Mayor Jerry Sanders
Environmental Services Department
www.SDClimateMAP.org

# City of San Diego
# Climate Mitigation & Adaptation Plan

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# ACKNOWLEDGEMENTS

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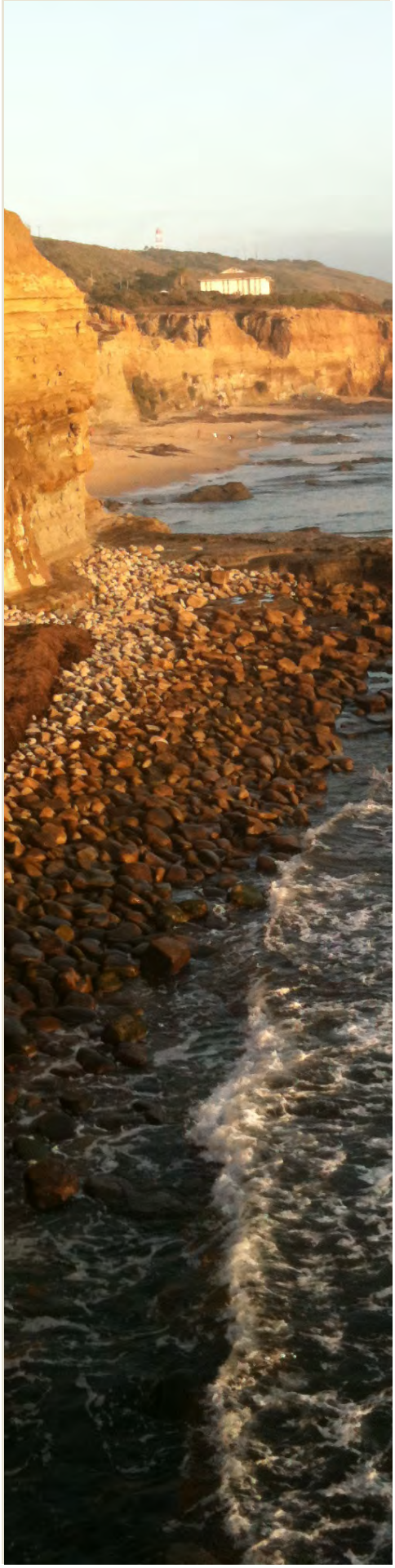

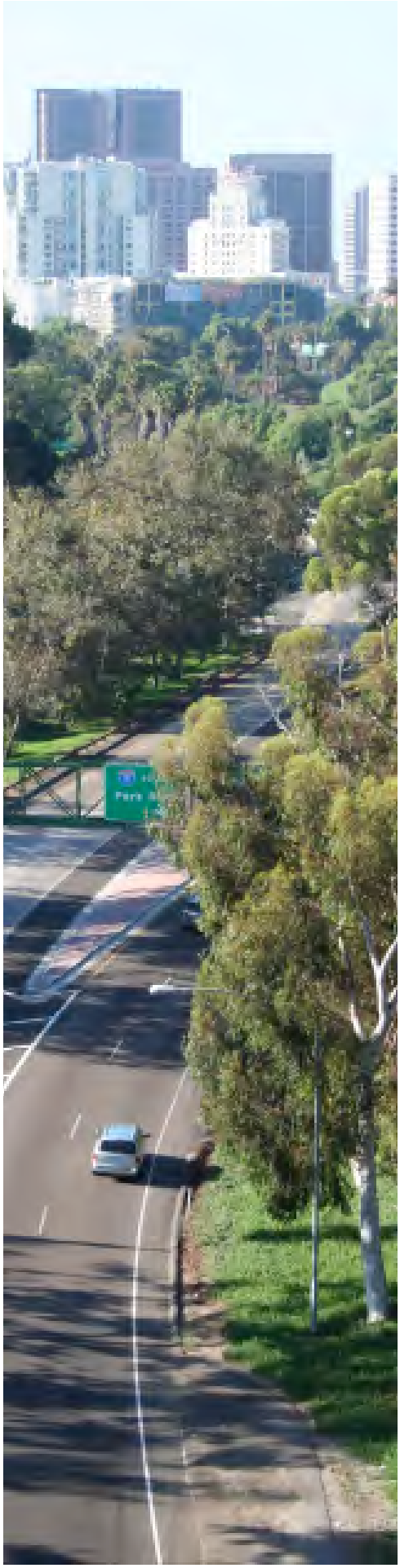

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# TABLE OF CONTENTS


Executive Summary ES-1

1. Introduction
   - 1.1 City Leadership 1-1
   - 1.2 Purpose 1-2
   - 1.3 Climate Science 1-3
   - 1.4 Economic Considerations for Climate Change 1-4

