2020 using the City's socioeconomic data. GHG emissions that would have been generated from the decomposition of waste in a landfill if it had not been diverted were quantified using the City's 2020 BAU waste emissions, 2020 BAU waste sent to landfills, and the goal diversion rate specified in the reduction measure description.

Water Consumption (Conveyance and Building Energy Reductions)

The CAP seeks to reduce energy and GHG emissions associated with water consumption through compliance with Senate Bill (SB) X7-7. Pursuant to SB X7-7, the City's urban water retailers will reduce per capita water consumption by 20% by 2020. Total community-wide forecasted water consumption in 2020 was provided by the water providers' Urban Water Management Plans. The difference in 2020 water usage between the SB X7-7 and the BAU scenarios was assumed to the represent the water reductions associated with the measure. Indirect GHG emissions from electricity required to pump, treat, distribute and/or heat the consumed water were calculated using state-specific emission factors.

Wastewater Treatment

The CAP targets emissions from the City's wastewater treatment plant by seeking to implement high-efficiency aeration diffusers at the Livermore Water Reclamation Plant (LWRP). A recent report prepared by Chevron was used to calculate expected GHG reductions associated with this measure (Chevron 2012).

³ VMT is the number of miles traveled by vehicles on the City's roads.

Urban Forestry

The City's CAP includes a measure to expand urban forestry programs to plant 100 new trees per year. Emissions benefits from increased shade and sequestration were quantified based on information provided by ICLEI and CAPCOA. The City's tree planting lists were consulted to determine the types of tree species appropriate for planting along City streets and in open spaces. It was assumed that tree planting would begin in 2013 and occur on an annual basis.

Municipal Energy-Efficiency Measures

The City is considering a suite of energy-efficiency measures for municipal operations based on an evaluation conducted by Chevron (Chevron 2012). The identified annual savings from the Chevron report are presented below. The report did not provide initial capital cost estimate or total discounted estimates of cost or savings.

C.3 Overview of Cost Analysis Methods

The cost analysis estimated the following metrics for each measure:

- Net additional one-time (capital) costs or savings. These costs represent the costs of purchasing new equipment, retrofitting equipment, planting trees—the "one-time" costs associated with implementing a measure. In many cases, these one-time costs are assumed to occur at the same time; however, there are a few cases where these one-time costs are actually spread over several years as the measure is fully implemented.
- Net additional annual costs or savings in 2020. Annual costs generally represent maintenance costs. Annual savings often represent avoided energy costs or avoided maintenance costs. Net annual costs/savings can vary by year, so this document presents the annual net costs anticipated in 2020.
- **Total Costs/Savings**. Total costs or savings were calculated by considering the stream of all costs and savings over the lifetime of the equipment and applying a discount rate for future costs or savings. In some cases, there is no associated lifetime of equipment, and total costs/savings were calculated for the 2012-2020 time period. A discount rate of 5 percent was used.
- Annualized net costs /savings per ton of CO₂e reduction in 2020 (essentially, \$/ton). The total costs/savings were divided by an annuity factor to estimate the annualized costs/savings. This value is from the perspective of annual costs and savings, taking into account the time value of money. Because costs and savings are incurred over a period of several years, it is necessary to calculate the annualized so that it can be evaluated against the GHG reductions that occur in a single year (2020). This value provides an estimate of the cost per ton of implementing the measure.
- **Simple payback period.** The simple payback period is calculated by dividing the one-time costs by the annual savings, or (when annual costs vary) by calculating the break-even point. In some cases, the payback period would exceed the lifetime of the equipment, and this never would actually be "repaid." These instances are noted as "N/A" (for Not Applicable) in

the summary tables. Note that the savings and costs are sometimes born by different entities, so the payback period does not necessarily indicate that a given entity would actually be paid back on its investment.

There are some important caveats to note regarding the cost analysis. First, the numbers presented in this document are meant to provide order-of-magnitude estimates and assist in evaluating the relative costs/savings of each measure. There are numerous factors that will affect the actual costs incurred if the measures are implemented. In some cases, assumptions had to be made about the specific actions taken to implement a given measure, although the actual approach to implementing the measure could vary. Second, it is important to understand that in many cases, costs and savings are born by different entities. For example, a local government may incur costs associated with planting and maintaining urban trees, but the savings from reduced electricity bills accrue to local businesses and residents. Where appropriate, we distinguish among the key players incurring the costs and savings.

C.4 Overview of Measure Benefits

Many of the GHG reduction measures would result in financial, environmental, and public benefits for the City and community that are additional to the expected GHG emission reductions. These benefits include cost savings over conventional activities, reductions in criteria pollutants, job growth, economic growth, and public health improvements. Studies have shown that some climate actions in California can produce net gains for the statewide economy, increasing growth and creating jobs while others will result in net costs. Climate policies can produce positive economic growth through monetary savings from improvements in energy efficiency and reduced energy bills, as well as investing in technologies for innovation, which can provide new stimulus for employment (Roland-Holst 2008). Another study demonstrated that addressing and mitigating GHG emissions on a national level can yield a large savings potential, benefit the global economy, and can be mostly achieved through implementation of existing technology (Vattenfall 2007). Based on literature reviews, a qualitative discussion of anticipated benefits is provided for each of the City's GHG reduction measures. Benefits are identified using the following icons.



Benefits for the City of Livermore's GHG Reduction Measures

Appendix C. GHG Reduction Measure and Cost/Benefit Methodology



Reduced Air Pollution



Reduced Urban Heat Island Effect

Increased Property Values

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Smart Growth

C.5 Common Assumptions

As discussed in Section C.1, the measure write-ups include all assumptions used in calculating emissions reductions and costs. Because the majority of measures utilize the same assumptions, Table C-1 provides a master list of assumptions. Each assumption is numbered for reference.

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
Business-as-	Usual Emissions Data (MT CO2e)			
1	2020 Emissions from Transportation	182,643	City of Livermore Inventory Update	
2	2020 Emissions from Transportation: Heavy-Duty Trucks	23,067	City of Livermore Inventory Update	
	Only			
3	2020 Emissions from Building Energy	269,682	City of Livermore Inventory Update	
4	2020 Emissions from Residential Building Energy	140,726	City of Livermore Inventory Update	
5	2020 Emissions from Commercial/Industrial Building Energy	128,956	City of Livermore Inventory Update	
6	2020 Emissions from Waste	37,948	City of Livermore Inventory Update	
7	2020 Emissions from Water	6,073	City of Livermore Inventory Update	
8	2020 Emissions from Wastewater	956	City of Livermore Inventory Update	
9	2020 City Wide Emissions	497,302	City of Livermore Inventory Update	
Socioeconon	nic Data and Growth Factors			
10	2005 Housing	28,646	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
11	2005 Existing Single Family Homes (units)	22,583	Email from Ingrid Rademaker on 1/24/12	
12	2005 Existing Multi Family Homes (units)	6,063	Email from Ingrid Rademaker on 1/24/12	
13	2005 Existing Other Homes (units)	0	Email from Ingrid Rademaker on 1/24/12	
14	2011 Housing	30,661	City of Livermore Candidate Measures for the Community	
			Climate Action Plan - Data Needs Questionnaire	
15	2011 Existing Single Family Homes (units)	22,382	Email from Ingrid Rademaker on 1/24/12.	
16	2011 Existing Multi Family Homes (units)	8,279	Email from Ingrid Rademaker on 1/24/12	
17	2011 Existing Other Homes (units)	0	Email from Ingrid Rademaker on 1/24/12	
18	2020 Housing	34,742	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
19	2020 Single Family Homes (units)	23,947	Email from Ingrid Rademaker on 1/24/12	
20	2020 Multi Family Homes (units)	10,795	Email from Ingrid Rademaker on 1/24/12	
21	2020 Other Homes (units)	0	Email from Ingrid Rademaker on 1/24/12	
22	"New" Housing in 2020 (2020-2012)	4,081	2020 minus 2011 values	
23	"New" Single Family Homes in 2020 (units)	1,565	2020 minus 2011 values	
24	"New" Multi Family Homes (units) in 2020	2,516	2020 minus 2011 values	

Table C-1.	Fable C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)		
25	"New" Other Homes (units) in 2020	0	2020 minus 2011 values		
26	2005 Population	79,046	Livermore 2005 GHG Inventory		
27	2011 Population	80,968	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
28	2020 Population	91,500	Livermore 2005 GHG Inventory		
29	"New" Population in 2020 (persons) (2020–2012)	10,532	2020 minus 2011 values		
30	2005 Employment	32,340	Livermore 2005 GHG Inventory		
31	2011 Employment	42,204	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
32	2020 Employment	40,030	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
33	"New" Employment in 2020 (jobs) (2020–2012)	-2,174	2020 minus 2011 values		
34	2005 Commercial Floor space (square feet)	5,532,840	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
35	2011 Commercial Floor space (square feet)	5,954,638	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
36	2020 Commercial Floor space (square feet)	6,588,299	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
37	"New" Commercial Floor space 2020 (2020–2012)	633,661	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
38	2005 Industrial Floor space (square feet)	8,603,079	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
39	2011 Industrial Floor space (square feet)	15,902,334	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
40	2020 Industrial Floor space (square feet)	16,449,286	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
41	"New" Industrial Floor space 2020 (2020–2012)	546,952	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
42	Growth in housing between 2005 and 2020	1.21	ICF International 2010		
43	Growth in employment between 2005 and 2020	1.24	ICF International 2010		
44	Growth in population between 2005 and 2020	1.16	ICF International 2010		

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
Global Warr	ning Potentials			
45	Carbon Dioxide	1	IPCC 1996 and 2001	
46	Methane	21	IPCC 1996 and 2001	
47	Nitrous Oxide	310	IPCC 1996 and 2001	
48	CFC-11	4,750	California Climate Action Registry 2010	
49	HCFC-141b	725	California Climate Action Registry 2010	
Emission Fa	ctors			
50	2005 PG&E Electricity Emissions Factor (lbs CO ₂ /MWh)	493	Livermore 2005 GHG Inventory	
51	2005 Default Electricity Emissions Factor (lbs CH4/MWh)	0.072000	Livermore 2005 GHG Inventory	
52	2005 Default Electricity Emissions Factor (lbs N2O/MWh)	0.0540000	Livermore 2005 GHG Inventory	
53	2020 PG&E Electricity Emissions Factor (lbs CO ₂ /MWh)	375	Calculated based on California Energy Commission 2007	
54	2020 Statewide Electricity Emissions Factor (lbs CH ₄ /MWh)	0.0536000	Calculated based on California Energy Commission 2007	
55	2020 Statewide Electricity Emissions Factor (lbs N ₂ O/MWh)	0.0402000	Calculated based on California Energy Commission 2007	
56	2005 and 2020 Natural Gas Emissions Factor (kg CO ₂ /MMBtu)	53.05	Livermore 2005 GHG Inventory	
57	2005 and 2020 Natural Gas Emissions Factor (g CH ₄ /M ³)	0.214398873	Livermore 2005 GHG Inventory	
58	2005 and 2020 Natural Gas Emissions Factor (g N_2O/M^3)	0.036338792	Livermore 2005 GHG Inventory	
59	Ratio—Single: Multi Family Housing—Electricity	1.39	Energy Information Administration 2009	
60	Ratio—Single: Multi Family Housing—Natural Gas	1.23	Energy Information Administration 2009	
61	Groundwater Importation Energy Proxy (kWh/MG)	896	California Air Pollution Control Officers Association 2010	
62	Surface water Importation Energy Proxy (kWh/MG)	1,510	California Air Pollution Control Officers Association 2010	
63	State Water Project Importation Energy Proxy (kWh/MG)	896	California Air Pollution Control Officers Association 2010	
64	Water Treatment Energy Proxy (kWh/MG)	111	California Air Pollution Control Officers Association 2010	
65	Water Distribution Energy Proxy (kWh/MG)	1,272	California Air Pollution Control Officers Association 2010	
66	Wastewater Distribution Energy Proxy (kWh/MG)	2,028	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
67	Gasoline (MT CO ₂ /GJ)	0.0658	GHGID Model Tool	
68	Gasoline (MT CH ₄ /GJ)	0.0000	GHGID Model Tool	
69	Gasoline (MT N ₂ O/GJ)	0.0000	GHGID Model Tool	

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
70	Diesel (MT CO ₂ /GJ)	0.0704	GHGID Model Tool	
71	Diesel (MT CH4/GJ)	0.00001	GHGID Model Tool	
72	Diesel (MT N ₂ O/GJ)	0.0000006	GHGID Model Tool	
73	LGP (MT CO ₂ /GJ)	0.0599	GHGID Model Tool	
74	LGP (MT CH ₄ /GJ)	0.0000	GHGID Model Tool	
75	LGP (MT N ₂ O/GJ)	0.0000	GHGID Model Tool	
76	Kg CO ₂ /gallon diesel	10.15	Climate Registry 2011	
Detailed Bui	ilding Energy Data			
77	CEC Forecast Climate Zone	4	California Air Pollution Control Officers Association 2010	
78	2005 Residential Electricity Usage (kWh)	223,300,000	Livermore 2005 GHG Inventory	
79	2005 Commercial and Industrial Electricity Usage (kWh)	331,800,000	Livermore 2005 GHG Inventory	
80	2011 Residential Electricity Usage (kWh)	236,755,960	ICF International 2010	
81	2011 Commercial and Industrial Electricity Usage (kWh)	361,305,801	ICF International 2010	
82	2020 Residential Electricity Usage (kWh)	258,475,401	ICF International 2010	
83	2020 Commercial and Industrial Electricity Usage (kWh)	410,556,341	ICF International 2010	
84	"New" Residential Energy Usage (kWh) (2020–2011)	21,719,441	2020 minus 2011 values	
85	"New" Commercial and Industrial Energy Usage (kWh) (2020–2012)	49,250,540	2020 minus 2011 values	
86	2005 Residential Natural Gas Usage (therms)	13,400,000	Livermore 2005 GHG Inventory	
87	2005 Commercial and Industrial Natural Gas Usage (therms)	5,600,000	Livermore 2005 GHG Inventory	
88	2011 Residential Natural Gas Usage (therms)	14,207,478	ICF International 2010	
89	2011 Commercial and Industrial Natural Gas Usage (therms)	6,097,988	ICF International 2010	
90	2020 Residential Natural Gas Usage (therms)	15,510,839	ICF International 2010	
91	2020 Commercial and Industrial Natural Gas Usage (therms)	6,929,221	ICF International 2010	
92	"New" Residential Natural Gas Usage (therms) (2020-2011)	1,303,361	2020 minus 2011 value	
93	"New" Commercial and Industrial Natural Gas Usage (therms) (2020-2011)	831,233	2020 minus 2011 value	

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
94	New Residential Natural Gas Usage (therms) (2020-2005) (For state measures only)	2,110,839	2020 minus 2005 value	
95	New Commercial + Industrial Natural Gas Usage (therms) (2020-2005) (For state measures only)	1,329,221	2020 minus 2005 value	
Reduction	for 1% Improvement in T24 (Residential)			
	Electricity (%)			
96	Single Family	0.09%	CAPCOA 2010	
97	Multi Family	0.12%	CAPCOA 2010	
98	Townhome	0.09%	CAPCOA 2010	
	Natural Gas (%)			
99	Single Family	0.91%	CAPCOA 2010	
100	Multi Family	0.88%	CAPCOA 2010	
101	Townhome	0.90%	CAPCOA 2010	
Reduction	for 1% Improvement in T24 (Commercial)			
102	Electricity (%)	0.27%	CAPCOA 2010	
103	Natural Gas (%)	0.71%	CAPCOA 2010	
104	Percent of Commercial Electricity from Outdoor Lighting (Commercial)	5.20%	CEC 2006	
105	Percent of Commercial Electricity from Interior Lighting (Commercial)	28.90%	CEC 2006	
106	Percent of Commercial Electricity from Outdoor Lighting (Lodging-Used for Residential)	4.74%	CEC 2006	
107	Percent of residential electricity used for other appliances and lighting (%)	39.13%	EIA 2005	
108	Percent of "other appliances and lighting" that is lighting (%)	50.00%	EIA 2005	
109	Percent heating associated with commercial boilers (%)	12.00%	CAPCOA 2010	
110	Percent reduction in natural gas emissions associated with a fan-assisted non condensing boiler or condensing (%)	8.30%	CAPCOA 2010	
111	Percent of commercial natural gas used for heating equipment (%)	73.50%	CEC 2006	

