Appendix XX: Cost Effectiveness Methodology Documentation

This document provides information about the data, methodologies, and sources used to estimate the cost of a subset of measures to reduce greenhouse gas included in the City of San Diego Climate Mitigation and Adaptation Plan (CMAP). Table 1 provides a summary of the cost, which is shown in the net present value in 2010 dollars per metric ton of carbon dioxide equivalent ($2010/MT CO2e) for the measures analyzed.

Table 1. Summary Table of CMAP Mitigation Strategies Cost Effectiveness ($2010/MT CO2e)

Electric/Natural Gas Measures	2020
Commercial Retro-Commissioning	($193)
Commercial Efficiency Retrofits	$42
Residential Solar Water Heating Retrofit - SF	$72
Residential Efficiency Retrofit - MF	$189
Residential Photovoltaics	$175

es.

ELECTRIC AND NATURAL GAS MEASURES

The City of San Diego CMAP estimated cost effectiveness for 7 electric and natural gas measures. The following provides details about the data and methods used to the cost per metric ton of greenhouse gas reductions from these 7 measures.

Overall Methodology

Cost estimates for electric and natural gas measures were derived by calculating the net present value of each measure and dividing this value by the total greenhouse gas emissions reductions realized from each measure. The net present value calculation discounts to the

present (at 5%) the capital expenditure, future operational costs, and the future stream of cost savings from energy savings. The resulting dollar-per-metric-ton value normalizes the cost so they can be compared across all measures.

Calculations for electric and natural gas measures take into account direct costs and benefits and do not account for health or environmental costs and benefits.

Residential Efficiency Retrofits

The residential sector in the City of San Diego accounts for about 30% of electricity use and 33% of natural gas use. Much of this consumption is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in single family and multi-family homes.

- **Cost of Residential Energy Reductions** – The CMAP cost calculations assume that the cost of a residential retrofit is $13,000 in 2010 and 2020 for single-family units and $4,000 in 2010 and 2020 for multifamily units.
- **Energy Reduction from Retrofits** – Energy reductions from retrofits are assumed to be 30% in 2010 and 2020 for single-family units and 20% in 2010 and 2020 for multifamily units.
- **Useful Life -** Cost calculations are made assuming a useful life of 12 years.

Sources:

- California Center for Sustainable Energy. Single-family cost and energy reduction estimates for 2010 are rules of thumb based on a limited number of projects in the Energy Upgrade California Program.
- Heschong Mahone Group. Multi-family cost and energy reduction estimates for 2010 are rules of thumb based on a limited number of multi-family retrofits projects.

Commercial Efficiency Retrofits

The commercial sector accounts for 43% of electricity use and 25% of natural gas use in the City of San Diego. Much of this is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in commercial buildings.

- **Cost of Commercial Retrofits** –A 2005 Lawrence Berkeley National Laboratory (LBNL) study of ESCO projects found an average cost for a range of commercial energy retrofits of $2.32/ft^2 across all sectors. This value is comparable to values cited in an analysis of commercial efficiency projects related to New York City's Energy Leasing Legislation, which showed a range of costs from $2.00/ft^2 - $2.25/ft^2 for a 20% energy reduction. A review of commercial retrofit project conducted in the SDG&E territory as part of the Savings Bid Program in 2006 and 2007 found a weighted average cost of electricity efficiency projects to be $0.75/kWh and for natural gas efficiency $4.35 per therm. Converting these values to a dollar-per-square foot value, based on the participation rates used to determine greenhouse gas reduction levels, results in a value of about $2.00/ft^2. CMAP cost calculations are based on $2.25/ft^2 for a 15% energy reduction in 2010 and 2020.
- **Energy Reduction from Commercial Retrofits** – The LBNL study found a median total energy reduction of about of 15 kBTU/ft2, or 18% of the average commercial energy

consumption in 2010 of about 82 kBTU/ft^2. CMAP cost calculations assumed a 15% energy reduction in 2010 and 2035.

- **Useful Life** – Cost calculations are made assuming a useful life of 12 years.

Sources

- SDG&E Standard Performance Contract program data for 2006 and 2007.
- New York City's Office of Long-Term Planning and Sustainability (OLTPS), A Model Energy Aligned Lease Provision, City of New York Planning Division. Available at http://www.nyc.gov/html/planyc2030/html/about/ggbp.shtml#more.
- Goldman, C., N. Hopper, J. Osborn, and T. Singer. Review of U.S. ESCO Industry Market Trends: An Empirical Analysis of Project Data. LBNL-52320. January 2005. Available at http://eetd.lbl.gov/ea/emp/reports/52320.pdf.
- Goldman, C., J. Osborn and N. Hopper, LBNL, and T. Singer, NAESCO, Market Trends in the U.S. ESCO Industry: Results from the NAESCO Database Project LBNL-49601. May 2002 Available at http://eetd.lbl.gov/ea/emp/reports/50304.pdf.

Commercial Retro-commissioning

The California Energy Commission defines retro-commissioning as the process of "systematically investigat[ing] the operation of a building's energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems." Retro-commissioning is typically only done in commercial buildings and is analogous to a tune up for a car.