2. Regulatory and Policy Guidance
   - 2.1 State Policies 2-1
   - 2.2 Regional Actions 2-3
   - 2.3 City Actions 2-5
   - 2.4 CMAP Consistency with CEQA 2-6

3. Emissions Inventory, Forecasts, and Reduction Targets
   - 3.1 Community and Municipal Baseline Emissions 3-1
   - 3.2 Emissions for 2020 and 2035 3-3
   - 3.3 Target Reductions for 2020 and 2035 3-4

4. Greenhouse Gas Emissions Reduction Measures
   - 4.1 The Role of Local Measures 4-1
   - 4.2 Energy 4-9
   - 4.3 Transportation 4-15
   - 4.4 Land Use and Food Systems 4-18
   - 4.5 Waste Management 4-21
   - 4.6 State and Federal Actions 4-22
   - 4.7 Cost-Effectiveness of Strategies 4-23

5. Climate Adaptation
   - 5.1 Introduction 5-1
   - 5.2 Vulnerabilities, Potential Impacts, and Adaptation Recommendations 5-2
   - 5.3 Next Steps 5-10
   - 5.4 Cost-Benefit Analysis of Adaptation 5-19

6. Monitoring and Implementation 6-1

7. Conclusion 7-1

## APPENDICES


I. Glossary of Terms and Acronyms

II. Methodology for Estimating Greenhouse Gas Reductions

III. Cost-Effectiveness Methodology

IV. Participation Rates for CMAP Measures Chart

V. City of San Diego Adaptation Economic Analysis


## LIST OF FIGURES


Figure ES.1 City of San Diego Greenhouse Gas Emissions Projection, CMAP Target, and Estimated Contribution to Reduction by Emission Category

Figure 1.1 Trends in Atmospheric Concentrations and Anthropogenic Emissions of Carbon Dioxide

Figure 2.1 Per Capita Electricity Consumption versus Per Capita Gross Domestic Product

Figure 2.2 Public Agencies Addressing Climate Change in the San Diego Region

Figure 3.1 Community Emissions by Category in MMT of $Co_2e$

Figure 3.2 Municipal Emissions by Category in MMT of $Co_2e$

Figure 3.3 Greenhouse Gas Emissions Per Capita

Figure 3.4 Electricity Consumed Per Capita

Figure 3.5 Gross VMT and VMT Per Capita

Figure 3.6 Projected Community Emissions by Category

Figure 3.7 City of San Diego Greenhouse Gas Emissions Projection, CMAP Target, and Estimated Contribution to Reduction by Emission Category

Figure 4.2 Cost of Transportation Measures for 2020 – Effects of Health Benefits on Selected Measures

Figure 5.1 Estimated Cost in Terms of Percent Rainfall Increase

Figure 6.1 Monitoring Flow Diagram


## LIST OF TABLES


Table ES.1 2020, 2035 and 2050 Target Reductions in Million Metric of $Co_2e$

Table ES.2 Emission Categories, Strategies, and Target

Table 3.1 GHG Inventory for 2004, 2007, and 2008 in MT of $Co_2e$

Table 3.2 Baseline, Projections, and Target Emissions

Table 4.1 Local and State/Federal Strategies and Related GHG Emission Reductions for 2020 and 2035 to Reach Target

Table 4.2 Greenhouse Gas Reduction Strategies for 2020 and 2035 in Metric Tons

Table 4.3 Emission Categories and Related Strategies

Table 4.4 Energy Measures
Table 4.5 Residential Building Retrofit Targets
Table 4.6 Commercial Building Retrofit Targets
Table 4.7 City Facility Retrofit Targets
Table 4.8 Commercial Retrocommissioning Targets
Table 4.9 New Construction Efficiency Targets
Table 4.10 Water Efficiency Targets
Table 4.11 Residential Solar Water Heating Targets
Table 4.12 Commercial Solar Water Heating Targets
Table 4.13 Clean and Efficient Distributed Generation Targets
Table 4.14 On-Site Renewable Energy Generation Targets
Table 4.15 Transportation Measures
Table 4.16 Single-Occupancy Vehicle Reduction Targets
Table 4.17 Expanded Bicycle Infrastructure Targets
Table 4.18 Parking Management Targets
Table 4.19 Traffic Signal and Roundabout Targets
Table 4.20 Electric Vehicle Targets
Table 4.21 City Fleet Zero Emissions Vehicle Targets
Table 4.22 Land Use and Food Systems Measures
Table 4.23 Smart Growth Targets
Table 4.24 Local Food Production and Availability Targets
Table 4.25 Waste Management Local Measures
Table 4.26 Trash Diversion Targets
Table 4.27 Landfill Gas Capture Targets
Table 4.28 Sewage Treatment Gas Targets
Table 4.29 Summary Strategies Cost Effectiveness ($2010/MT $CO_2e$)
Table 5.1 Adaptation Strategies Table
Table 5.2 Year 2050 Losses/Costs Associated with Beach Erosion (millions of 2010 dollars)
Table 5.3 100-Year Flood Damages (millions of 2010 dollars)
Table 5.4 Approximate Volume of Rainfall in Mission Beach