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
Detailed St	reetlight and Traffic Signal Data			
112	Number of existing traffic signals (2005)	92	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
113	Number of existing street lights (2005)	6,800	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
114	Number of 2020 BAU traffic signals	110	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
115	Number of 2020 BAU street lights	7,400	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
116	Percent electricity savings per outdoor LED light	75%	U.S. Environmental Protection Agency 2011	
117	Percent electricity savings per traffic light LED light	90%	CAPCOA 2010	
118	Incandescent Wattage of a Traffic Signal	150	CAPCOA 2010	
119	Traffic Signal Daily Hours of Operation	24	ICF Assumption	
120	Streetlight Daily Hours of Operation	11	ICLEI 2010	
BAU Street	light Profile			
121	Mercury Vapor (%)	0%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
122	Metal Halide (%)	0%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
123	High Pressure Sodium Cutoff (%)	100%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
124	Low Pressure Sodium Cutoff (%)	0%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
125	LED (%)	0%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
Lighting W	'attage (kW)			
126	Wattage of Mercury Vapor Lamps	0.18	ICLEI 2010	
127	Wattage of Metal Halide Lamps	0.20	ICLEI 2010	
128	Wattage of High Pressure Sodium Lamps	0.19	ICLEI 2010	
129	Wattage of Low Pressure Sodium Lamps	0.18	ICLEI 2010	
130	Wattage of LED streetlight	0.12	ICLEI 2010	

Table C-1. Master List of Quantification Assumptions					
Number	Parameter	Assumption	Source (if applicable)		
Detailed Cool Roof Data					
131	Annual Electricity Savings per Roof Square Foot (kWh)	0.84	ICLEI 2010		
132	Annual Natural Gas Savings per Roof Square Foot (therm)	0.00	ICLEI 2010		
Detailed Co-	Generation Data				
133	$\rm CO_2$ reductions from a 100 kW Reciprocating Engine in the PG&E Service District	2%	CAPCOA 2010 Table AE-4.1		
Detailed Tra	insportation Data				
134	Percent Emissions Light-Duty	75	ICF International 2010, EPA 2010, and EMFAC 2007		
135	Percent Emissions heavy, medium-duty, and busses	23	ICF International 2010, EPA 2010, and EMFAC 2007		
136	Percent emissions heavy-duty only	13	ICF International 2010, EPA 2010, and EMFAC 2007		
137	Number of parking spaces per multifamily home - Studio/1 Bedroom	1	Email from Ingrid Rademaker on 1/24/12		
138	Number of parking spaces per multifamily home - 2+ bedrooms	2	Email from Ingrid Rademaker on 1/24/12		
139	Number of parking spaces per multifamily home - guest spaces	0.25	Email from Ingrid Rademaker on 1/24/12		
140	Number of parking spaces per multifamily home – average	1.75	Average of assumptions 95 and 96, added to assumption 97		
141	2005 Daily VMT	1,642,169	Livermore Existing Inventory		
142	2005 Annual VMT	569,832,643	Livermore Existing Inventory		
143	2020 Daily VMT	2,035,818	Livermore Existing Inventory		
144	2020 Annual VMT	706,428,846	Livermore Existing Inventory		
145	2020 Annual HDT VMT	17,620,819	Livermore Existing Inventory		
146	2020 HDT average speed (mph)	45.1	EMFAC 2007 and ICF International 2010		
147	Daily VMT Reduction from On-Road 2	12,215	Fehr & Peers 2012		
148	Daily VMT Reduction from On-Road 3	4,072	Fehr & Peers 2012		
149	Daily VMT Reduction from On-Road 5	7,736	Fehr & Peers 2012		
150	Daily VMT Reduction from On-Road 6	407	Fehr & Peers 2012		
151	Number of parking spaces per commercial building - General Retail (spaces per sq ft)	0.004	Email from Ingrid Rademaker on 1/24/12		
152	Number of parking spaces per commercial building - Office (spaces per sq ft)	0.003	Email from Ingrid Rademaker on 1/24/12		

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
153	Number of parking spaces per commercial building - Service (spaces per sq ft)	0.003	Email from Ingrid Rademaker on 1/24/12	
154	Number of parking spaces per office building less than 50,000 square feet (space per 200 square feet)	1.0	ICF Assumption	
155	Number of parking spaces per office building greater than 50,000 square feet (space per 500 square feet)	1.0	ICF Assumption	
156	Number of covered commercial parking spaces	550	Email from Ingrid Rademaker on 1/24/12	
157	Size of a parking space (square feet)	171.0	ICF Assumption	
158	Percent of commercial parking space that is covered (%)	1%	ICF Assumption	
159	Percent of commercial parking space that is stacked (%)	25%	ICF Assumption	
160	Percent of multifamily parking space that is covered (%)	5%	ICF Assumption	
ailed Water	Data			
161	2005 Water Consumption from the State Water Project (gallons)	4,060,890,849	Livermore Municipal Water 2005 Urban Water Management Plan (UWMP), California Water Service Company 2007 UWMP, and ICF International 2010	
162	2005 Water Consumption from Surface Water (gallons)	1,015,222,712	Livermore Municipal Water 2005 Urban Water Management Plan (UWMP), California Water Service Company 2007 UWMP, and ICF International 2010	
163	2005 Water Consumption from Ground Water (gallons)	1,000,038,036	Livermore Municipal Water 2005 Urban Water Management Plan (UWMP), California Water Service Company 2007 UWMP, and ICF International 2010	
164	2020 BAU Water Consumption by source (percentage)	GW - 12% SW -18% Delta -70%	Livermore Municipal Water 2005 Urban Water Management Plan (UWMP), California Water Service Company 2007 UWMP, and ICF International 2010	
165	2020 BAU Water Consumption per capita per day (gallons)	194.6	Livermore Municipal Water 2010 Urban Water Management Plan (UWMP).	
166	2020 BAU Water Consumption (gallons)	6,499,153,500	Calculated by ICF International from per capita per day factor and 2020 forecasted population	
167	2005 Water Delivered by the City of Livermore - Residential (MGD per year)	1,210.0	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
168	2005 Water Delivered by the City of Livermore - Commercial (MGD per year)	412.5	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
169	2005 Water Delivered by the City of Livermore - Industrial (MGD per year)	32.9	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
170	2010 Water Delivered by the City of Livermore - Residential (MGD per year)	1,043.7	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
171	2010 Water Delivered by the City of Livermore - Commercial (MGD per year)	315.7	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
172	2010 Water Delivered by the City of Livermore - Industrial (MGD per year)	0.0	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
173	1992 California Standard for Residential Lavatory Faucets (gallons/minute)	2.5	1992 Energy Policy Act	
174	2010 California Standard for Residential Lavatory Faucets (gallons/minute)	2.2	CAPCOA 2010	
175	Mandatory CALGreen Standard for Residential Lavatory Faucets (gallons/minute)	1.65	CAPCOA 2010	
176	1992 California Standard for Commercial Lavatory Faucets (gallons/minute)	2.5	1992 Energy Policy Act	
177	2010 California Standard for Commercial Lavatory Faucets (gallons/minute)	0.5	CAPCOA 2010	
178	Mandatory California Standard Commercial Lavatory Faucet(gallons/minute)	0.4	CAPCOA 2010	
179	Voluntary California Standard Commercial Lavatory Faucet(gallons/minute)	0.35	CAPCOA 2010	
180	1992 California Standard for Residential Kitchen Faucets (gallons/minute)	2.5	1992 Energy Policy Act	
181	2010 California Standard for Residential Kitchen Faucets (gallons/minute)	2.2	CAPCOA 2010	
182	Mandatory CALGreen Standard for Residential Lavatory Faucets (gallons/minute)	1.8	CAPCOA 2010	
183	1992 California Standard for Commercial Kitchen Faucets (gallons/minute)	2.5	1992 Energy Policy Act	
184	2010 California Standard for Commercial Kitchen Faucets (gallons/minute)	2.2	CAPCOA 2010	

Table C-1. Master List of Quantification Assumptions			
Number	Parameter	Assumption	Source (if applicable)
185	Mandatory CALGreen Standard for Commercial Lavatory Faucets (gallons/minute)	1.8	CAPCOA 2010
186	Voluntary CALGreen Standard for Commercial Lavatory Faucets (gallons/minute)	1.6	CAPCOA 2010
187	Average Per Capita Kitchen Faucet Duration (minutes/day)	4	2010 Green Building Code
188	Average Per Capita Kitchen Faucet Use	1	2010 Green Building Code
189	Average Per Capita Lavatory Faucet Duration (minutes/day)	0.25	2010 Green Building Code
190	Average Per Capita Lavatory Faucet Use	3	2010 Green Building Code
191	Number of employees per faucet	40	2010 Green Building Code
192	Percent Hot Water Use for Faucets and Showers (%)	70%	ICELI 2010
193	Percent Hot Water Use for Dishwashers (%)	100%	Based on professional experience
194	Percent of Homes with Electric Water Heaters	11%	EIA 2005
195	Electricity Use to Heat Gallon of Hot Water (kWh)	0.19	ICLEI 2010
196	Natural Gas Use to Heat Gallon of Hot Water (therms)	0.0098	ICLEI 2010
197	1992 California Standard for Showerheads (gallons/minute)	2.5	1992 Energy Policy Act
198	2010 California Standard for Showerheads (gallons/minute)	2.5	CAPCOA 2010
199	Mandatory California Standard for Showerheads (gallons/minute)	2	CAPCOA 2010
200	Average Shower Time (min/day/person)	8	2010 Green Building Code
201	1992 California Standard for Residential Toilets (gallons/flush)	1.6	1992 Energy Policy Act
202	2010 California Standard for Residential Toilets (gallons/flush)	1.6	CAPCOA 2010
203	Mandatory CALGreen Standard for Residential Toilets (gallons/flush)	1.28	CAPCOA 2010
204	1992 California Standard for Commercial Toilets (gallons/flush)	1.6	1992 Energy Policy Act

Table C-1. Master List of Quantification Assumptions			
Number	Parameter	Assumption	Source (if applicable)
205	2010 Current California Standard Commercial Toilet (gallons/flush)	1.6	CAPCOA 2010
206	Mandatory 2010 CALGreen Commercial Toilet (gallons/flush)	1.28	CAPCOA 2010
207	Voluntary 2010 CALGreen Commercial Toilet (gallons/flush)	1.12	CAPCOA 2010
208	Flushes per commercial toilet per day (men)	1	2010 Green Building Code
209	Flushes per commercial toilet per day (women)	3	2010 Green Building Code
210	1992 GPF for baseline urinals	1.6	1992 Energy Policy Act
211	2010 GPF for baseline urinals	1	CAPCOA 2010
212	GPF for low-flow urinals (CALGreen Mandatory)	0.5	CAPCOA 2010
213	GPF for low-flow urinals (CALGreen Voluntary)	0.5	CAPCOA 2010
214	Flushes per commercial urinals per day (men)	2	2010 Green Building Code
215	Average Dishwasher Size in 1992 (Standard Dishwashers) (gallons/cycle / cubic foot)	15	ConSol 2010
216	2010 California Standard for Standard Dishwashers (gallons/cycle / cubic foot)	6.5	CAPCOA 2010
217	Voluntary CALGreen Standard for Standard Dishwashers (gallons/cycle / cubic foot)	5.8	CAPCOA 2010
218	ENERGY STAR Standard Dishwasher (gallons/ cycle / cubic foot)	5	CAPCOA 2010
219	ENERGY STAR Compact Dishwasher (gallons/ cycle / cubic foot)	3.5	CAPCOA 2010
220	2010 California Standard for Compact Dishwashers (gallons/cycle / cubic foot)	4.5	CAPCOA 2010
221	Voluntary CALGreen Standard for Compact Dishwashers (gallons/cycle / cubic foot)	3.5	CAPCOA 2010
222	Ratio of Compact to Standard Dishwashers (unit less)	50%	ICF International assumption
223	Average Dishwasher (runs per unit per week)	5	Dethman & Associates 1999
224	Average Dishwasher (runs per person per day)	0.1	Aquacraft, Inc 1999
225	Residential Graywater Use (showers, bathtubs, and washbasins) (gallons per day per residential occupant)	25	CAPCOA 2010

Table C-1. Master List of Quantification Assumptions				
Number	Parameter	Assumption	Source (if applicable)	
226	Laundry Machine Water Use (gallons per day per residential occupant)	15	CAPCOA 2010	
227	Average Lawn Size for Homes with Lawn (acres/home)	0.20	Chapman 2005	
228	Annual Gallons of Water Used per Acre (gallons/acre)	652,000	ICLEI 2010	
229	Percent residential water usage for landscaping	57%	ConSol 2010	
230	Percent commercial water usage for landscaping	35%	YUDELSON 2010	
231	Dishwashers per Multi Family Home	0.58	California Energy Commission 2010	
232	Dishwashers per Single Family Home	0.74	California Energy Commission 2010	
Detailed Of	ff-road Data			
233	Fuel Consumption for Heavy Duty Equipment for 1 Hour at Idle—High Idle (gallons)	1.2	Environmental Protection Agency 2009a	
234	Fuel Consumption for Heavy Duty Equipment for 1 Hour at Idle—Low Idle (gallons)	0.6	Environmental Protection Agency 2009a	
235	Emissions from One Hour of Operation for One Mid-Sized Tractor (kg CO ₂)	64.11	URBEMIS: modeled tractor for one hour	
236	Equipment Operating time (hours/day)	8	Based on professional experience	
237	Percent idling time for average CA heavy-heavy-duty diesel truck	29.40%	Environmental Protection Agency 2009a	
238	BAU heavy duty vehicle idling time (min)	5	Based on CARB regulation for heavy duty trucks	
Detailed W	lastewater Data			
239	Heating Value of Methane (BTU/cubic foot of CH4)	1,012	CAPCOA 2010	
240	Fraction of Methane in Biogas (%)	0.65	CAPCOA 2010	
241	Efficiency Factor (unitless)	0.85	CAPCOA 2010	
242	CH4 Unflare: Contribution from CH4 which is captured for flaring, but remains unconverted due to incomplete combustion (MT/cubic feet)	3.93E-06	CAPCOA 2010	
243	CO_2 Flare: Contribution from CO2 generated from the flaring of methane (MT/cubic feet)	5.44E-05	CAPCOA 2010	
244	Percent of 2005 Methane that was converted to electricity (%)	33%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	
245	Percent of 2020 Methane that will be converted to electricity (%)	90%	City of Livermore Candidate Measures for the Community Climate Action Plan - Data Needs Questionnaire	