- **Cost of Retro-Commissioning** – The average participant cost in 2010 was assumed to be $0.55 per square foot (ft^2). This values is based two sources: Lawrence Berkeley National Laboratory estimated average retro-commissioning costs to be $0.41 per square foot, the California Energy Commission estimated those costs to be $0.68 based on projects completed in California. The $0.55/ft^2 cost value is conservative given the Lawrence Berkeley National Laboratory median cost estimate was $0.27/ft^2. For 2020, it is assumed that the average cost for retro-commissioning will be $0.45/ft$^{2.}$
- **Energy Reductions Calculation**- The average energy reduction in 2010 from retro-commissioning was assumed to be 15%. This value is based on the same two sources referenced above: Lawrence Berkeley National Laboratory estimates average energy savings to be 19%, the California Energy Commission estimates energy savings to be 13%. To be conservative, the value used for average reductions was slightly lower than the average between the two sources but equal to the median energy reduction estimate from Lawrence Berkelely National Laboratory. The average energy reduction value used for 2020 calculations remained 15%.
- **Useful Life** – Cost calculations assumed that the useful life of retro-commissioning energy reductions was 10 years.

Sources

- Cost-effectiveness of Commercial-Buildings Commissioning. A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, Lawrence Berkeley National Laboratory, LBNL-56637, 2004. Available at eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf.

- CEC Options for Energy Efficiency in Existing Buildings - http://www.energy.ca.gov/2005publications/CEC-400-2005-039/CEC-400-2005-039-CMF.PDF.

Residential Solar Water Heating Retrofit (Single-family Units Only)

On January 21, 2010, the CPUC approved a Decision creating the CSI-Thermal Program, which allocates significant funding to promote solar water heating (SWH) through a program of direct financial incentives to retail customers, training for installers and building inspectors, and a statewide marketing campaign. Assumptions used to estimate the emission reductions from solar water heaters are provided below.

- **Cost of Solar Water Heater Installation –** CMAP cost calculations are based on an average installation cost of $6,500 for single-family units in 2010 and $6,000 in 2020. The 2010 value is based on a 2011 Itron evaluation of California Center for Sustainable Energy's (CCSE) Solar Water Heating Pilot Program. The 2020 value assumes a slight reduction in installation cost over time as more systems are installed in the City of San Diego.
- **Ratio of Electric and Natural Gas Water Heaters** – The CMAP estimate assumes that solar water heaters are installed in combination with both electric and natural gas water heaters. We further assume that 60% of the systems offset natural gas water heaters; 40% offset electric water heaters.
- **Energy Savings** – Based on Itron's evaluation, we assume that the average annual energy reduction is 117 therms for a natural gas water heater, 2,700 kWh for an electric.
- **Useful Life** – Estimates assumes a useful life of 25 years for solar water heaters.

Sources

- CSI Solar Water Heating Pilot Program Final Evaluation Report, Itron. March 2011, available at http://energycenter.org/index.php/incentive-programs/solar-water-heating/swhpp-documents/doc_download/727-swh-pilot-program-itron-final-evaluation-report.
- CPUC Decision 10-01-022 (January 21, 2010), available at http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/112748.htm.

Clean and Efficient Distributed Generation –Photovoltaics

The California Solar Initiative provides financial incentives for electric customers to install photovoltaics system on their homes and businesses.

- **Installation Cost** – CMAP cost calculations assume that the cost of installed residential photovoltaics was $8.00/watt in 2010 and will be $6.00/watt in 2020, about a 3% annual decrease. For commercial systems, the calculations assume an installed cost of $7.00/watt in 2010 and $5.00/watt in 2020, about a 3.5% annual decrease.
- **Capacity Factor** – Calculations assume a capacity factor of 20% to calculate the energy production of solar photovoltaics.
- **Useful Life** – The CMAP assumes that photovoltaics have a useful life of 25 years.
- **Decline in Energy Production** – Calculations a1% per year decline in energy production due to module degradation.

- **Operations and Maintenance** – Cost calculations include a $0.01/kWh operations and maintenance adder and an inverter replacement every 10 years. Inverter costs are assumed at $0.75/watt in 2010 and $0.50 in 2020.

Sources

- CSI Single-Installation Cost Effectiveness Tool, ES, August 2010, available at http://ethree.com/documents/CSI/CSI%20Individual%20Installation%20Tool%203_11_2011.xls
- CA solar initiative California Solar Statistics, available at http://www.californiasolarstatistics.ca.gov/.
- Galen Barbose, Naïm Darghouth, Ryan Wiser, and Joachim Seel, Tracking the Sun IV:An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1990 to 2010. Lawrence Berkeley Laboratory, December 2010, available at http://eetd.lbl.gov/ea/ems/reports/lbnl-5047e.pdf.