Old Town San Diego

# EXECUTIVE SUMMARY

The City of San Diego (the City) 2012 Climate Mitigation and Adaptation Plan (CMAP) identifies strategies and measures to meet greenhouse gas (GHG) reduction targets, and lists general approaches to adapt to a changing climate. Attainment of the reduction targets requires commitment to local and regional actions as well as continued implementation of federal and state mandates. These actions and associated co-benefits will contribute to the City's current and future prosperity and sustainability by: 1) conserving resources such as energy and water; 2) fostering the creation of green jobs; and 3) furthering San Diego's leadership in clean technology industries. Chapter 1 details the City's leadership thus far, and also summarizes the climate science and economic considerations for taking action to reduce GHG emissions.

The 2012 CMAP establishes a planning horizon of 2013-2035 and quantifies GHG emissions from the community-at-large and City operations; establishes reduction targets for 2020, 2035 and 2050 (See Figure E.1 below); identifies strategies and measures to reduce GHG levels, focusing on those that the City has authority to implement; and provides guidance for monitoring progress on an annual basis. In addition, the CMAP highlights climate change vulnerabilities, adaptation strategies, and recommendations for further research.

**Table ES.1: 2020, 2035, and 2050 Target Reductions in MMT of $CO_2e$**

| Target | MMT $CO_2e$ | Percent Reduction |
|---|---|---|
| Baseline | 12.65 | 0% below baseline |
| 2020 Target | 10.75 | 15% below baseline |
| 2035 Target | 6.45 | 49% below baseline |
| 2050 Target | 2.15 | 83% below baseline |

The 2012 CMAP includes the following four categories of GHG sources and associated reduction strategies:

1. The **Energy** strategy aims to reduce GHG emissions by improving the energy efficiency of both new and existing residential and commercial buildings, increasing the use of renewable and efficient energy production, improving communitywide understanding of energy management, and highlighting the water-energy nexus.

2. The **Transportation** strategy focuses on reducing emissions by reducing vehicle miles traveled (VMT) through multimodal transportation options, by decreasing the energy intensity per mile traveled by reducing idling, and increasing electric vehicle use by improving the electric vehicle infrastructure.

3. The **Land Use & Local Food System** strategy reduces emissions by supporting the City's General Plan (GP) that will result in more compact, walkable, transit-accessible neighborhoods and by strengthening the regional food system, including expanding urban agriculture activities.

4. The **Waste** strategy reduces emissions by diverting waste from landfills, and supports continual improvement in equipment and operations for wastewater treatment and landfill management.

Implementing the 2012 CMAP demonstrates to investors, businesses and residents that San Diego is acknowledging the impacts of a changing climate and is committed to keeping this in the forefront of decision-making. Successful implementation will allow the City to contribute its fair share toward achieving California's 2020 Greenhouse Gas reduction target.

While some see the threat of climate change as pitting the needs of the planet against those of progress and business, some entrepreneurs will seize the opportunities created by efforts to build a more sustainable future.

Chapter 2 provides an overview of the actions taking place at the federal, state, regional and local level that supports GHG reductions and climate adaptation.