Table C-1. Master List of Quantification Assumptions					
Number	Parameter	Assumption	Source (if applicable)		
246	Percent of 2005 Methane that was flared (%)	100%	ICF Assumption		
247	Percent of 2020 Methane that will flared (%)	100%	ICF Assumption		
248	2005 Wastewater Treated and Collected at the LWRP (AF)	7,953	City of Livermore Candidate Measures for the Community		
			Climate Action Plan - Data Needs Questionnaire		
249	2005 Wastewater Digester Gas (CF)	64,623,000	Stoops pers. comm.		
Detailed Waste Data					
250	2020 BAU Diversion Rate	63%	CalRecycle		
251	Landfilled Waste (2005 BAU) (tons)	133,578	ICF International 2010		
252	Landfilled Waste (2006 BAU) (tons)	134,887	ICF International 2010		
253	Landfilled Waste (2007 BAU) (tons)	136,209	ICF International 2010		
254	Landfilled Waste (2008 BAU) (tons)	137,544	ICF International 2010		
255	Landfilled Waste (2009 BAU) (tons)	138,892	ICF International 2010		
256	Landfilled Waste (2010 BAU) (tons)	140,253	ICF International 2010		
257	Landfilled Waste (2011 BAU) (tons)	141,627	ICF International 2010		
258	Landfilled Waste (2012 BAU) (tons)	143,015	ICF International 2010		
259	Landfilled Waste (2013 BAU) (tons)	144,417	ICF International 2010		
260	Landfilled Waste (2014 BAU) (tons)	145,832	ICF International 2010		
261	Landfilled Waste (2015 BAU) (tons)	147,261	ICF International 2010		
262	Landfilled Waste (2016 BAU) (tons)	148,704	ICF International 2010		
263	Landfilled Waste (2017 BAU) (tons)	150,162	ICF International 2010		
264	Landfilled Waste (2018 BAU) (tons)	151,633	ICF International 2010		
265	Landfilled Waste (2019 BAU) (tons)	153,119	ICF International 2010		
266	Landfilled Waste (2020 BAU) (tons)	154,620	ICF International 2010		
Detailed Urban Forestry Data					
267	First year tree planting will occur as a result of Land-Use-3	2013	ICF Assumption		
268	Number of tree planting years till 2020	7	ICF Assumption		
269	Annual energy savings per tree from reduced urban heat island effect (kWh)	7	ICLEI 2010		
270	CAPCOA annual sequestration rates (MT CO2e/year)				
271	Soft Maple	0.04330	CAPCOA 2010		

Table C-1. Master List of Quantification Assumptions					
Number	Parameter	Assumption	Source (if applicable)		
272	Hardwood Maple	0.05210	CAPCOA 2010		
273	Pine	0.03190	CAPCOA 2010		
274	Douglas Fir	0.04470	CAPCOA 2010		
Detailed Green Roof Data					
275	Average roof space to floor space per home (square feet)	2,386	U.S. Census n.d.		
276	Percent of roof space that can be covered by a green roof	25%	ICF Assumption		
277	Annual energy savings per square foot of rooftop garden (kWh/sq ft)	0.70	ICLEI 2010		
Addition Detailed Cost Data					
278	Discount rate	5%	Assumption		
279	PG&E average residential electricity rate (\$/kWh)	\$0.157	CEC 2012		
280	PG&E average residential natural gas rate (\$/therm)	\$1.188	CEC 2012		
281	PG&E average commercial electricity rate (\$/kWh)	\$0.168	CEC 2012 (assuming small/medium commercial customer)		
282	PG&E average commercial natural gas rate (\$/therm)	\$0.928	CEC 2012		
283	PG&E average street lighting rate (\$/kWh)	\$0.163	CEC 2012		
284	Price of diesel (\$/gal)	\$4.25	Assumption, based on recent range of diesel prices in Livermore		

State-1: Title 24 Standards for Non-Residential and Residential Buildings

Measure Description

Requires that building shells and building components be designed to conserve energy and water.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Title 24 update for 2014 is 25% better than 2008 standards for single-family residential, 14% better than 2008 standards for multi-family residential and 30% better than 2008 standards for non-residential buildings
- Stringency of the residential Title 24 standards will be increased by 17% in 2017 2020.
- Stringency of the nonresidential Title 24 standards will be increased by 7% in 2017 2014 and 2020.

Analysis Details

GHG Analysis

Energy efficiency upgrades as a result of the Title 24 standards will reduce electricity and natural gas consumption, thereby resulting in GHG emissions savings.

Baseline Emissions

Baseline emissions were not utilized in the analysis of this measure.

Emissions Reductions

The 2014 single-family residential Title 24 Standard will be increased by 25% and the multi-family residential standard will be increased by 14% relative to the 2008 standard. The 2014 nonresidential standard will be increased by 30% during this same timeframe. Between 2014 and 2020, both standards will be updated twice (2017 and 2020). Assuming a 17% and 7% tri-annual increase in the stringency of the residential and non-residential Title 24 standards, respectively, 2020 residential energy use would be reduced to 54.0% of the 2008 baseline code.⁴ Non-residential energy use would likewise be reduced to 60.5% of the 2005 baseline code. However, because the Title 24 code is revised on a tri-annual basis, only a fraction of total energy use is subject to each code revision. To avoid-double counting, estimated energy reductions were multiplied by the annual fraction of electricity subject to each code revision. The average reduction in residential energy use in 2020 as a result of the Title 24 Standards was therefore estimated to be 18.0%, and the average non-residential reductions were estimated to be 19.5%.

Energy reductions achieved by Title 24 were calculated by multiplying 18.0% and 19.5% by the City's 2020 BAU electricity and natural gas consumption for residential and non-residential development, respectively. GHG emissions reductions were quantified by multiplying the total energy reductions by the appropriate utility emission factors.⁵

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of the Title 24 standards.

Reduced Energy Use: Energy retrofits and standards would improve the efficiency of residential and non-residential buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity would be lowered.

⁴ Assumes 100% in 2005 and a 17% reduction every three years beginning in 2008.

⁵ Utility emission factors account for decreased carbon intensities as a result of the State's RPS.

Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity) and local air pollution (from reduced burning of natural gas).

Resource Conservation: Increased building efficiency would reduce water consumption, which would help conserve freshwater.



Increased Property Values: Energy-efficient bulidings have higher properity values and resale prices than less efficient buildings.

Public Health Improvements: Reduced regional and local air pollution would contribute to overall improvements in public health. A well-built, energy-efficient structure is also more durable and directly reduces certain health aliments. For example, properly sealed ducts help prevent mold and dust mites that can cause asthma.



Increased Quality of Life: The reduction of health aliments (see above) contributes to increased quality of life. Additionally, energy-efficient structures improve general comfort by equalizing room temperatures and reducing indoor humidity.

State-2: Senate Bills 1078/107/X 1-2 (Renewable Portfolio Standard)

Measure Description

Obligates investor-owned utilities (IOUs), energy service providers (ESPs), and Community Choice Aggregations (CCAs) to procure 20% of retail sales from eligible renewable sources by 2013, 25% by 2016. EO S-14-08 also sets forth a longer range target of procuring 33% of retail sales by 2020.

Assumptions

See Table C-1.

Analysis Details

GHG Analysis

Implementation of the Renewable Portfolio Standard (RPS) will increase the proportion of renewable energy within PG&E's energy supply mix. Renewable resources, such as wind and solar power, produce the same amount of energy as coal and other traditional sources, but do not emit any GHGs. By generating a greater amount of energy through renewable resources, electricity provided to the City by PG&E will be cleaner and less GHG intensive.

Baseline Emissions

The City of Livermore's existing GHG Inventory (Appendix B) and scaling by ICF International estimates that community-wide building energy consumption in 2020 would generate approximately 269,682 MT CO_2e .

Emissions Reductions

Achievement of the RPS will reduce the carbon intensity of PG&E's 2020 CO₂ emission factor from 493 pounds per MWh to 375 pounds per MWh (City of Livermore 2005a; California Energy Commission 2007). Similar reductions will be achieved by the statewide CH_4 and N_2O emission factors (Table C-1). GHG emissions that would be generated by community-wide electricity consumption in 2020 will therefore be lower as a result of the RPS-adjusted emission factors.

GHG emissions generated from electricity consumption were calculating assuming implementation of the RPS by multiplying 2020 community-wide electricity consumption by the RPS-adjusted emissions factors. The difference in emissions between the 2020 BAU and 2020 RPS scenarios represents the emissions reductions achieved by this measure.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The RPS provides California with a flexible, market-based strategy to increase renewable energy generation and distribution. As discussed above, renewable energy provides the same amount of power as tradition sources (e.g., coal), but does not emit any GHGs or other criteria pollutants. Renewable energy therefore represents a clean source of power for the State and the City of Livermore. The following benefits are expected from implementation of the RPS (IEA 2007; U.S. EPA 2009b).



Reduced Air Pollution: PG&E generates power through a combination of sources, but the majority of electricity is provided by fossil fuels (e.g., coal, natural gas). The extraction and processing of fossil fuels generates localized pollutants emissions at the place of mining and at the source of power generation. These pollutants may be dispersed into the atmosphere, where they can be transported over long distances and result in regional air pollution. Reducing the amount of fossil fuels processed at power stations through increased generation of renewable energy would contribute to cumulative reductions in criteria pollutants throughout the State.

Waste Reduction: The generation of electricity from fossil fuels (e.g., coal, natural gas) generates a substantial amount of waste including, but not limited to: fly ash, bottom ash, flue gas, and sludge. These products can have detrimental effects on the environment if absorbed into groundwater, soil, and/or biota. The extraction and mining of fossil fuels also generates waste. Increasing renewable energy production would reduce waste created by fossil fuel supplied power.



Energy Diversity and Security: Fuels that are traded in the open market are subject to energy supply constrains and interruptions from political unrest, conflict, and trade embargoes. Centralized power structures (e.g., stations, substations, refineries, ports) may also be targets of energy terrorism. Providing a diversified and domestic energy supply reduces foreign fuel dependency.

Reduced Price Volatility: Energy supply constraints and the uneven global distribution of fossil fuels increase the instability of the energy market. As the demand for global fossil fuels rises, energy prices would likely be subject to fluctuations and frequent price spikes. Renewables would contribute to the diversification of the energy supply mix, thereby buffering local economies from the volatile global energy market.

Economic Development: Development of renewable energy infrastructure (e.g., solar farms, wind turbines) would create new jobs, taxes, and revenue for local and regional economies.

Public Health Improvements: Reduced regional air pollution and waste generation would contribute to overall improvements in public health.

State-3: AB 1109 (Huffman) Lighting Efficiency and Toxics Reduction Act

Measure Description

Structured to reduce statewide electricity consumption in the following ways: 1) At least 50% reduction from 2007 levels for indoor residential lighting, and 2) At least 25% reduction from 2007 levels for indoor commercial and outdoor lighting, by 2018.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered..

- Approximately 5.20% of electricity is used for commercial outdoor lighting (CEC 2006).
- Approximately 28.90% of electricity is used for commercial indoor lighting (CEC 2006).
- Approximately 20.00% of electricity is used for residential indoor lighting (CEC 2006; NEED 2011).

Analysis Details

GHG Analysis

Lighting requires the production of electricity to power the lights, which represents an indirect source of GHG emissions. Different light fixtures have different efficacies; in other words, certain bulbs can utilize less energy to obtain the same output. Replacing less efficient bulbs with energy-efficient ones therefore reduces energy consumption, and thus GHG emissions.

Baseline Emissions

Electricity usage from outdoor lighting in commercial developments within the City was estimated by multiplying the total anticipated energy use in 2020 under BAU conditions by 5.2% (CEC 2006). Electricity usage from indoor lighting in residential and commercial developments within the City was estimated by multiplying the total anticipated energy use in 2020 under BAU conditions by 20.00% and 28.90%, respectively (CEC 2006; NEED 2011).

Emissions Reductions

AB 1109 will reduce indoor residential lighting by at least 50%. Energy reductions within the residential sector were calculated by multiplying the baseline indoor energy consumption for residential lighting by 0.50. AB1109 will reduce both outdoor and indoor commercial lighting by at least 25%. Energy reductions within the commercial sector were calculated by multiplying the baseline energy consumption for commercial lighting by 0.25. GHG emissions reductions were then quantified by multiplying the total energy reductions by the appropriate utility emission factors.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of AB1109.



Reduced Energy Use: Energy-efficient lighting (e.g., compact fluorescent lamps [CFL]) consumes, on average, 75% less electricity than incandescent bulbs.

Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity).



Increased Property Values: Energy-efficient bulidings have higher properity values and resale prices than less efficient buildings.

Increased Quality of Life: CFLs have a much longer lifetime than incandescent bulbs, resulting in reduced bulb turn-over and the need to purchase new fixtures.

State-4: AB 1470 Solar Water Heating and Efficiency

Measure Description

Creates a \$25 million per year, 10-year incentive program to encourage the installation of solar water heating systems that offset natural gas use in homes and businesses throughout the state.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Solar water heaters reduce natural gas use by 130 therms (CARB 2008).
- An average of 0.013 water heaters per home will be replaced as a result of AB 1470 (CARB 2008; California Department of Finance 2000).

Analysis Details

GHG Analysis

California relies heavily on natural gas for water heating. Rooftop solar water heating technologies are designed to reduce fuel consumption, and thus GHG emissions. It is estimated that by creating a mainstream market, California can save more than 1 billion therms of natural gas per year—24% of the state's residential natural gas usage. (Huffman et. al. 2007)

Baseline Emissions

Baseline emissions were not utilized in the analysis of this measure.

Emissions Reductions

CARB estimates that implementation of AB 1470 would result in the installation of 200,000 solar water heaters by 2020. Assuming that an average of 0.013 heaters per home would be replaced as a result of AB 1470, and that Livermore would have 34,742 single- and multifamily homes in 2020 (Rademaker pers. comm.), a total of 434 water heaters would be replaced with solar systems. Each solar water heater will reduce natural gas use by 130 therms (CARB 2008). Natural gas reductions were therefore calculated by multiplying 130 therms by 434. GHG emissions reductions were then quantified by multiplying the total energy reductions by the appropriate utility emission factors.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of AB 1470.

Reduced Energy Use: Solar water heaters consume, on average, 130 therms less natural gas than non-solar units.



Reduced Air Pollution: Reduced energy use would contribute to corresponding reductions in local air pollution (from reduced burning of natural gas).

Increased Property Values: Energy-efficient buildings have higher properity values and resale prices than less efficient buildings.

State-5: AB 1493 (Pavley I)

Measure Description

Pavley I will reduce GHG emissions from automobiles and light duty trucks by 30% from 2002 levels by the year 2016. The regulations affect 2009 models and newer.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

• Pavley I will reduce statewide emissions from passenger vehicles by 27.7 million MT CO₂e (California Air Resources Board 2011).

Analysis Details

GHG Analysis

Engine efficiency improvements will reduce fuel consumption, thereby reducing GHG emissions from fossil fuel combustion.

Baseline Emissions

The City of Livermore's GHG Inventory Update quantified emissions associated with on-road transportation in 2020 under BAU conditions (Appendix B). Pavley I applies to light-duty vehicles, medium duty vehicles, and motorcycles. Accordingly, baseline emissions from these sources were quantified by multiplying BAU emissions from the transportation sector by 0.84.⁶

Emissions Reductions

CARB estimates that implementation of Pavley I will reduce statewide emissions from passenger vehicles by 27.7 million MT CO₂e, or by approximately 17% (California Air Resources Board 2011). GHG reductions achieved by Pavley I within Livermore were therefore quantified by multiplying baseline emissions calculated above s by 0.17.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of Pavley I.

Reduced Energy Use: Pavley I would increase the fuel efficiency of passenger vehicles, which would reduce the amount of fossil fuels consumed per mile travelled.



Reduced Air Pollution: Efficient vehicles burn less fuel per mile travelled then less efficient vehicles. Air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide⁷, and ozone precursors⁸, would therefore be reduced.

Public Health Improvements: Fossil fuel combustion releases several toxic air containments known to cause adverse human health effects. Improvements in vehicle efficiency would reduce the amount of fuel combusted, resulting in corresponding reductions in toxic air containments.

⁶ Value based on an EMFAC2007 model run for Alameda County in 2020. Light-duty auto assumed to represent "light-duty auto (LDA)", "light-duty trucks (LDT1)" and "light-duty trucks (LDT2)"; medium duty assumed to represent "medium-duty trucks" (MDV); motorcycles assumed to represent "motorcycles" (MC).