TRANSPORTATION MEASURES

On-road transportation accounted for approximately 53% of all greenhouse gas emissions in the City of San Diego in 2008. The City of San Diego CMAP estimated costs for 6 measures. For two measures, mass transit and signal re-timing, separate cost benefits are provided that also include monetized health benefits.

Mass Transit

Mass transit costs were based on SANDAG's estimates to increase the mode share from the current 5% all day for commuters in the region to 7.8% in 2020 and 10.1% in 2035. We assume the same changes scaled to the City commuter population. The cost to achieve the new percentage in each target year is the additional costs incurred by SANDAG for transit compared with the previous period, 1999-2010. The fuel cost saved by individuals was subtracted from the SANDAG costs. SANDAG costs are net of revenues from bus fares. The cost of a gallon of fuel was held at $3.50.

Recent estimates of monetized health benefits (Litman, 2010) from mass transit use are included as a separate cost per metric ton item in the cost effectiveness calculations. Including the estimated health benefits results in change in cost effectiveness of use of mass transit from positive to negative.

Sources

- SANDAG RTP 2020, page 327, Table 12-5 2020 Transit Plan Projected Costs and Revenues, for estimates of the operating and capital costs for transit for 1999-2010.
- SANDAG RTP 2050, Appendices, page A-26, Table A.6 Major Transit Expenditures - Revenue Constrained Plan, for the cost estimates from 2010-2020 and 2020-2035.
- 2050 Regional Transportation Plan/ Sustainable Communities Strategy, Final Environmental Impact Report, Appendices A-F, October 2011, Appendix F-1.
- Todd Litman, Evaluating Public Transportation Health Benefits, *14 June 2010, Victoria Transport Policy Institute,* For *The American Public Transportation Association, (www.vtpi.org/thbc.xls), Table 6.*

Parking Fee Strategy

Increasing parking fees for residential and commercial uses has been shown to decrease the use of vehicles in those areas. Parking fee increases and the resulting greenhouse gas reductions were applied to research-based best estimates of the number of parking spaces in the City metropolitan area over which the City has jurisdiction.

Fees obtained from the increase are assumed offset by the revenue to the City, making this a revenue neutral measure, except for minimal administrative costs for the City to operate the system.

Source

- SANDAG, Regional Transportation Plan 2050, available at: http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

Bicycle Strategy

SANDAG's regional bicycle strategy includes increasing the number of bicycle lanes conducive to commuter use. A portion of these lanes is within City boundaries and is thus expected to reduce miles commuted by conventional vehicles to provide GHG reductions within the City.

Costs were based on SANDAG's estimates of the cost for Class I and II per bicycle lane mile. Fuel savings by individuals amount to the equivalent of 8 miles per day avoided by use of a conventional vehicle. The fuel economy of personal vehicles in 2020 was estimated as 23.93 in 2020 and 27.42 in 2035. The price of gasoline was held at $3.50 per gallon.

Sources

- SANDAG, San Diego Regional Bike Plan, Riding to 2050, Unit Costs Used for Estimating Costs of Regional Bicycle Network, Table 6.1, at http://www.sandag.org/index.asp?projectid=353&fuseaction=projects.detail

- SANDAG, communication, for average bicycle commute distance in City of San Diego

Preferred Parking for Electric Vehicles

By reserving 10% and 20% of the total parking spaces in the City for electric vehicles, no additional costs are incurred except for minimal City administrative costs. Enforcement costs are assumed offset by parking fees. An administrative cost of $8 per space was assumed.

Source

- http://legacy.signonsandiego.com/uniontrib/20080601/news_1n1pkmain.html# for typical enforcement, administrative costs and fines revenues estimates in the City of San Diego.

Signal Retiming

By harmonizing speeds, traffic light retiming reduce emissions and crash damages. The cost per signal retiming was estimated from a SANDAG study of 1993, which comprehensively addressed the potential for signal retiming in the whole region. Low and high costs for

installation and engineering costs are also provided in that report. High cost estimates were used for CMAP. Capital costs are offset by individual fuel savings.

The SANDAG study also provides time savings and air pollution cost benefits. These additional savings are included as a second separate estimate for cost per metric ton of GHG avoided.

Source

- SANDAG, Traffic Signal Optimization Program, April 1994, page 4-17, Appendix C Exhibit 5.2, provided by SANDAG; and costs of pollutant emissions reductions and public health effects.

Roundabouts

Like synchronized traffic lights, roundabouts at intersections in place of stop signs or traffic signals lead to reduced emissions and reduced crash damages.

Capital costs for roundabouts are offset over their lifetime by fuel savings.

The net costs do not include costs avoided from traffic lights potentially replaced by roundabouts, time savings, air pollution savings, or crash reduction benefits.

Source

- Continued Reliance on Traffic Signals: The Cost of Missed Opportunities to Improve Traffic Flow and Safety at Urban Intersections, Casey Bergh, Richard A. Retting, Edward Myers. September 2005. Insurance Institute for Highway Safety, at www.iihs.org.
- City of San Diego Manager's Report, Feb 4, 2004, Report No 04-028, for discussions of cost of Traffic Management Plan for the Bird Rock area of La Jolla.