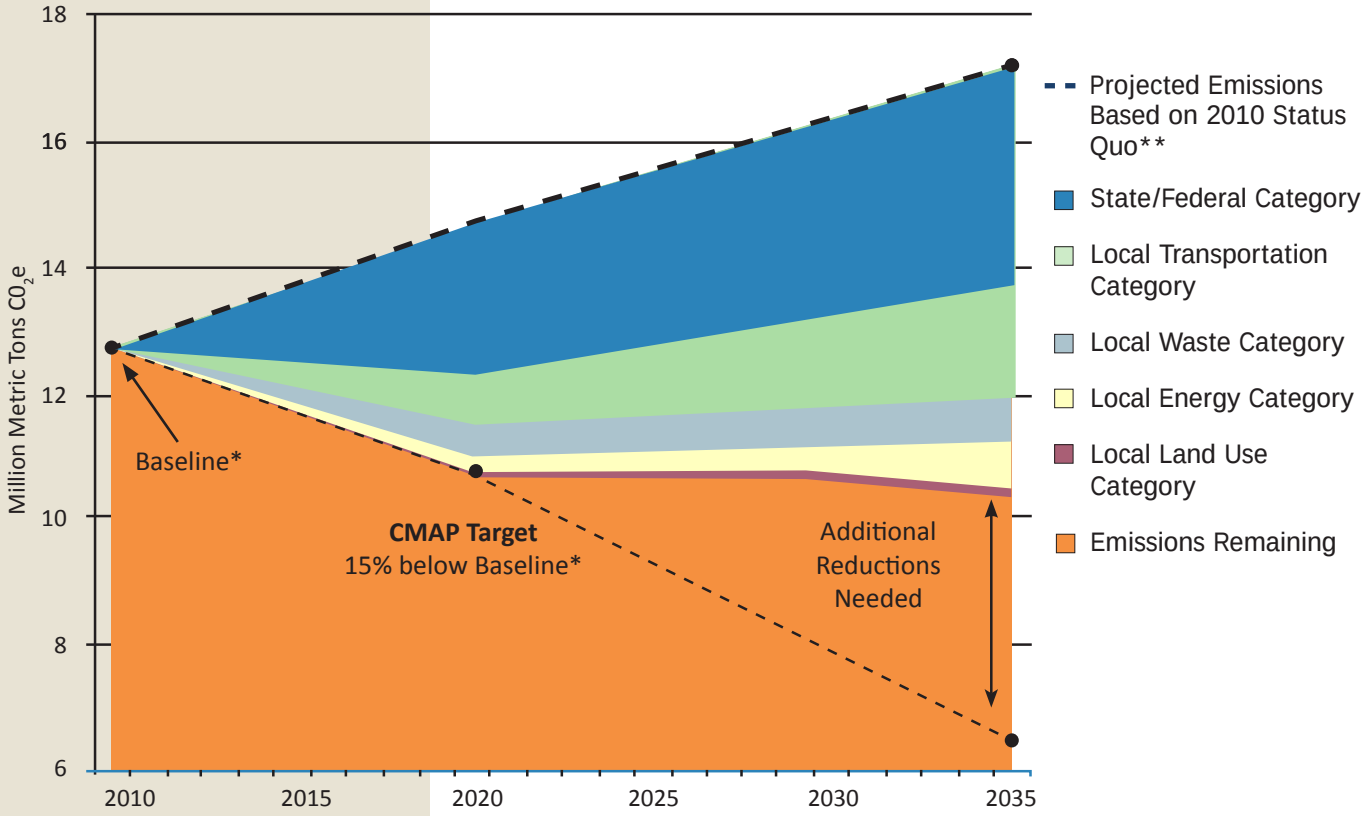
Chapter 3 identifies the GHG emissions as they relate to key sources such as transportation and electricity, and provides more details about the projections and reduction targets.

Chapter 4 is a detailed review of the GHG reduction measures. Table ES.2 is a summary of these measures, and includes the City's proposed GHG reduction categories.

As previously noted, the CMAP identifies the long-term impacts from a changing climate. Chapter 5 explains these impacts and offers recommendations for the City to take prudent action that will ensure a more resilient community for generations to come.

Figure ES.1 illustrates the reduction trajectory and highlights the role that State and Federal mandates have in achieving approximately 59% of the 2020 target and approximately 51% of the 2035 target.

**Figure ES.1: City of San Diego Greenhouse Gas Emissions Projection, CMAP Target, and Estimated Contribution to Reduction by Emission Category**




* Baseline is an average of 2004, 2007, and 2008

** Status Quo includes the proportion of the Renewable Portfolio Standard and Pavley 1 that was implemented as of 2010

The 2012 CMAP introduces the annual Monitoring Report in Chapter 6 that will track the progress of GHG emissions reductions. This will be comprised of two sets of information. First, an expanded stakeholder working group will develop more specific action steps for a number of measures. Second, and as a way to inform this process, an inventory of GHG emissions will be completed on an annual basis. The Monitoring Report will be a public document and presented to the Mayor and City Council each year.