⁷ Sulfur dioxide contributes to acid rain.

⁸ Ozone precursors (reactive organic compounds and nitrogen oxides) contribute to smog formation.

Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing fuel consumption by passenger vehicles would lessen the demand for petroleum and ultimately the demand for imported oil.

State-6: Advanced Clean Cars

Measure Description

Introduces new standards for model years 2017–2025, and will increase fuel economy up to 62 miles per gallon by 2025.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

• Advanced Clean Cars will reduce statewide emissions from passenger vehicles by 3.8 million MT CO₂e (California Air Resources Board 2011).

Analysis Details

GHG Analysis

Engine efficiency improvements will reduce fuel consumption, thereby reducing GHG emissions from fossil fuel combustion.

Baseline Emissions

The City of Livermore's GHG Inventory Updated quantified emissions associated with on-road transportation in 2020 under BAU conditions (Appendix A). The Advanced Clean Cars initiative applies to light-duty vehicles, medium duty vehicles, and motorcycles. Accordingly, baseline emissions from these sources were quantified by multiplying BAU emissions from the transportation sector by 0.84.⁹

Emissions Reductions

CARB estimates that implementation of the Advanced Clean Cars initiative will reduce statewide emissions from passenger vehicles by 3.8 million MT CO_2e^{10} , or by approximately 2.5% (California Air Resources Board 2011). GHG reductions achieved by the Advanced Clean Cars initiative within Livermore were therefore quantified by multiplying baseline emissions by 0.025.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of the Clean Cars Initiative.

Reduced Energy Use: The Clean Cars Initiative would increase the fuel efficiency of passenger vehicles, which would reduce the amount of fossil fuels consumed per mile travelled.

Reduced Air Pollution: Efficient vehicles burn less fuel per mile travelled then less efficient vehicles. Air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide¹⁵, and ozone precursors¹⁶, would therefore be reduced.

Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Improvements in vehicle efficiency would reduce the amount of fuel

⁹ Value based on an EMFAC2007 model run for Alameda County in 2020. Light-duty auto assumed to represent "light-duty auto (LDA)", "light-duty trucks (LDT1)" and "light-duty trucks (LDT2)"; medium duty assumed to represent "medium-duty trucks" (MDV); motorcycles assumed to represent "motorcycles" (MC).

¹⁰ Reductions calculated based on the existing Pavley II standard, which applies to model years 2017 to 2020 and will improve fuel economy to 43 miles per gallon. New standards for model years 2017 to 2025 have neither been officially proposed nor quantified. Actual reductions achieved by State-6 will therefore likely be higher than those quantified.

combusted, resulting in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.

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Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing fuel consumption by passenger vehicles would lessen the demand for petroleum and ultimately the demand for imported oil.

State-7: Low Carbon Fuel Standard

Measure Description

Requires a 10% reduction in the carbon intensity of California's transportation fuels by 2020.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

• Low Carbon Fuel Standard (LCFS) will reduce statewide emissions from transportation-based fuels¹¹ by 15 million MT CO₂e (California Air Resources Board 2011).

Analysis Details

GHG Analysis

The LCFS is a policy-based strategy that targets carbon emissions generated through the lifecycle of transportation fuels (i.e., from extraction to production to consumption). The standard assigns a maximum level of GHG emissions per unit of fuel produced for several refiners and importers. Companies that exceed the LCFS through development of biofuels and other clean technologies are able to sell their excess credits, creating a flexible and dynamic market for low-carbon transportation fuels. (Sperling and Yeh 2009)

The U.S. Fresno Federal District court ruled in December 2011 that the LCFS violates the Commerce Clause of the U.S. Constitution and issues an injunction preventing California from implementing the LCFS. CARB appealed this ruling in early January, 2012. While the legal issues are being resolved, given the pending appeal by CARB, it is assumed for the time being that the LCFS will be ultimately implemented by 2020 as proposed. If the LCFS were ultimately to be blocked from implementation due to federal legal constraints, then the goal for reduction for the CAP would be adjusted downward accordingly.

Baseline Emissions

The City of Livermore's GHG Inventory Update quantified emissions associated with on-road and off-road transportation in 2020 under BAU conditions (Appendix A). Reductions achieved by overlapping state and local measures (e.g., Pavley I, Trans-1) were subtracted to obtain baseline emissions for the transportation and off-road sectors.

Emissions Reductions

CARB estimates that implementation of the LCFS will reduce statewide emissions from transportationbased fuels¹⁷ by 15 million MT CO₂e, or by approximately 8.9% (California Air Resources Board 2011). GHG reductions achieved by the LCFS within Livermore were therefore quantified by multiplying baseline transportation and off-road emissions by 0.089.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of LCFS.



Reduced Air Pollution: The LCFS would reduce the carbon content of transportation fuels by 10%. The combustion of hydrocarbons generates numbers air pollutants, including particulate matter, carbon monoxide, sulfur dioxide¹⁵, and ozone precursors¹⁶. Reducing the carbon content of transportation fuels would therefore reduce local and regional air pollution.



Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Improvements in vehicle efficiency would reduce the amount of fuel combusted, resulting in corresponding reductions in toxic air containments. Additionally, reductions in

¹¹ Excludes aviation fuel, residual fuel oil, and lubricants.

ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.

Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing the carbon-content of transportation fuels would reduce the consumption and demand for imported petroleum.

Reduced Price Volatility: Energy supply constraints and the uneven global distribution of fossil fuels increase the instability of the energy market. As the demand for global fossil fuels rises, fuel prices would likely be subject to fluctuations and frequent price spikes. Biofuels and other renewable technologies would contribute to the diversification of the energy supply mix, thereby buffering local economies from the volatile global energy market.



Economic Development: The development of biofuels and other clean technologies would create new jobs, taxes, and revenue for local and regional economies.

State-8: Vehicle Efficiency Strategies

Measure Description

The AB 32 Scoping Plan includes vehicle efficiency measures (in addition to Pavley and LCFS) that focus on maintenance practices. The Tire Pressure Program will increase vehicle efficiency by assuring properly inflated automobile tires to reduce rolling resistance. The Low Friction Oils Program will increase vehicle efficiency by mandating the use of engine oils that meet certain low friction specifications. The Heavy-Duty Vehicle GHG Emission Reduction Program will increase heavy-duty vehicle (long-haul trucks) efficiency by requiring installation of best available technology and/or CARB approved technology to reduce aerodynamic drag and rolling resistance.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Tire Pressure Program will reduce statewide emissions from passenger vehicles by 0.6 million MT CO₂e (California Air Resources Board 2011).
- Low Friction Oils Program will reduce statewide emissions from passenger vehicles by 2.8 million MT CO₂e (California Air Resources Board 2011).
- Heavy-Duty Vehicle GHG Emission Reduction Program will reduce statewide emissions from heavy-duty vehicles by 0.9 million MT CO₂e (California Air Resources Board 2011).

Analysis Details

GHG Analysis

Improvements in engine efficiency and vehicle technology will reduce fuel consumption, thereby reducing GHG emissions from fossil fuel combustion.

Baseline Emissions

The City of Livermore's GHG Inventory Update quantified emissions associated with on-road transportation in 2020 under BAU conditions (Appendix B). The Tire Pressure and Low Friction Oils programs primarily affect light-duty vehicles, whereas the Heavy-Duty GHG Emissions Reduction Program affects heavy-duty vehicles. Baseline emissions from light-duty autos and heavy-duty vehicles were quantified by multiplying BAU emissions from the transportation sector by 0.75 and 0.13, respectively.¹²

Emissions Reductions

Tire Pressure

CARB estimates that implementation of the Tire Pressure Program will reduce statewide emissions from passenger vehicles by 0.6 million MT CO₂e, or by approximately 0.39% (California Air Resources Board 2011). GHG reductions achieved by the Tire Pressure Program within Livermore were therefore quantified by multiplying baseline emissions from passenger vehicles by 0.0039.

Low Friction Oils

CARB estimates that implementation of the Low Friction Oils Program will reduce statewide emissions from passenger vehicles by 2.8 million MT CO₂e, or by approximately 1.8% (California Air Resources Board 2011). GHG reductions achieved by the Low Friction Oils Program within Livermore were therefore quantified by multiplying baseline emissions from passenger vehicles by 0.018.

Heavy-Duty Vehicle GHG Emissions Reductions

CARB estimates that implementation of the Heavy-Duty Vehicle GHG Emission Reduction Program will reduce statewide emissions from heavy-duty vehicles by 0.9 million MT CO₂e, or by approximately 2.2% (California Air Resources Board 2011). GHG reductions achieved by the Heavy-Duty Vehicle GHG Emission Reduction Program within Livermore were therefore quantified by multiplying baseline emissions from

¹² Value based on an EMFAC2007 model run for Alameda County in 2020. Light-duty auto assumed to represent "light-duty auto (LDA)", "light-duty trucks (LDT1)" and "light-duty trucks (LDT2)".

heavy-duty vehicles by 0.022.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of AB 32 Transportation Reduction Strategies.



Reduced Energy Use: The AB32 Transportation Reduction Strategies would increase the efficiency of passenger vehicles and heavy-duty trucks, which would reduce the amount of fossil fuels consumed per mile travelled.

Reduced Air Pollution: Efficient vehicles burn less fuel per mile travelled then less efficient vehicles. Air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide¹⁵, and ozone precursors¹⁶, would therefore be reduced.



Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Improvements in vehicle efficiency would reduce the amount of fuel combusted, resulting in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.



Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing fuel consumption by passenger vehicles would lessen the demand for petroleum and ultimately the demand for imported oil.

State-9: AB 32 Landfill Methane Program

Measure Description

CARB's Landfill Methane Rule requires gas collection and control systems on landfills with greater than 450,000 tons of waste-in-place. The measure also establishes statewide capture performance standards.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

• Two landfills (see below) would install a methane system with a capture efficiency of 75%.

Analysis Details

GHG Analysis

Methane capture systems can reduce the amount of methane released from the decomposition of waste. CARB estimates that approximately 53 landfills will be affected by the Landfill Methane Rule, resulting in a statewide reduction of 0.8 million MT CO₂e in 2020 (California Air Resources Board 2008).

Baseline Emissions

Baseline emissions were not utilized in the analysis of this measure.

Emissions Reductions

According to CalRecycle, in 2005 the City disposed of waste that was directed to over 15 landfills. The City does not have jurisdiction over which landfills are used for its waste disposal. A review of the waste-in-place at these landfills indicates that the following two landfills would be subject to CARB's Landfill Methane Rule:

- Foothill Sanitary Landfill.
- North County Landfill.

Neither of these landfills currently has methane capture systems. Pursuant to the Landfill Methane Rule, it was assumed that by 2020, both landfills would install a methane system with a capture efficiency of 75%.¹³ GHG emissions generated by City waste in 2020 were re-calculated by multiplying the percentage of the City's waste sent to the two landfills listed above and the City's 2020 BAU waste emissions from the City's GHG Inventory Update.

Cost Analysis

Costs not estimated.

Co-Benefit Analysis

The following benefits are expected from implementation of the Landfill Methane Rule.



Reduced Air Pollution: Capture systems prevent methane from migrating into the atmosphere and contributing to local smog.





Increased Quality of Life: Methane capture helps reduce odors and other hazards associated with landfill gas emissions.

¹³ Based on the Clean Air and Climate Protection protocol for default methane capture efficiency assumptions.
Energy-1: Energy Efficiency Voluntary Programs to Promote Retrofits for Existing Residential Buildings

Measure Description

Incentivize, or otherwise support voluntary energy efficiency retrofits of existing residential buildings to achieve reductions in natural gas and electricity usage. Adopt standards and/or promote voluntary programs that retrofit indoor lights, electric clothes dryers, energy-star thermostats, window seals, duct sealing, air sealing, and attic insulation.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Market penetration of 20% for energy audits.
- 50% of homes that conducts audits will perform retrofits.
- Homes will perform the following retrofits
 - Replace high use incandescent lamps with compact fluorescent lamps.
 - Replace electric clothes dryers with natural gas dryers.
 - Install of a programmable thermostat.
 - o Replace windows with double-pane solar-control low-E argon gas wood frame windows.
 - Seal ducts and air leaks.
 - Replace natural gas furnaces with an ENERGY STAR-labeled model.
 - Insulate the attic.
- Anticipated energy reductions associated with the above retrofits are 1,687 kWh and 195 therms per single family home (US DOE 2011).

Analysis Details

GHG Analysis

Residential electricity and natural gas consumption are indirect sources of GHG emissions. Power plants emit GHGs in the production and delivery of energy to residences. Retrofitting existing residences would increase home energy efficiency, which would decrease energy consumption and GHG emissions.

Baseline Emissions

Baseline emissions are the emissions associated with residential electricity and natural gas consumption in 2011.

Emissions Reductions

Energy savings associated with retrofitting were estimated using the Home Energy SaverTM (HES), which is based on models and data developed at DOE's Lawrence Berkley National Laboratory (U.S. DOE 2011). HES estimates energy savings, emission reductions, and costs associated with various energy-efficient measures. For this analysis, energy-efficient upgrades were assumed to be conducted on an average single family home in the City of Livermore, built in 1979.¹⁴ Upgrades assumed to be performed included upgrading to CFLs in all high-use indoor lights; switching to a gas clothes dryer; installing an ENERGY STAR-labeled programmable thermostat; installing energy-efficient windows, duct and air sealing; switching to an ENERGY STAR gas furnace; and installing attic insulation.

The HES calculated the annual electricity and natural gas savings. To determine the total energy reduction from this measure, the energy savings per home were multiplied by the number of homes in the City, and the penetration rate chosen by the City (20% of homes conduct an energy audit, approximately 50% of those homes retrofit). The total energy reductions were multiplied by utility emission factors to determine the total GHG emissions reductions.

¹⁴ For other assumptions, the model defaults were employed.

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Cost Analysis

Total initial costs to homeowners are estimated to range from \$12.4 to \$21.9 million. These retrofits are expected to result in energy cost savings of about \$1.1 million per year, delivering a payback period of 6 to 15 years. Cost-per-ton is estimated to range from $-$17/MTCO_2e$ (net savings) to $$253/MTCO_2e$ (net costs). Total costs are estimated to range from - \$0.6 million (net savings) to \$8.9 million (net costs).

Initial costs associated with conducting home energy audits were estimated based on the total number of participating homes (as calculated by the GHG Analysis), the cost per square foot for home audits, and the average single family home size (U.S. Census 2011c). The cost per square foot for home energy audits depends on building size and the complexity of home energy systems, and can range from \$0.03 for a light and heating, venting, and air conditioning (HVAC) audit to \$0.50 for a comprehensive audit (AECOM 2010).

Initial capital costs associated with energy-efficient retrofitting were estimated for the advanced upgrade options described above. The retrofit cost per home was estimated to range from about \$3,047 to \$6,833 for advanced retrofits (U.S. DOE 2011a).

Annual energy cost savings were calculated by multiplying the mitigated electricity and natural gas usage for each retrofit level—as calculated by HES—by the average residential PG&E utility rates. A lifetime of 18 years was assumed for this measure, based on the lifetimes of individual energy-efficient upgrades reported in CPUC (2009).

Co-Benefit Analysis

The following benefits are expected from implementation of Energy-1.



Reduced Energy Use: Energy retrofits would improve the efficiency of residential buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity would be lowered.



Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity) and local air pollution (from reduced burning of natural gas).



Increased Property Values: Energy-efficient homes have higher properity values and resale prices than less efficient homes.



Public Health Improvements: Reduced regional and local air pollution would contribute to overall improvements in public health. A well-built, energy-efficient structure is also more durable and directly reduces certain health aliments. For example, properly sealed ducts and air leaks helps prevent mold and dust mites that can cause asthma.