**Table ES.2: Emissions Categories, Strategies, and Target**

| Emissions Categories | Strategies | Target |
|---|---|---|
| State and Federal | Support implementation of related state and federal policies | Achieve a 33% Renewable Portfolio Standard by 2020. |
| | | CAFE/Pavley I: Achieve 39 mpg for new passenger cars and 34 mpg for light duty trucks by 2016. |
| | | Low Carbon Fuel Standard: Achieve 10% reduction in carbon intensity of transportation fuels by 2020. |
| | | CARB Tire Pressure Program. |
| | | CARB Heavy Duty Vehicle Regulation. |
| Transportation | Improve Multimodal Transportation Options | Increase mode share by 8% by 2020 and 10% by 2035. |
| | | Support SANDAG in achieving target of reducing per capita emissions from transportation 7% by 2020 and 13% by 2020. |
| | | Increase bike lane miles per square mile to 4 by 2020 and 8 by 2035. |
| | | Decrease parking spaces in the San Diego Metro area 10% by 2020 and 20% by 2035. |
| | | Increase downtown parking prices per day to $24 by 2020 and $30 by 2035. |
| | Conserve Fuel | Re-time traffic signals on 15 intersections and install roundabouts on 15 intersections by 2020 and 20 intersections by 2035. |
| | Switch to Alternative Fuels | Reserve 10% of parking spaces for electric vehicles by 2020 and 20% by 2035. |
| | | Increase the number of miles driven by electric vehicles to 4% by 2020 and 11% by 2035. |
| | | Increase zero emissions passenger and light duty trucks to 50% of the City's municipal fleet by 2020 and 100% by 2035. |
| Waste | Improve waste management efficiency | Divert 75% of trash from landfill disposal by 2020. |
| | | Capture 80% of methane from landfills by 2020. |
| | | Capture 98% of wastewater treatment gas by 2020. |
| Energy | Improve Building Efficiency | Retrofit existing single-family homes for 30% energy savings per unit (10% of homes by 2020, and 25% by 2035). Retrofit existing multi-family homes for 20% energy savings per unit (15% by 2020, and 30% by 2035). |
| | | Retrofit existing commercial square footage to achieve 15% energy savings per unit (10% of units by 2020, and 25% by 2035). |
| | | Retrofit existing City facilities and infrastructure to achieve energy savings of 20% by 2020, and 30% by 2035. |
| | | Retrocommission 10% of existing commercial square footage to achieve 15% energy savings per unit by 2020, and 25% of existing commercial square footage to achieve 15% energy savings per unit by 2035. |
| | | Improve energy efficiency of new residential and commercial buildings by 15% by 2020. |
| | Increase Water Conservation | Improve water use efficiency by reducing daily per capita water consumption to achieve SB7X goal of 142 daily gallons per capita by 2020 and 116 daily gallons per capita by 2035. |
| | Increase Renewable Energy Use | Install solar water heaters on 5% of existing homes by 2020 and 15% by 2035. Replace 5% of commercial natural gas used to heat water by 2020 and 15% by 2035. |
| | | Achieve 350 megawatts (200 MW photovoltaic, 150 MW cogeneration) of clean and efficient distributed energy generation by 2020 and 800 megawatts (550 MW photovoltaic, 250 MW cogeneration) by 2035. |
| Land Use and Food Systems | Effective Land Use | Achieve better walkability and transit-supportive densities in targeted locations identified in community plans by increasing population density 12% by 2020 and 27% by 2035. |
| | | Implement strategies to reduce the urban heat island effect. |
| | | Advocate for sequestration of GHG through land use practices. |
| | Expand Development of Local Food Systems | Increase availability of local food options 50% by 2020. |

**Otay Water Treatment Plant**

# CHAPTER 1 - INTRODUCTION

San Diego is a vibrant city of 1,307,000 people with a magnificent natural setting featuring the sea on one side and mountains on the other. It is a mosaic of diverse neighborhoods and a revitalized, thriving downtown. The San Diego regional economy continues to undergo a dynamic transformation from one that had been based on military and defense spending to an economy that is propelled by high-technology companies competing in the international marketplace. Following manufacturing and the military, the tourism industry is the third largest economic sector in the City. Collectively, there have been dramatic increases in the gross regional product, exports, per capita income, and employment. This resilient economy is a testament to the determination and ingenuity of the people.

San Diego has the distinction of being a national leader in many areas, including:

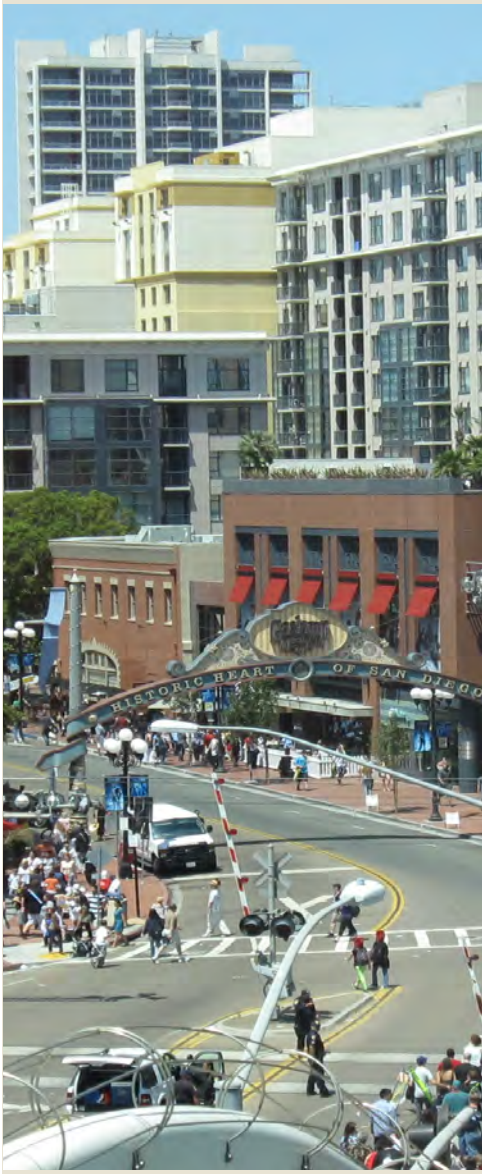
- More solar power generation than any other city in the nation for four years, and continues to be the leader in the State of California.
- State designated iHub Innovation Center created for solar, energy storage and biofuels, and an established reputation for successful collaboration between wireless and life science industries.
- Early adoption of electric vehicle use, with large investments in infrastructure to support the thousands of electric vehicles projected to be in use in San Diego in the next few years.
- Leading research and development programs funded by the United States Department of Defense to design and apply more sustainable energy generation, micro grid and smart grid systems.
- More organic farms and more organically grown produce than any other county in the nation.
- World-class academic and research institutions with at least three universities and three nonprofit organizations investing in climate science.

## 1.1 CITY LEADERSHIP

The City has taken great strides to increase energy efficiency and the generation of renewable energy. Through a California Public Utilities Commission (CPUC) funded initiative, San Diego Gas and Electric (SDG&E) and the City established a Local Government Partnership (LGP) that focuses on reducing the use of electricity and natural gas in municipal operations and within the community. Between 2006 and 2009, the goal of the LGP was to reduce electricity use by 3.8 million kilowatt hours (kWh) and gas use by 110,000 therms. The actual reductions were more than 4 million kWh, 106% of the electricity target, and nearly 131,000 therms, 119% of the natural gas target.

In total, the City's renewable energy generation is equal to about 50% of the City's total municipal electricity needs. Over 22 Megawatts (MW) of renewable energy is produced annually at City facilities. This is a benefit to the City and also decreases the energy load on the SDG&E system. The City's Miramar Landfill and the Metro Biosolids Center provide methane gas for a cogeneration facility that produces more than 13 MW of energy. This meets the needs of the North City Water Reclamation Plant, the Metro Biosolids Center, and the Miramar

The commitment by all sectors of the community is pivotal to the City's economic growth and a healthier environment.




A major accomplishment of the 2009-2012 **Local Government Partnership** was a regional collaboration on standards for upgrading outdoor streetlights. The City led the way with a streetlight conversion of more than 37,000 fixtures. This initiative reduces annual energy consumption by 50 million kWh, which equates to a reduction of 22,000 tons of GHG emissions, and an annual savings to taxpayers of about $3 million in combined energy and maintenance costs.

The City's **"Cleantech Initiative"** provides economic development assistance to local cleantech companies. According to CleanTECH San Diego (www.cleantechsandiego.org) there are more than 850 cleantech companies in the San Diego region. These companies are pursuing advances in biofuels, clean transportation, clean energy storage, energy efficiency, smart grid, and solar energy generation. The City's primary economic development platform is the Business & Industry Incentive Program. This authorizes City services for cleantech project advocacy and streamlined permit review processes, as well as reimbursement of all or a portion of building and/or development-related fees.

The 2012 CMAP builds on the **2005 Climate Protection Action Plan**. The most significant additions are: 1) more emphasis on communitywide emissions; and 2) incorporation of adaptation principles and regional vulnerability. The most significant risks for this region include: increased temperature and heat waves; pressure on water and energy resources; increase in the frequency and size of wildfires; diminished air quality; increases in respiratory and cardiovascular diseases; and sea level rise with coastal erosion.

Landfill, and the excess energy is sent to the Marine Corps Air Station Miramar and the power grid. The Point Loma Wastewater Treatment Plant (PLWTP) has a gas utilization facility that produces 4.6 MW of electricity and a hydroelectric system that produces 1.4 MW. The PLWTP is also injecting its excess digester gas into the SDG&E natural gas pipeline for use in 4.5 MW of ultra clean fuel cells. The City also has photovoltaic (solar) systems installed at various facilities, including water treatment plants. The combined renewable energy produced is approximately 2 MW of renewable energy.