Increased Quality of Life: The reduction of health aliments (see above) contributes to increased quality of life. Additionally, energy-efficient homes improve general comfort by equalizing room temperatures and reducing indoor humidity.

Energy-2: Energy Efficiency Voluntary Programs for Existing Commercial Development

Measure Description

Under this measure, the City would promote voluntary programs for existing commercial facilities to improve building-wide energy efficiency. In addition, the City would adopt a program that encourages existing commercial facilities improve building-wide energy efficiency by 20% by 2020 (compared to 2005). Increased energy efficiency in commercial facilities would result in decreased energy consumption.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Market penetration of 20% for energy audits and retrofits.
- Electricity and natural gas usage by existing commercial development remains constant between 2005 and 2020

Analysis Details

GHG Analysis

Existing buildings generate a considerable amount of GHG emissions. Older developments are typically less energy-efficient and therefore consume greater amounts of electricity and natural gas, relative to newly constructed facilities.

Baseline Emissions

Electricity and natural gas consumption associated with existing commercial development in 2005 were quantified in the GHG Inventory. Energy consumption from overlapping measures was subtracted from the existing year consumption. The 2005 consumption was assumed to remain constant in 2020 and represent 2020 baseline emissions.

Emissions Reductions

The magnitude of GHG emissions achieved by this measure is dependent on the degree of implementation. It was assumed that 20% of existing commercial facilities would perform an energy audit, and of those, 100% would actual perform the energy retrofits. Energy reductions from overlapping measures were subtracted from the baseline electricity and natural gas usage to avoid double counting. Energy reductions from a 20% reduction in building energy consumption were quantified by multiplying baseline electricity and natural gas usage by the percentage of participating commercial facilities (20%) and then by the goal reduction in energy consumption (20%). GHG savings were then quantified by multiplying the energy reductions by the appropriate utility emission factors.

Cost Analysis

Total initial costs to retrofit existing non-residential buildings are estimated at \$4.1 million to \$6.6 million, including the cost of energy audits. These retrofits are expected to result in significant energy cost savings for non-residential buildings of \$2.4 million per year, with a payback period of 2 to 3 years. Costs-per-ton is estimated to range from - $$569/MTCO_2e$ (net savings) to - $$510/MTCO_2e$ (net savings). Total costs are estimated to range from -\$23.7 million (net savings) to -\$21.2 million (net savings).

Initial costs of conducting building energy audits were estimated based on the total square footage of participating commercial buildings (as calculated by the GHG Analysis, based on existing commercial development in 2005 and the penetration rate), and the cost per square foot for energy audits. The cost per square foot for building energy audits depends on building size and the complexity of energy systems, and can range from \$0.03 for a light and HVAC audit to \$0.50 for a comprehensive audit (AECOM 2010).

Initial capital costs associated with energy-efficient retrofits or retrocommissioning are estimated to range from \$0.81 to \$1.01 per square foot for a 5–20% energy efficiency improvement (AECOM 2010; Gregerson 1997).¹⁵

Annual energy cost savings were calculated by multiplying the mitigated electricity and natural gas usage—as calculated by the GHG Analysis—by the average commercial PG&E utility rates. A lifetime of 18 years was assumed for this measure, based on the lifetimes of individual energy-efficient upgrades reported in CPUC (2009).

Co-Benefit Analysis

The following benefits are expected from implementation of Energy-2.

Reduced Energy Use: Energy retrofits and standards would improve the efficiency of commercial buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity would be lowered.



Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity) and local air pollution (from reduced burning of natural gas).



Increased Property Values: Energy-efficient bulidings have higher properity values and resale prices than less efficient buildings.



Public Health Improvements: Reduced regional and local air pollution would contribute to overall improvements in public health. A well-built, energy-efficient structure is also more durable and directly reduces certain health aliments. For example, properly sealed ducts and air leaks helps prevent mold and dust mites that can cause asthma.



Increased Quality of Life: The reduction of health aliments (see above) contributes to increased quality of life. Additionally, energy efficient structures improve general comfort by equalizing room temperatures and reducing indoor humidity. Employee satisfaction and out may therefore be increased.

¹⁵ The lower bound cost is based on estimated costs of retrocommissioning, as reported by Gregerson (1997), and adjusted to 2011 dollars using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator.

Energy-3: Exceed Title 24 Requirements for New Buildings

Measure Description

Under this measure, the City would periodically update and strengthen its Green Building Ordinance to reduce energy consumption. Existing Livermore Green Building Ordinance includes the Voluntary Tier 1 standard in Title 24. This measure would require the City to "stay ahead" of Title 24 future requirements by periodically updating the Green Building Ordinance to exceed Title 24 Standards (or any subsequent standards that replace the current Title 24 Standards) by 15% through 2020.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered:

- Single-family homes that exceed the Title 24 standards between 2008 and 2020 by 15% will achieve a 1.35% reduction in electricity use and a 13.65% reduction in natural gas use in 2020 (CAPCOA 2010:Table BE-1.2).
- Multifamily homes that exceed the Title 24 standard s between 2008 and 2020 by 15% will achieve a 1.80% reduction in electricity use and a 13.20% reduction in natural gas use in 2020 (CAPCOA 2010:Table BE-1.2).
- Commercial facilities that exceed the Title 24 standards between 2008 and 2020 by 15% will achieve a 4.05% reduction in electricity use and a 10.65% reduction in natural gas use in 2020 (CAPCOA 2010:Table BE-1.1).

Analysis Details

GHG Analysis

Energy consumption is not only dependent on the type and size of building, but also the climate zone in which the building is located. According to CAPCOA, Livermore is located within the CEC Forecast Climate Zone 4 (CAPCOA 2010). For single-family homes, multifamily homes, and commercial establishments, the CEC has published anticipated percent deductions in energy use resulting from a 1% exceedence of the 2008 Title 24 energy efficiency standards. Values for Climate Zone 4 were utilized for this analysis and obtained from Tables BE-1.1 and BE-1.2 in CAPCOA (2010).

Baseline Emissions

Electricity and natural gas consumption associated with new residential and commercial development in 2020 was quantified by scaling 2005 energy consumption data to 2011 and 2020, and subtracting the 2011 values from the 2020 values. The resulting emissions can be found by multiplying the consumption values by the appropriate utility emission factor. Individual values for single-family and multifamily homes were not available. Consequently, rates were calculated by scaling total residential electricity and natural gas use by 1.39 and 1.23, respectively (EIA 2009). Reductions achieved by overlapping State (e.g., Title 24) measures were subtracted from the final usage values to obtain baseline energy consumption.

Emissions Reductions

Energy deductions for exceeding the 2008 Title 24 standards by 1% were obtained from CAPCOA (2010). Separate values were provided for single-family homes, multifamily homes, and commercial developments. Because Energy-1 assumes the standard will be exceeded by 15%, the reductions for a 1% improvement over the 2008 Title 24 standard were multiplied by 15. These values were then multiplied by baseline energy consumption for each building type to obtain total energy reductions associated with the measure. For example, baseline electricity usage by new single-family homes is estimated to be 6,083 MWh. The anticipated energy reduction for exceeding the 2008 Title 24 standard by 15% is 1.35%. Mitigated electricity usage for new single-family homes was therefore determined by multiplying 6,083 MWh by 1.35%. GHG emissions reductions achieved by this measure were quantified by multiplying the energy reductions for each building type by the appropriate utility emission factors.

Cost Analysis

Initial costs to building owners include costs associated with energy-efficient upgrades, as well as the cost

of initial energy audits. Total initial capital costs to building owners are estimated to range from about \$6.5 to \$10.8 million (including the cost of an energy audit). The simple payback period of this measure overall is estimated as 13 to >20 years. This measure is estimated to result in total costs of \$0.3 million (net costs) to \$4.5 million (net costs). Costs per ton are estimated to range from \$16/MTCO₂e (net costs) to \$254/MTCO₂e (net costs).

Initial costs associated with conducting home energy audits were estimated based on the total number of participating homes (as calculated by the GHG Analysis), the cost per square foot for home audits, and the average single family home size (U.S. Census 2011c). The cost per square foot for home energy audits depends on building size and the complexity of home energy systems, and can range from \$0.03 for a light and heating, venting, and air conditioning (HVAC) audit to \$0.50 for a comprehensive audit (AECOM 2010). Initial capital costs associated with energy-efficient upgrades for residential buildings were estimated to range from about \$1,634 to \$2,267 for single-family homes and from \$902 to \$1,882 for multi-family homes (U.S. DOE 2011a). Initial capital costs for commercial building retrofits are estimated to range from \$0.59 to \$3.13 per square foot for a 5 to 20% energy efficiency improvement (AECOM 2010; Gregerson 1997).¹⁶

Annual energy cost savings were calculated by multiplying the mitigated electricity and natural gas usage—as calculated by HES—by the average residential PG&E utility rates. A lifetime of 20 years was assumed for this measure, based on individual energy-efficient upgrade lifetimes reported in DEER (2008).

Co-Benefit Analysis

The following benefits are expected from implementation of Energy-3.

Reduced Energy Use: Energy retrofits and standards would improve the efficiency of residential and non-residential buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity would be lowered.



Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity) and local air pollution (from reduced burning of natural gas).



Resource Conservation: Increased building efficiency would reduce water consumption, which would help conserve freshwater.

Increased Property Values: Energy-efficient bulidings have higher properity values and resale prices than less efficient buildings.



Public Health Improvements: Reduced regional and local air pollution would contribute to overall improvements in public health. A well-built, energy-efficient structure is also more durable and directly reduces certain health aliments. For example, properly sealed ducts and air leaks helps prevent mold and dust mites that can cause asthma.



Increased Quality of Life: The reduction of health aliments (see above) contributes to increased quality of life. Additionally, energy-efficient structures improve general comfort by equalizing room temperatures and reducing indoor humidity.

¹⁶ The lower bound cost is based on estimated costs of retrocommissioning, as reported by Gregerson (1997), and adjusted to 2011 dollars using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator.

Energy-4: Streetlights

Measure Description

Under this measure, the City would adopt municipal lighting standards to reduced electricity consumption. The measure would require the following for municipal lighting:

- **Street Lighting:** Require 15% reduction in electricity use by street lighting 2020.
- **Airport lighting:** Consider retrofitting outdoor runway and taxiway lighting fixtures from incandescent to LED

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Penetration rate of 25% for streetlight bulb replacement.
- Installation of an outdoor CFL fixture achieves a 75% reduction in energy usage, relative to an incandescent bulb (EPA 2011).
- A total of 7,400 streetlights will operate in the City in 2020 (City of Livermore 2012).
- Streetlights are assumed to operate 11 hours per day, 365 days per year (ICLEI 2010).
- The BAU streetlight profile for incandescent bulbs will be 100% High Pressure Sodium Cutoff (192 watts) (City of Livermore 2012)
- The wattage of a LED street light is 121

Analysis Details

GHG Analysis

Lighting requires the production of electricity to power the lights, which represents an indirect source of GHG emissions. Different light fixtures have different efficacies; in other words, certain bulbs can utilize less energy to obtain the same output. Replacing less efficient bulbs with energy-efficient ones therefore reduces energy consumption, and thus GHG emissions.

Baseline Emissions

The number of existing and future streetlights within the City was determined based on information provided by City staff. Baseline electricity consumption by City streetlights was calculated using the following equation:

Emissions Reductions

To determine energy reductions, it was assumed that 25% of streetlights would be replaced with energyefficient fixtures. Electricity consumption associated with these new LED bulbs was quantified assuming an average LED wattage of 0.12. The difference in electricity usage between the LED bulbs and the BAU electricity usage represents the energy reductions achieved by the measure. GHG emissions savings were calculated by multiplying the energy reductions by the appropriate utility emission factors.

Cost Analysis

Several elements factor in to the overall cost of this measure. More energy-efficient bulbs are typically more expensive than less efficient bulbs, and thus, the installation of more efficient ones incurs incremental (additional) materials costs. In terms of maintenance costs, however, because the rated life of more efficient bulbs is typically longer than less efficient ones, more efficient bulbs generally result in maintenance cost savings. In addition, because the replacement of less efficient bulbs with energy-efficient ones reduces energy consumption, energy cost savings are also realized.

Total capital costs to the City to replace streetlights are estimated at \$0.65 to \$1.5 million, with an estimated payback period of about 5 to 13 years. Annual cost savings to the City (including both reduced maintenance needs and energy cost savings) are estimated at about \$0.14 to \$0.12 million. Cost per ton is estimated to range from -\$842/MTCO₂e (net savings) to $207/MTCO_2$ e (net cost). Total costs are estimated to range from -\$0.88 million (net savings) to \$0.22 million (net cost).

The number of streetlights to be replaced was estimated by the GHG Analysis. To estimate initial costs, this number was multiplied by the incremental cost per fixture, which ranged from \$350 to \$825, as reported in DOE street lighting case studies for San Francisco and Palo Alto (Energy Solutions 2008; PNNL 2010). Annual incremental maintenance cost savings per fixture were also estimated based on reported values from these case studies, which ranged from approximately \$15 to \$27 per fixture.

Annual energy cost savings were calculated by multiplying the mitigated electricity usage—as calculated in the GHG Analysis—by PG&E utility rates.¹⁷ A lifetime of 17 years was assumed for this measure, based on the rated life and estimated annual hours of operation.

Co-Benefit Analysis

The following benefits are expected from implementation of Energy-4.

Reduced Energy Use: Energy-efficient lighting (e.g., CFL fixtures) consumes, on average, 75% less electricity than incandescent bulbs.



Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity).



Increased Property Values: Energy efficient buildings have higher properity values and resale prices than less efficient buildings.



Increased Quality of Life: CFLs have a much longer lifetime than incandescent bulbs, resulting in reduced bulb turn-over and the need to purchase new fixtures.

 $^{^{17}}$ In the absence of streetlight utility rates, small commercial rates were applied.

Energy-5: Voluntary Residential and Non-Residential Rooftop Solar

Measure Description

Under this measure, the City would encourage businesses and residents to install rooftop solar on existing buildings using Power Purchase Agreements (PPAs) and other low or zero up-front cost options for installing solar photovoltaic systems. This measure would reduce reliance on sources of energy that emit GHGs, thereby reducing GHG emissions.

This measure assumes 10% of existing commercial electricity use and 5% of existing residential electricity use were provided entirely by solar electricity in 2020. This measure would include any existing residential or non-residential solar retrofits that are installed between 2005 and 2020.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Market penetration rate of 5% for residential electricity
- Market penetration rate of 10% for commercial electricity.

Analysis Details

GHG Analysis

Utilizing electricity generated by renewable resources displaces electricity demand that would ordinarily be provided by PG&E. Although PG&E purchases a substantial amount of energy from renewable sources, electricity supplied by PG&E still represents a source of indirect GHG emissions. Carbon neutral sources, such solar, do not emit GHGs (CAPCOA 2010).

Baseline Emissions

2005 electricity usage was provided in the City's GHG inventory, and consumption BAU for 2011 was projected using population growth for residential electricity and job growth for commercial electricity. Electricity savings from overlapping measures was subtracted from 2011 consumption.

Emissions Reductions

It was assumed that 5% of residential and 10% of commercial total existing electricity consumption will be provided by solar electricity in 2020. Total electricity reductions were determined by multiplying residential and commercial electricity consumption for the existing year (2011) by 5% and 10%, respectively. The resulting GHG emissions reductions were determined by multiplying the electricity reductions by the appropriate utility emission factors.