The City of San Diego Car Share electric vehicle (EV) pilot project (Car2Go) is the first of its kind in the United States. National studies show that each shared car removes 15 personally owned vehicles from the road. Car2Go will have 300 EVs available for members to lease. This is possible because the City and strategic partners are installing 1,000 electric charging stations throughout the San Diego region, and about 70% will be within the City. It is projected that by the end of 2012 the total number of EV owners will be more than 2,500 City of San Diego residents.

## 1.2 PURPOSE

The City's first Climate Protection Action Plan was approved by the Mayor and City Council in 2005, and was central to fostering heightened awareness and "climate change literacy" within the City organization and the community. Most of the measures were focused on City operations, and many of the reduction goals were achieved. However, the communitywide GHG inventories for 2004, 2007, 2008, and 2009 show that emissions have continued to increase.

The City of San Diego's General Plan Program Environmental Impact Report (PEIR) Mitigation Monitoring and Reporting Program (MMRP) specifically discusses the mitigation of climate change (pages 49-50). The MMRP references the General Plan Action Plan (Action Plan), which was adopted in 2009; one year after the General Plan was adopted. The Action Plan is monitored and a progress assessment is reported annually. Therefore, the CMAP will support the City's actions to reduce GHG emissions of future development under the General Plan. The two key polices in the General Plan's Conservation Element are:

- Policy CE-A.2 to "reduce the City's carbon footprint" and to "develop and adopt new or amended regulations, programs and incentives as appropriate to implement the goals and policies set forth" related to climate change.
- Policy CE-A.13 to "regularly monitor, update, and implement the City's Climate Protection Action Plan, to ensure, at a minimum, compliance with all applicable federal, state, and local laws."

Strengthened policies that reduce the City's carbon footprint referenced in the CMAP include support of sustainable land use patterns and alternative modes of transportation, guidance for improved energy efficiency in buildings and appliances and reducing the Urban Heat Island effect, and actions to reduce GHG emissions associated with landfills and wastewater treatment. To summarize, the 2012 CMAP addresses the following needs:

- Identifies targets, strategies and measures to reduce GHG emissions consistent with AB32 and CEQA guidelines;

- Complies with the adopted 2008 City of San Diego General Plan which specifically references the development of a Climate Action Plan in the Conservation Element; and
- Identifies climate change vulnerabilities, adaptation strategies, and areas for further research.

## 1.3 CLIMATE SCIENCE

What are greenhouse gases? Many chemical compounds found in the Earth's atmosphere act as "greenhouse gases." These gases allow sunlight to enter the atmosphere freely. When sunlight strikes the Earth's surface, some of it is reflected back towards space as infrared radiation (heat). GHGs absorb this infrared radiation and trap the heat in the atmosphere. Over time, the amount of energy sent from the sun to the Earth's surface should be about the same as the amount of energy radiated back into space, leaving the temperature of the Earth's surface roughly constant. Many gases exhibit these "greenhouse" properties. Some of them occur in nature, such as water vapor, carbon dioxide, methane, and nitrous oxide; others, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$) result exclusively from human industrial processes. For thousands of years, the interaction between GHGs created through natural processes and the natural "sinks" that absorb them have kept levels fairly constant. The natural sources include decomposition of organic material, forest fires and volcanic activity. The largest natural sinks that absorb carbon dioxide are forests and oceans.

Levels of several important GHGs have increased by about 25% since large-scale industrialization began around 150 years ago (Figure 1.1). During the past 20 years, approximately three-quarters of human-made carbon dioxide emissions were from burning fossil fuels (EIA.DOE.GOV). Many other human activities result in higher concentrations of GHG, such as raising livestock and deforestation. The once stable levels of GHG are now increasing at a rate of about two parts per million (ppm) per year since the 1970s. In 2012, the GHG concentration reached 392 ppm, the highest level in more than 850,000 years (US DOC, NOAA, ESRL-GMD). This problem is compounded because it takes about 100 years for GHG to break down. Therefore, our actions, in addition to those of our parents and grandparents, combine in the atmosphere to trap infrared radiation (heat) from the sun.

**What is considered the baseline for GHG emissions?**

For additional definitions, please refer to Appendix I - Glossary of Terms and Acronyms.

According to the California Air Resources Board (CARB), in general, Baseline Actual Emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a two-year period which precedes the particular date and which is representative of normal source operation. For purposes of creating the baseline emissions, local governments estimate emissions from government operations and community-level.