Cost Analysis

Total First Costs

For this measure, two financing scenarios were estimated: one scenario where the building owner purchases and installs the solar panels, and one scenario where the building owner enters into a power purchase agreement (PPA) with a local company who owns and maintains the solar panels. In general, the financials are more attractive to the building owner by entering into a PPA. Costs were calculated on a perproject basis, and then multiplied by the number of projects. A 25-year lifetime is assumed for these projects.¹⁸

For the owner-financed scenario, total initial costs to home owners/building developers to install solar panels on residential and non-residential properties are estimated to be \$161 million, as calculated by the NREL System Advisor Model (SAM). Initial costs include the direct capital costs (e.g., the cost of the system equipment) as well as the indirect costs (e.g., the cost of labor to install it). These costs are driven by project size (assumed to be 5 kW per residential project and 25 kW per commercial projects). These costs amount to \$142,850 per commercial project and \$27,320 per residential project.¹⁹ These cost estimates

¹⁸ NREL Solar Advisor Model (May 2012). <u>https://sam.nrel.gov/</u>.

¹⁹ NREL Solar Advisor Model (May 2012). <u>https://sam.nrel.gov/</u>.

are calculated by SAM using default values. The total number of projects undertaken is assumed to be 1,414 residential installations and 855 commercial installations. The number of projects was determined by diving the goal energy savings (kWh) set by the measure by the solar electricity production (kWh) modeled per project.

Commercial projects are eligible for a California PBI via the California Solar Initiative, of \$0.03 per kWh, which is the payment level of Tier 10, the Tier at which PG&E is paying out. Residential projects are eligible for the EPBB incentive of \$0.25 per watt.²⁰ The EPBB incentive equates to \$1,250 per residential project. The CSI ratchets down to lower incentives over time, so actual incentives received depend on when the projects are initiated. The initial costs are also eligible for a federal ITC of 30% of the initial costs, which results in \$42,855 in federal tax savings per residential project and \$8,571 in tax savings per commercial project.²¹ However, this credit is taken at the end of the initial year to align with a lag time in receiving tax credits for project expenditures.

For the Power Purchase Agreement (PPA) scenario, the total initial cost to home owners/commercial entities was assumed to be zero.

Net Annual Costs

For the owner financed scenario, the value of electricity is drawn from the SAM's PG&E costs database. Livermore is located in PG&E's E-1 - Baseline Region X.²² Electricity production is based on the nameplate capacity (assumed to be 5 kW per residential project and 25 kW per commercial project) and on Livermore-area climate and latitude information (which affects solar exposure). Livermore-specific climate and latitude information was used. Electricity production decreases slightly each year due to system degradation.

Cost savings are reduced by the annual operating costs, which are assumed to be \$100 per project in the initial year for residential projects and \$500 per project in the initial year for commercial projects, as calculated by SAM. These costs increase slightly each year to account for inflation. The annual operating costs for a PPA are incorporated into the resident's/commercial entity's electricity costs.

For the PPA scenario (where there are no initial costs), annual operating costs are incorporated into the discounted electricity rate. Savings were estimated using California-based case studies published by a Sunrun (Sunrun 2012), a solar PPA company. The case studies provide a variety of examples of residents who have entered into PPAs with the company. For this analysis, we selected the six case studies located in California that did not have any start-up costs (terms of PPAs vary, and can include upfront costs, often in exchange for lower rates in the future). These case studies provided a range of annual savings of \$70 to \$326 per kW. These savings were scaled based the assumed system size and number of systems for this measure. Please note this estimate is a rough approximation of savings. As noted previously, terms of PPAs can vary, as can the associated savings. However, most often, customers enter into PPAs because they experience net savings.

Total Costs

Under both financing scenarios, the net cash flow is positive after the initial year for both residential and commercial projects. A 25-year analysis period was used.

With the owner financed scenario, neither the residential nor commercial projects break even. Total net costs are estimated as \$43.7 million.

Under the PPA scenario, because there is no initial outlay of capital, there are only net savings to the building owner. Total net savings are estimated as \$7.0 to \$32.4 million.

Co-Benefit Analysis

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=1. ²² NREL Solar Advisor Model (May 2012). https://sam.nrel.gov/.

 ²⁰ California Solar Initiative - Statewide Trigger Tracker (May 2012). <u>http://csi-trigger.com/</u>.
²¹ DSIRE Energy Investment Tax Credit (ITC)

The following benefits are expected from implementation of Energy-5.

Reduced Air Pollution: Generating community electricity through renewable sources would displace a significant portion of electricity generated by fossil fuels. As such, combustion at regional power stations would be reduced, contributing to cumulative reductions in criteria pollutants.

Waste Reduction: The generation of electricity from fossil fuels (e.g., coal, natural gas) generates a substantial amount of waste including, but not limited to: fly ash, bottom ash, flue gas, and sludge. These products can have detrimental effects on the environment if absorbed into groundwater, soil, and/or biota. The extraction and mining of fossil fuels also generates waste. Increasing renewable energy production would reduce waste created by fossil fuel supplied power.



Energy Diversity and Security: Fuels that are traded in the open market are subject to energy supply constrains and interruptions from political unrest, conflict, and trade embargoes. Centralized power structures (e.g., stations, sub-stations, refineries, ports) may also be targets of energy terrorism. Providing a diversified and domestic energy supply reduces foreign fuel dependency.



Reduced Price Volatility: Energy supply constraints and the uneven global distribution of fossil fuels increase the instability of the energy market. As the demand for global fossil fuels rises, energy prices would likely be subject to fluctuations and frequent price spikes. Renewables would contribute to the diversification of the energy supply mix, thereby buffering the local economy from the volatile global energy market.

Economic Development: Development of renewable energy infrastructure (e.g., solar farms, wind turbines) would create new jobs, taxes, and revenue for the local economy.

Public Health Improvements: Reduced regional air pollution and waste generation would contribute to overall improvements in public health.

Increased Property Values: If renewable infrastcuture is added to Stockton-area buildings as a result of this measure, properity and resale values of those structures may be increased.

Energy-6: Voluntary Solar Parking Program

Measure Description

Under this measure, the City would establish a goal for 15% of existing commercial development and multifamily housing complexes to install either solar panels or cool roofs on unused roof space and over carports by 2020 (California Attorney General's Office 2010a). In addition, the City would continue to provide incentives for the installation of solar technology. This measure would reduce reliance on sources of energy that emit GHGs, thereby reducing GHG emissions.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- An average of 1.75 parking spaces is required per multifamily dwelling unit (ICF International assumption).
- The number of covered commercial parking spaces in the City is 550 (Rademaker pers. comm.)
- 5% of multi-family unit parking space is covered (ICF International assumption).
- 25% of covered commercial parking space is stacked (ICF International assumption).
- Parking spaces are 171 square feet (ICF International assumption).
- Each solar system will generate 2,296 kWh per year (SAM Output).
- Penetration rate for multi-family unit parking space is 15%.

Analysis Details

GHG Analysis

Utilizing electricity generated by renewable resources displaces electricity demand that would ordinarily be provided by PG&E. Although PG&E purchases a substantial amount of energy from renewable sources, electricity supplied by PG&E still represents a source of indirect GHG emissions. Carbon neutral sources, such as solar, do not emit GHGs (CAPCOA 2010). Renewable energy supplied through this measure can be used to power building energy or sold to the local utility.

Baseline Emissions

Baseline emissions were not utilized in the analysis of this measure.

Emissions Reductions

In 2011, the City had approximately 8,279 multi-family homes (pers. comm. Rademaker). Based on professional experience in preparing CAPs for other jurisdictions in California, it was assumed that 15% of the multi-family homes will comply with the measure, that there are 1.75 parking spaces per multi-family home, and that all spaces are 171 square feet.

Total available roof space available for PV installation at multi-family homes was therefore calculated by multiplying the number of dwelling units by the number and size of required parking. This value was then multiplied by .05, as it was assumed that 5% of the multi-family homes have covered parking space.

In 2011, the City had 550 covered commercial parking spaces (pers. comm. Rademaker). It was assumed that 25% of the covered commercial parking is stacked and therefore unsuitable for PV installation. Total roof space available for PV installation at commercial parking space was calculated by multiplying the number of covered commercial spaces (550) by the assumed parking area of each space (171 feet), and subtracting 25% of the parking space that is assumed to be stacked parking.

The SAM model was used to calculate the energy potential of each solar installation.²³ This value was multiplied by the available number of multi-family and commercial parking spaces to determine energy

²³ These costs were adjusted to 2011 dollars using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator.

reductions achieved by the measure. GHG reductions were then quantified by multiplying the energy reductions by the appropriate utility emission factors.

Cost Analysis

For this measure, two financing scenarios were estimated: one scenario where the building owner purchases and installs the solar panels, and one scenario where the building owner enters into a power purchase agreement (PPA) with a local company that owns and maintains the solar panels. The financials are more attractive to the building owner by entering into a PPA.

Total First Costs

Under the owner financed scenario, total initial costs to building developers/owners to install solar panels on residential and commercial carports are estimated to be approximately \$25.5 million Costs were developed using the NREL SAM. Costs were calculated on a per-project basis, and then multiplied by the number of projects. A 25-year lifetime is assumed for these projects, and they and are expected to have no payback period. Initial costs include the direct capital costs (e.g., the cost of the system equipment) as well as the indirect costs (e.g., the cost of labor to install it). These costs are driven by project size (assumed to be 1.7 kW per project). These costs amount to \$9,714 per commercial project and \$9,289 per residential project. These cost estimates are calculated by SAM using default values. The total number of projects undertaken is assumed to be 2,723 (including both residential and commercial installations), based on assumptions used in the GHG Analysis for total area available for installations, as well as the assumed average size of a parking space (171 square feet).

Commercial projects are eligible for a California PBI via the California Solar Initiative, of \$0.03 per kWh, which is the payment level of Tier 10, the Tier at which PG&E is paying out. Residential projects are eligible for the EPBB incentive of \$0.25 per watt. The EPBB incentive equates to \$425 per residential project. The CSI ratchets down to lower incentives over time, so actual incentives received depend on when the projects are initiated. The initial costs are also eligible for a federal ITC of 30% of the initial costs, which results in \$2,914 in federal tax savings per residential and commercial project. However, this credit is taken at the end of the initial year to align with a lag time in receiving tax credits for project expenditures.

Because this measure targets carports and rooftops, it was assumed that sufficient infrastructure is already in place on which to install the panels. If solar panels are installed in an uncovered parking lot, additional infrastructure would need to be installed, such as the addition of a pole or other structure on which to hang the panels. This additional cost typically amounts to about \$1.30 per watt, or about \$2,230 per parking space.

For a Power Purchase Agreement (PPA) scenario, the total initial cost to multi-family residences and commercial entities is assumed to be zero.

Net Annual Costs

For the owner financed scenario, the value of electricity is drawn from the model's PG&E costs database. Livermore is located in PG&E's E-1 - Baseline Region X. Electricity production is based on the nameplate capacity (assumed to be 1.71 kW per project, as determined by the GHG calculations) and on Livermore-area climate and latitude information (which affects solar exposure). Livermore-specific climate and latitude information are climate and latitude information (which affects solar exposure). Livermore-specific climate and latitude information was used. Electricity production decreases slightly each year due to system degradation. Cost savings are reduced by the annual operating costs, which are assumed to be \$34 per project in the initial year, as calculated by SAM. These costs increase slightly each year to account for inflation.

The annual operating costs for a PPA are incorporated into the resident's/commercial entity's electricity costs. ICF modeled three financing scenarios: one where the initial cost of the project is paid in cash (0% financing), one where 25% of the initial costs are paid in cash and the rest is financed (75% financing scenario), and a PPA scenario where there are no initial costs and operating costs are incorporated into the discounted electricity rate. These three financing scenarios represent the bounds of the cost estimate range. Under both financing scenarios, the net cash flow is positive after the initial year for both residential and commercial projects.

Total Costs

Under both financing scenarios, the net cash flow is positive after the initial year for both residential and commercial projects. A 25-year analysis period was used.

With the owner financed scenario, neither the residential nor commercial projects break even. Total net costs are estimated as \$9.5 million.

Under the PPA scenario, because there is no initial outlay of capital, there are only net savings to the building owner. Total net savings are estimated as \$3.6 to \$17.0 million.

Co-Benefit Analysis

The following benefits are expected from implementation of Energy-6.

Reduced Air Pollution: Solar systems provide a direct source of renewable electricity. If this energy is consumed onsite, electricity usage supplied by PG&E would be reduced. The energy may also be sold to the utility, where it would be incorporated into their overall energy supply mix. In either scenario, electricity is displaced by a renewable source, which would reduce fossil fuel combustion at power stations and contribute to cumulative reductions in criteria pollutants.

Waste Reduction: The generation of electricity from fossil fuels (e.g., coal, natural gas) generates a substantial amount of waste including, but not limited to: fly ash, bottom ash, flue gas, and sludge. These products can have detrimental effects on the environment if absorbed into groundwater, soil, and/or biota. The extraction and mining of fossil fuels also generates waste. Increasing renewable energy production would reduce waste created by fossil fuel supplied power.



Energy Diversity and Security: Fuels that are traded in the open market are subject to energy supply constrains and interruptions from political unrest, conflict, and trade embargoes. Centralized power structures (e.g., stations, sub-stations, refineries, ports) may also be targets of energy terrorism. Facilities that generate a portion of their electrical demand from domestic, renewable sources would likely be buffered by any potential energy insecurities.



Reduced Price Volatility: Energy supply constraints and the uneven global distribution of fossil fuels increase the instability of the energy market. As the demand for global fossil fuels rises, energy prices would likely be subject to fluctuations and frequent price spikes. Facilities that diversify their energy supply mix through the generation of renewable energy would likely be buffered from the volatile global energy market.



Economic Development: Solar panel installation would create new jobs within the local economy.

Public Health Improvements: Reduced regional air pollution and waste generation would contribute to overall improvements in public health.

Increased Property Values: Bulidings with renewable infrasturcutre have higher properity values and resale prices than conventioanl buildings.

On Road-1: Idling Restrictions

Measure Description

Under this measure, the City would adopt an ordinance that limits idling time for heavy-duty trucks beyond CARB regulations. The recommended idling limit is 3 minutes. The reduced idling time would in turn reduce fuel usage and the associated GHG emissions.

Assumptions

Quantification of this measure employs the assumptions 1, 2, 70-72, 76, 145, 146, 233, 234, 236-238 in Table C-1.

- The BAU idling time is 5 minutes, and the goal idling time is 3 minutes.
- Heavy duty trucks idle 29.4% of their operating time (EPA 2009a)

Analysis Details

GHG Analysis

Vehicles idle during rest periods, which require fuel and results in GHG emissions. Regulating idling time would therefore reduction fuel consumption and GHG emissions. This measure primarily affects mediumand heavy-duty vehicles.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update. Reductions achieved by overlapping state measures were subtracted to obtain baseline emissions for the transportation sector.

Emissions Reductions

Using the percent idling time for an average California heavy duty diesel truck, and idling and running emission factors from the EPA and Climate Registry, the ratio of idling to running fuel consumption (7%) was found. The total amount of fuel consumed from heavy duty trucks in Livermore was found by dividing the total heavy duty emissions from the City's GHG inventory update by diesel carbon intensity factors from the GHGID Model Tool. The total amount of fuel consumed was multiplied by 7% to obtain fuel consumed by idling trucks. GHG emissions due to idling trucks were found by multiplying the idling fuel consumption by the GHGID Model Tool carbon intensity factors. The measure's emissions reductions were found by multiplying idling emissions by a factor of 40%, which was found by dividing the new idling time limit (3 minutes) by the BAU idling limit (5 minutes).

Cost Analysis

Total first costs for this measure ranges from \$0 million to \$0.13 million, with a payback period of 0 to 1 years. Annual cost savings (from reducing maintenance and fuel needs) for this measure are about \$0.22 million per year. Cost per ton is estimated to range from -\$454/MTCO₂e (net savings) to -\$421/MTCO₂e (net savings).

Several elements factor into the overall cost of this measure. The number of heavy-duty vehicles and technologies implemented directly affects the cost of the measure.

The number of heavy-duty vehicles was determined from the GHG Analyses and by using formula below. These vehicles were estimated to operate for 8 hours/day and were assumed to spend 29% time daily idling, consuming 0.9 gallons/hour.

Number of Vehicles = [2020 BAU Emissions from Heavy Duty Vehicles (MTCO₂e)]/[2011 BAU Emissions from Idling Heavy Duty Vehicles (MTCO₂e) per vehicle]

Technology Costs

Technology costs would depend on the response to the anti-idling measure. One feasible measure is to simply shut off engines, which would not have any technology costs. U.S. EPA's Smart Way Transport Partnership has identified a range of technologies including automatic engine shutdown/start up technologies, direct fired heaters, auxiliary power units, and electrification capabilities. The per-unit cost of

these technologies varies according to type, and ranges from \$1,000/unit for automatic engine shutdowns/start ups to \$11,000/unit for electrification. For this measure it was assumed that the high range of average cost would be \$1,000/unit (corresponding to automatic engine shutdown) as it is unlikely that this ordinance alone would incentivize installation of more expensive technologies such as electrification.

The O&M costs of using these technologies are not estimated under this measure.

Cost Savings Analysis

Savings are mainly derived from avoided O&M costs. Idling often has the same effect on the vehicle as driving it; that is, the engine and other mechanical parts experience the same wear and tear effects. Reduction in idling over time will provide savings in avoided fuel use, reduction in maintenance costs in relation to oil changes, and engine overhauls.

The calculation of cost savings from a reduction in idling time (from 5 to 3 minutes) has the following steps:

- a) Reduction in Fuel Use = (Fuel Consumption/hour x hours/year spent idling x fuel price/gallon)
- b) Cost of Oil Changes per year = [(Miles per oil change/ cost of oil change) x (gallons/ hour x hours/year x average fuel economy)]
- c) Engine Overhaul Costs = [(Miles per overhaul/ cost of overhaul) x (gallons/hour x hours/year x average fuel economy)]

In the end, total avoidable costs (and thus savings), are calculated this way:

Total Avoidable Cost per vehicle = Savings from Fuel Reduction + Savings from Reduction in Maintenance Costs (equations b + c above)

Total Avoidable Costs for City Vehicle Fleet = Total Avoidable Cost per vehicle x no. of vehicles

Total costs are estimated as -\$1.7 million (net savings) to -\$1.6 million (net savings).

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-1.



Reduced Air Pollution: Because less petroleum would be consumed by heavy-duty trucks within the city, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced.

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Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.



Reduced Energy Use: Reduced idling time will reduce fuel consumption.

On Road-2: Transit Oriented Development

Measure Description

Under this measure, the City would expand land use planning to support increased transit use and alternatives to vehicle travel. Specifically, this measure includes land use regulations that would encourage Transit Oriented Development (a mixed-use area designed to maximize access to public transport) at the Vasco and Downtown ACE stations. Such development would reduce the amount of vehicle miles traveled by residents, thereby reducing emissions from automobiles and consequently GHG emissions.

At the Vasco Road ACE Station, development would include a total of 510 new housing units and 16 acres of open space north of ACE station/parking. Housing types anticipated include: 110 clustered townhomes, 84 clustered condos, 200 row-homes, and 116 duets. At the Downtown Ace Station, the Downtown Specific Plan would allow mixed uses with development maximums as follows:

- Commercial: 1,000,000 square feet
- Office: 356,000 square feet
- Entertainment: 2,500 performance art seats and up to 15 movie theatre screens
- Lodging: 300 rooms
- Residential: 3,600 units (approximately 3,200 new units)

For the purposes of the CAP, it is expected that by 2020, the following new uses would have been constructed in the Downtown area, including uses constructed between 2005 and 2011:

- 28,905 square feet of office (constructed)
- 318,014 square feet of commercial (288,014 square feet constructed; an additional
- 30,000 square feet assumed by 2020)
- 500 seat Performing Arts Theater (constructed)
- 13 screen Movie Theater (constructed)
- 959 housing units (250 units constructed, an additional 709 units assumed by 2020)
- 120-room boutique hotel (planned for constructed by 2020)

Assumptions

See Table C-1.

Analysis Details

GHG Analysis

Reductions in VMT from this measure would reduce the amount of GHGs directly emitted from vehicles.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update.

Emissions Reductions

Based on modeling conducted by Fehr & Peers, On Road-2 was assumed to result in a VMT reduction of 12,215 daily miles. Emission reductions associated with this measure were calculated by dividing the 2020 BAU on-road emissions by the 2020 BAU VMT, and then multiplying by the annual VMT reductions expected from this measure.

Cost Analysis

Costs were not estimated due to the lack of data on the costs of downtown development and infrastructure relative to costs of comparable amount of development outside of the downtown. Thus, the incremental costs of downtown development have not been identified. Costs for downtown development may be less or more than comparable development outside downtown areas. Sometimes, more compact development can minimize the cost of infrastructure due to the presence of existing infrastructure and shorter roadway and utility lengths to serve new development. However, downtown development can incur costs for remediation or removal of prior structures and can incur other costs not experienced in development in

outlying areas. The ultimate cost effectiveness of this measure would depend on the balance of the incremental costs of development compared to the fuel and vehicle savings from reduced VMT.

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-2.



Reduced Air Pollution: Because less petroleum would be consumed by vehicles within the city, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced. Likewise, reductions in congestion from fewer vehicles on the roadway network would contribute reductions in emissions generated by vehicle idling.

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Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.



Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing fuel consumption would lessen the demand for petroleum and ultimately the demand for imported oil.



Increased Quality of Life: Increased density along transit routes, employment corridors, and in the downtown would increase the accessibility of public transportation and basic services. Reductions in the number of vehicle trips may also reduce congestion and travel times.



Smart Growth: Increased density in the urban core is a form of smart growth development that creates more walkable and accessible environments.

On Road-3: Transit Enhancements

Measure Description

Although the City of Livermore is not a transit provider, the City can encourage and require new developments to provide transit amenities within the Project area including the potential for bus stop amenities, transit signal priority at intersections; or encouraging new residences be located within a half-mile walk of an existing or planned transit route.

The Livermore Amador Valley Transit Authority (LAVTA) is the primary transit provider in the City of Livermore. Regular transit service is provided in the Tri-Valley area, serving the Cities of Dublin, Pleasanton and Livermore. Sixteen fixed routes are providing connecting primary activity centers, including the both BART stations in the Tri-Valley. Additional routes serving various schools are also provided. In 2009, service was cut approximately 25 percent. One Bus Rapid Transit (BRT) route was implemented in 2011. There are no plans to expand the number of BRT routes or the level of service on the existing route, and the primary goal of LAVTA over the next few years is to restore service cuts.

For this assessment, it was assumed that by 2020, service would be restored to the same per capita level that was provided in 2005 and that the recently implemented BRT route would continue to operate increasing ridership levels per capita above the 2005 levels. This would result in a potential daily VMT reduction of 4,072 miles above the BAU case.

Assumptions

See Table C-1.

Analysis Details

GHG Analysis

Reductions in VMT from this measure would reduce the amount of GHGs directly emitted from vehicles.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update.

Emissions Reductions

Based on modeling conducted by Fehr & Peers, On Road-3 was assumed to result in a VMT reduction of 4,072 daily miles. Emission reductions associated with this measure were calculated by dividing the 2020 BAU on-road emissions by the 2020 BAU VMT, and then multiplying by the annual VMT reductions expected from this measure.

Cost Analysis

No cost analysis was completed for this measure as this measure assumes actions by LAVTA that are not directly under the control of the City of Livermore. Costs could be incurred where transit amenities are included in new developments. Traffic light synchronization costs are included in On-Road 4. LAVTA service costs are under LAVTA control, not the City's control.

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-3.

Reduced Energy Use: More attractive transit would encourage motorists to utilize public transportation instead of private vehicles. As a result, the number of vehicle trips made within the City, and thus gasoline and diesel consumption, would be reduced.

Reduced Air Pollution: Because less petroleum would be consumed by vehicles within the City, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced. Likewise, reductions in congestion from fewer vehicles

on the roadway network would contribute reductions in emissions generated by vehicle idling.

Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.



Increased Quality of Life: Increased transit service would help reduce transit passenger travel time and may make public transportation more comfortable and enjoyable. Reductions in the number of vehicle trips may also reduce congestion and travel times.

On Road-4: Traffic Signal Synchronization

Measure Description

Under this measure, the City will improve travel speed by enhanced signal synchronization. This measure would reduce idling time for vehicles traveling within and through the city, and the reduced idling time would in turn reduce fuel usage and the associated GHG emissions.

This measure would not reduce VMT, but rather idling time and resultant emissions.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Traffic signal synchronization reduces GHGs by approximately 1% (ICF International assumption)
- The scaling factor applied to the GHG reduction percent is 0.5 (ICF International assumption)

Analysis Details

GHG Analysis

Vehicles idle during periods spent stationary at traffic signal red lights, which requires fuel and results in GHG emissions. Enhancing traffic signal synchronization would decrease the amount of time that cars spend idling and reduce GHG emissions.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update. Reductions achieved by overlapping state measures were subtracted to obtain baseline emissions for the transportation sector.

Emissions Reductions

Using professional experience from the preparation of CAPs for other jurisdictions, it was assumed that GHG reductions can be reduced by 1% due to traffic signal synchronization. A scaling factor of 0.5 was applied to the percent reduction, to give a reduction in GHGs of 0.5%. This reduction factor was applied to the 2020 GHG emissions from on-road transportation quantified in the Inventory Update.

Cost Analysis

The one-time costs of based on a range of \$2,586 per intersection (from an Alameda County synchronization project estimate) \$20,000 per intersection (based on an estimate of adaptive traffic control system (ATCS) cost). City of Livermore (2012) provided estimates of the number of traffic signal intersections currently in place (as of 2011) as 92, and projected that there would be 110 traffic signal intersections by 2020. This analysis assumed a linear increase between these two end points. The number of intersections was multiplied by the range of ATCS installation costs per intersection. One-time costs ranged from \$0.3 to \$2.2 million, and are spread over the time period 2012 to 2020.

Savings in on-road vehicle emissions due to this measure were calculated by the GHG analysis. Reductions in gallons of diesel fuel and gasoline were calculated. These annual savings (which reach \$0.31 million by 2020) are experienced by the drivers, while the one-time costs are experienced by the local government.

Total costs are estimated to range from -\$0.03 million (net savings) to \$1.9 million (net costs).

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-4.



Reduced Air Pollution: Because less petroleum would be consumed by vehicles within the city, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced.

Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.

Reduced Energy Use: Traffic signalization will improve the efficiency of transit service, reducing wasted fuel.



Increased Quality of Life: Reduced vehicle congestion would improve the efficiency of the transportation network.

On Road-5: Bicycles and Pedestrian System Improvements

Measure Description

Under this measure, the City would complete its bikeway network identified in the General Plan and provide facilities for bicycle commuters, such as showers and bicycle lockers. These measures would encourage alternative modes of communication, thereby reducing vehicle miles traveled and consequently GHG emissions.

Livermore had approximately 60 miles of Class I and Class II bicycle path facilities in 2003 and expects to add approximately 18.5 more miles of off-street and on street facilities, including facilities constructed between 2003 and 2011, closing gaps in the network and connecting new development areas to the existing system by 2020. This measure is expected to decrease daily VMT by approximately 7,736 miles.

Assumptions

See Table C-1.

Analysis Details

GHG Analysis

Cycling is a non-emissions forming mode of transportation that has a high potential for success in Livermore. Reductions in VMT from this measure would reduce the amount of GHGs directly emitted from vehicles.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update.

Emissions Reductions

Based on modeling conducted by Fehr & Peers, On Road-5 was assumed to result in a VMT reduction of 7,736 daily miles. Emission reductions associated with this measure were calculated by dividing the 2020 BAU on-road emissions by the 2020 BAU VMT, and then multiplying by the annual VMT reductions expected from this measure.

Cost Analysis

Initial capital costs for this measure ranged from \$2.5 million to \$6.8 million. This included construction of new multi-use trails on service roads or other routes, widening roadways to provide bike lanes, and marking bike lanes with signs and pavement legends. The costs ranged from \$20,000 to \$500,000 per mile (City of Livermore 2002) and would be incurred by the City.

Annual maintenance costs ranged from \$0.25 million to \$0.68 million and were estimated to be 10% of the initial capital costs (Moving Cooler 2009). These maintenance costs would be incurred by the City of Livermore and are driven by the need for upkeep of the gravel, signage, and other path maintenance activities. Annual savings were estimated at \$1.1 million and were driven by vehicle miles traveled (VMT) reduced. VMT savings were provided by the GHG Analysis and are experienced by residents who reduce their automobile use and the City (as they experience reduced road maintenance costs). These savings come from avoided fuel costs (\$0.188/mile; Caltrans 2007) and avoided maintenance costs of roads (\$0.239/mile; Caltrans 2007).

Total costs were estimated to range from -\$8.7 million (net savings) to \$1.0 million (net costs).

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-5.

Reduced Energy Use: Providing network connections and facilities for bicycle commuters, such as showers and bicycle lockers, can encourage them to use non-motorized transportation for short and medium length trips. As a result, the number of vehicle trips made within the City, and thus gasoline and

diesel consumption, would be reduced.

Reduced Air Pollution: Because less petroleum would be consumed by vehicles within the City, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced. Likewise, reductions in congestion from fewer vehicles on the roadway network would contribute reductions in emissions generated by vehicle idling.

Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity. Walking and bicycling would also provide exercise, which may help reduce obesity and other ailments caused by inactivity.

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Increased Quality of Life: Improving the connectivity of the pedestrian and bicycle network would increase public mobility. Amenities like showers and lockers may also make bicycling and walking more enjoyable. Finally, reductions in the number of vehicle trips may reduce congestion and travel times.



Smart Growth: Creating a more walkable and accessible environment is a tenant of smart growth development.

On Road-6: Car Sharing Program

Measure Description

This measure would include promotion of a car-sharing program to allow people to have on-demand access to a shared fleet of vehicles on an as-needed basis.

Car Sharing was assumed to be implemented at both ACE stations on a limited basis and is expected to result in a net-decrease of 407 daily VMT.

Assumptions

See Table C-1.

Analysis Details

GHG Analysis

Reductions in VMT from this measure would reduce the amount of GHGs directly emitted from vehicles.

Baseline Emissions

Emissions associated with on-road transportation in 2020 under BAU conditions were quantified in the Inventory Update.

Emissions Reductions

Based on modeling conducted by Fehr & Peers, On Road-6 was assumed to result in a VMT reduction of 407 daily miles. Emission reductions associated with this measure were calculated by dividing the 2020 BAU onroad emissions by the 2020 BAU VMT, and then multiplying by the annual VMT reductions expected from this measure.

Cost Analysis

Costs were not estimated for this measure as this measure would be implemented by private vendors (like Zipcar). City costs would be limited to providing several parking spaces in key locations, with minimal costs for signage and reduction in parking revenues.

Co-Benefit Analysis

The following benefits are expected from implementation of On Road-6.

Reduced Energy Use: Providing car sharing services will reduce personal vehicle use. As a result, the number of vehicle trips made within the City, and thus gasoline and diesel consumption, would be reduced.

Reduced Air Pollution: Because less petroleum would be consumed by vehicles within the city, air pollutants generated by fossil fuel combustion, including particulate matter, carbon monoxide, sulfur dioxide, and ozone precursors, would be reduced.

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Public Health Improvements: Fossil fuel combustion release several toxic air containments known to cause adverse human health effects. Reductions in the amount of fuel combusted would result in corresponding reductions in toxic air containments. Additionally, reductions in ozone precursors would reduce the formation of smog, which has numerous human and environmental effects, including respiratory irritation and reduced plant productivity.



Energy Security: In 2009, 51% of petroleum consumed by the U.S. was imported from oversees (EIA 2010). Reducing fuel consumption would lessen the demand for petroleum and ultimately the demand for imported oil.

Increased Quality of Life: Reduced vehicle congestion would improve the efficiency of the transportation network. In addition, the ability to obtain a shared vehicle for use could allow residents to use their vehicles less or own less vehicles, granting them the associated economic benefits of less car maintenance and ownership costs.

Water-1: Reduce Per Capita Urban Water Use 20% below 2005 per Capita levels

Measure Description

Under this measure, the City would implement a mix of voluntary and mandatory measures to reduce urban water use (including indoor and outdoor use) 20% by 2020 (compared to 2005 per capita levels) per the requirements of state regulation (SBX7 7). Decreased urban water use would decrease the amount of energy needed to transport and deliver this water, thereby reducing GHG emissions.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- The City of Livermore 2020 per capita goal is 155.7 gallons per person per day (City of Livermore 2012).
- The Calwater Livermore District 2020 per capita goal is 158 gallons per person per day (City of Livermore 2012).
- The Calwater Bay Area Regional Alliance 2020 per capita goal is 151 gallons per person per day (City of Livermore 2012).

Analysis Details

GHG Analysis

California homes and businesses consume a significant amount of water through indoor plumbing needs and outdoor irrigation. A large portion of water use can be attributed to inefficient fixtures (e.g., showerheads, toilets). Recognizing that water uses a great deal of electricity to pump, treat, and transport, the state adopted SB X7-7, which requires a 20% reduction in urban per capita use by December 31, 2020. Achieving this goal would not only reduce electricity consumption, but avoid GHG emissions and conserve water.

Baseline Emissions and Emissions Reductions

Using the estimated 2020 population from the GHG forecast and the estimated baseline consumption per capita of 195 gallons/capita/day (Livermore Municipal Water 2010 UWMP), the 2020 BAU water consumption was estimated as 6,499 million gallons (MG). A 20% reduction in the per capita level would reduce water consumption in 2020 to 156 gallons/capita/day. Achieving the 2020 goal would therefore reduce city-wide water consumption in 2020 to 5,200 MG.

Electricity savings from reduced water treatment, distribution, and wastewater treatment were quantified by multiplying the anticipated water reductions by the appropriate energy-intensities. Natural gas savings were also calculated from reduced hot water usage. GHG savings were then calculated by multiplying the energy reductions by the appropriate emission factors.

Two scenarios were analyzed for this measure. One scenario evaluated an equal level reduction for all forms of water use (indoor hot water, indoor cold water, outdoor irrigation) and the second scenario assumed that the reduction of outdoor water use would be twice the level of indoor water use. The first scenario resulted in an estimated 11,650 MTCO₂e reduction in GHG emissions while the second scenario resulted in an estimated 6,369 MTCO₂e reduction in GHG emissions. The reason for the large difference is that the first scenario has relatively higher reduction of hot water use than the second scenario and hot water use has higher emissions per gallon due primarily to natural gas consumption for heating. Since the precise balance of water efficiency measures that will be employed over the next 8 years to meet the SB X7 7 goal is not known, for the purposes of this study, the second scenario was used to estimate GHG reductions, as it is more conservative.

Cost Analysis

This measure is not an additional cost of the CAP as it is a requirement per prior state regulation.

Co-Benefit Analysis

The following benefits are expected from implementation of Water-1.

Resource Conservation: Reduced water consumption would help conserve freshwater resources.

Reduced Energy Use: Water uses a great deal of electricity to pump, treat, and transport. Consequently, reductions in water use would reduce electricity consumption.



Reduced Air Pollution: Reduced electricity use would contribute to reductions in regional air pollution.

(3)

Increased Property Values: Energy-efficient buildings have higher property values and resale prices than less efficient buildings.

Wastewater-1: Aeration Diffuser

Measure Description

This measure includes the replacement of inefficient aeration diffusers with high-efficiency blowers.

Assumptions

Replacement of inefficient blowers with high-efficiency blowers will reduce annual GHG emissions by 84,577 pounds of CO_2e .

Analysis Details

GHG Analysis

According to a recent analysis prepared by Chevron, old and fouled diffusers might result in inefficiencies requiring as much as 230 kW of energy. Chevron evaluated two alternatives to replace existing diffusers at the LWRP: FlexAir Magnum Tub Diffusers and FlexAir Mini Panel Diffusers. Installation of either high-efficiency design would result in GHG reductions by reducing energy consumption at the LWRP. (Chevron 2012.)

Baseline Emissions and Emissions Reductions

Chevron estimates that replacement of inefficient blowers with high-efficiency blowers will reduce annual GHG emissions by 84,577 pounds of CO₂e. GHG emissions associated with Wastewater-1 were therefore assumed to equal 38 metric tons. Please note that the Chevron calculations are based on activity data in 2011. Because energy consumption is expected to increase between 2011 and 2020, emissions reductions associated with Wastewater-1 likely underestimate potential reductions in 2020.

Cost Analysis

The Chevron Report only identified annual savings as \$13,899. Capital costs or discounted costs/savings over the lifetime of the measure were not identified (Chevron 2012).

Co-Benefit Analysis

The following benefits are expected from implementation of Water-1.

Reduced Energy Use: Utilizing efficient blowers will reduce electricity consumption.



Reduced Air Pollution: Reduced electricity use would contribute to reductions in regional air pollution.

Waste-1: Waste Diversion

Measure Description

Under this measure, the City would increase the amount of waste diverted from landfills per its previously adopted waste diversion target of 75% by 2015, which would reduce vehicle miles traveled associated with transporting waste to landfills, contribute to land conservation due to the reduced need for landfills, and reduce the use of energy through increased recycling and reuse of waste.

In 2005 (baseline inventory year), the City had a diversion rate of 63%. The City's current goal is to increase the City's diversion rate to 75% and is currently at a rate of 73%.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- The City had an average existing diversion rate of 63% for municipal solid waste in 2005 (CalRecycle n.d.).
- The diversion goal rate adopted by the City Council for 2015 is 75% and this rate was assumed for 2020

Analysis Details

GHG Analysis

Diversion programs reduce the amount of waste deposited in regional landfills. Because waste generates methane emissions during decomposition, reducing the volume of waste sent to landfills directly reduces GHG emissions. In general, waste diversion rates have risen dramatically since the early 1980s. The U.S. achieved 46% diversion in 2008.

Baseline Emissions

Waste volumes for the City in 2020 were projected using the 2005 waste volume from the existing GHG inventory (City of Livermore 2005a), and the population growth rate. According to CalRecycle (n.d.), the City diverted 63% of generated waste in 2005. It was assumed that this diversion rate would remain constant under 2020 baseline conditions.

Emissions Reductions

Implementation of Waste-1 would increase the baseline diversion rate to 75%. The amount of waste diverted under baseline conditions was therefore increased by 12% (75% minus 63%). To determine 2020 emissions from the increased diversion rate scenario, 2020 waste emissions (37,948 MTCO₂e) from the City's GHG inventory update (ICF 2010) was divided by 2020 waste volume (154,620 short tons) and then multiplied by the 2020 goal waste volume. Emissions reductions, GHG emissions that would have been generated by the diverted waste if it had been deposited in regional landfills, were determined by subtracting the 2020 goal waste volume emissions (25,641 MTCO₂e) from the 2020 baseline waste volume emissions (37,948 MTCO₂e).

Cost Analysis

The City has already adopted the 2015 waste diversion goal. As such, the costs to meet this goal are not an additional cost of the CAP.

Co-Benefit Analysis

The following benefits are expected from implementation of Waste-1.

Reduced Air Pollution: The decomposition of landfilled waste emits methane, which can react with other species in the atmosphere to form local smog. By sending less waste to regional landfills, methane emissions would be reduced.

Resource Conservation: Waste that is diverted to recycling centers can be converted into reusable products, thereby reducing the need for raw materials.

Urban Forestry-1: Urban Shade Trees

Measure Description

The City has development regulations and engineering standards that require a minimum number of new trees in new development and parking lots, as well as street trees for new private development. The City's Tree Preservation Ordinance also ensures that existing trees in new development are preserved; if the trees cannot be saved, the ordinance requires they be replaced at a minimum ratio of 3 to 1. Under this measure, the City would continue its existing program, requiring a minimum number of new trees to be planted with new development. A goal of 300 new trees to be planted each year is assumed.

Assumptions

In additional to assumptions listed in Table C-1, the following assumptions were also considered.

- Tree planting programs begin in 2013.
- Urban heat island energy saving factor for planting trees: 7kWh/tree
- Mature trees (as opposed to seedlings) would be planted.
- CAPCOA annual sequestration rates (MT CO₂e per year):
 - Flowering Pear —0.1666
 - Hackberry—0.0795.
 - Modesto Ash—0.0858.
 - Chinese Pistache—0.0381.
 - Sycamore—0.0828.

Analysis Details

GHG Analysis

Trees would both reduce the urban heat island effect and sequester carbon. Trees in cities can reduce summer cooling energy consumption by lessening the effect of the urban heat island effect. Trees also provide the benefit of carbon sequestration, The GHG benefits achieved from sequestration would vary based on the type of tree planted. Mature trees would function to sequester more carbon dioxide from the atmosphere than young trees.

Baseline Emissions

Baseline emissions were not utilized in the analysis of this measure.

Emissions Reductions

The Climate and Air Pollution Planning Assistant (CAPPA) tool created by ICLEI - Local Governments for Sustainability (ICLEI, n.d.), has derived an estimate for the amount of electricity saved due to the planting of one tree in an area affected by the urban heat island effect. This value, 7 kWh per tree planted, was multiplied by the number of trees to be planted by 2020 to determine the total energy saved from the decreased need for cooling buildings. The total energy saved, 14,700 kWh (in 2020), was multiplied by utility emission factors to obtain total GHG emissions reductions.

CAPCOA (2010) has quantified anticipated annual CO₂ accumulation rates associated with various tree species. The City has indicated that Sycamore, Flowering Pear, Modesto Ash, Hackberry, and other species are common in the City. It was assumed that the tree species planted will consist of the common species currently present. The average CO₂ accumulation rate for these species was multiplied by the number of planted trees per year (300) and by the number of planting years (7) to obtain total CO₂ sequestered in 2020.

Cost Analysis

Initial costs for planting, staking, and mulching were estimated at between \$142-\$197 per public tree.

Costs for planting were divided amongst seven years with initial costs for all years ranged between \$298,200 and \$413,700. Annual maintenance costs were estimated to range from \$4 to \$58 per tree, depending on the maturity of the trees; irrigation costs are higher in the first five years, whereas infrastructure repair and litigation/liability costs apply after the trees reach a certain size (McPherson et al. 1999). The higher end of maintenance costs included full pruning, pest and disease control, irrigation, infrastructure repair, litter removal, storm cleanup, litigation liability, and administration costs while the lower cost estimate focused more on basic maintenance such as pruning and irrigation. Operation and maintenance costs were estimated to range between \$68,550 and \$94,660 in 2020.

Trees have important impacts on their local surroundings but this study focused on direct cost savings to the community through electricity savings achieved by reduced energy use. Each tree was assumed to reduce electricity demand by 7 kWh on average, mostly from reductions in the urban heat island effect and shading. The energy savings result in \$2,700 in total annual savings for private residents and businesses by the year 2020.

The total discounted net costs for this measure would be \$0.8 million to \$1.1million. The total discounted net cost per ton of GHG reduced would range from \$266 to \$374 per ton. Actual net costs for the City may vary from those estimated. A lifetime of 40 years was assumed for this measure.

For all of the measures in this study, the only benefits quantified were energy or fuel savings, due to the lack of readily available data for quantifying other benefits. Street and shade trees have a wide range of benefits including energy savings, reduction in air pollutants, increase in home prices etc, of which only the energy savings were included in the cost analysis. In order to estimate a rough estimate of the value for this wider range of benefits for this measure, a per-tree lifetime (40 years) net savings ranging from \$417 to \$597 (average of \$507) was assumed, based on an equal mix of small and medium trees planted in the City of Livermore. These values are based on lifetime net savings as reported in a prior tree study (McPherson et al. 1999), grossly adjusted to 2011 dollars and net of building energy savings associated with shading included in the calculation above. This net benefit value includes CO₂ and air quality emission reductions, as well as property value increases. When using this estimate of net benefits, this measure would result in net savings of \$0.8 to \$1.3 million (instead of a net cost as noted above). The total savings per ton of GHG reduced would range from \$124 to \$178 per ton (compared to net costs per ton noted above). Actual net savings for the City may vary from those estimated, but the net benefit is expected to be highly positive if the wider range of benefits is included.

Co-Benefit Analysis

The following benefits are expected from implementation of Urban Forestry-1.

Reduced Energy Use: Trees planted adjacent to buildings shade, which cools buildings and reduces the need for summer-time air conditioning use. As a result, less electricity is consumed.

Reduced Air Pollution: Reduced electricity use would contribute to reductions in regional air pollution. Trees planted adjacent to congested roadways may also help filter particulate matter and other local pollutants.



Reduced Urban Heat Island Effect: Urban heat island effect occurs when the ambient temperature in urban areas increases as a reuslt of high energy consumption (e.g., air conditioning use during the summertime). Trees provide shade, which reduces the cooling load of buildings and helps mitigate the urban heat island effect.



Increased Quality of Life: Trees improve the aesthetic quality of buildings, as well as reduce stormwater runoff during periods of heavy rain.

Mun-1: Municipal Energy Efficiency Programs

Measure Description

Under this measure, the City would promote voluntary programs for existing government facilities to improve building-wide energy efficiency.

Analysis Details

GHG Analysis

Emissions Reductions and Cost Savings

Chevron conducted an analysis of GHG reductions and annual cost savings with a range of municipal energyefficiency measures as shown in the table below:

Municipal Energy-Efficiency Measures, Annual Cost Savings and Associated GHG Reductions^a

Measure Name	Annual Cost Savings	MTCO ₂ e Reduction in Municipal Emissions
Solar PV	\$610,951	1,310
Chiller Upgrade	\$1,293	3
Variable Primary Flow	\$16,589	46
HVAC Unit Upgrade	\$2,626	5
Solar Thermal Water Heating	\$1,465	7
EMS Upgrade at Multi Service Center	\$405	1
Interior & Exterior Lighting and Lighting	\$99,846	
Controls		222
Street Lighting	\$276,627	746
Total	\$1,009,082	2,340
^a Emissions calculations based on activity data in 2011 Because energy consumption is expected to		

^a Emissions calculations based on activity data in 2011. Because energy consumption is expected to increase between 2011 and 2020, emissions reductions presented above are likely an underestimate. Source: Chevron 2012

No calculation of initial capital costs or total discounted costs/savings were provided in the Chevron report.

Co-Benefit Analysis

The following benefits are expected from implementation of Mun-1.

Reduced Energy Use: Energy retrofits and standards would improve the efficiency of commercial buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity would be lowered.



Reduced Air Pollution: Reduced energy use would contribute to reductions in regional air pollution (from reduced generation of electricity) and local air pollution (from reduced burning of natural gas).

Increased Property Values: Energy-efficient bulidings have higher properity values and resale prices than less efficient buildings.

Public Health Improvements: Reduced regional and local air pollution would contribute to overall improvements in public health. A well-built, energy-efficient structure is also more durable and directly reduces certain health aliments. For example, properly sealed ducts and air leaks helps prevent mold and dust mites that can cause asthma.

Increased Quality of Life: The reduction of health aliments (see above) contributes to increased quality of life. Additionally, energy efficient structures improve general comfort by equalizing room temperatures and reducing indoor humidity. Employee satisfaction and out may therefore be increased.

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