**Government operations inventories** include emissions from all of the operations that a local government owns or controls. Common sectors in a government operations inventory include local government buildings and other facilities, streetlights and traffic signals, and water delivery facilities. After completing a government operations inventory, the local government can lead by example by pursuing mitigation efforts that illustrate the possibilities of mitigation actions to the community.

**Community-level inventories** include emissions from all community activities within the local government's jurisdiction, including emissions from all sectors in that community, such as energy, transportation, agricultural, industrial, and waste. A community-wide inventory is a useful planning tool in developing mitigation actions for the entire community.

In 2011, the **San Diego Regional Climate Education Partnership** commissioned a survey of residents in the region to determine the knowledge base about climate science. Within the City of San Diego, roughly 87% thought that climate change was happening and 13% thought it was not.

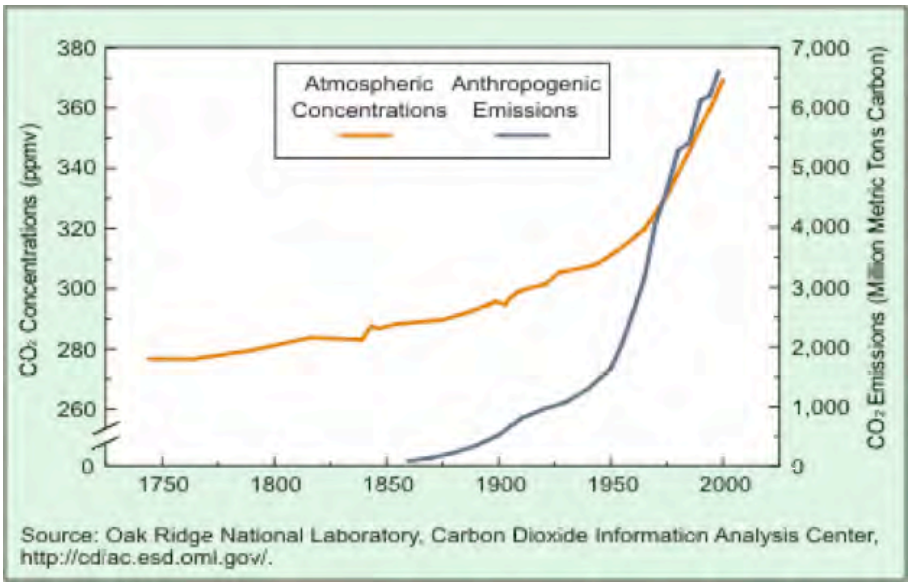
| Answers | % | |
|---|---|---|
| Yes, extremely sure | 36% | 87% |
| Yes, very sure | 28% | |
| Yes, somewhat sure | 18% | |
| Yes, but not sure | 5% | |
| | | |
| No, extremely sure | 4% | 13% |
| No, very sure | 3% | |
| No, somewhat sure | 4% | |
| No, but not sure | 2% | |

Reference: Fairbank, Maslin, Maullin, Metz & Associates for the San Diego Regional Climate Education Partnership

### What is a metric ton of $CO_2e$?

GHG emissions are reported as metric tons (MT) of $CO_2e$. Emitting 1 MT $CO_2e$ is equal to each of the following: emissions caused by the combustion of 102 gallons of gasoline; 41 propane cylinders used for home barbecues; and one month's worth of energy used in a house. In contrast, reducing 1 MT $CO_2e$ would require: Growing 25 tree seedlings for 10 years or recycling 600 pounds of waste instead of throwing it away. Equivalencies are approximate and were adapted from http://www.epa.gov/cleanenergy/energy-resources/.

**Figure 1.1: Trends in Atmospheric Concentrations and Anthropogenic Emissions of Carbon Dioxide**




Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.ornl.gov/.

The concentration of GHGs in the atmosphere, measured in parts per million, is the accumulation of gases for up to 100 years. This and other measurable data eliminates debate among credible scientists about fundamental climate science facts. In February 2007, thousands of scientific experts collectively known as the Intergovernmental Panel on Climate Change (IPCC) concluded that there is greater than 90% likelihood that people are causing global warming (IPCC, 2007). There is a direct correlation between increases in GHG and increases in the average global temperature (United States Global Change Research Program, 2012). Even very slight increases in the average global temperature impacts airflow patterns and ocean currents, and this is what plays a major role in changing the climate. While a one or two degree Celsius change in the overall global temperature may not seem noteworthy, the impacts are dramatic and felt worldwide in different ways. This includes more severe storms, desertification, heat waves and melting glaciers.

The State of California, informed by science and committed to environmental stewardship, established the 2020 GHG reduction mandates in the Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32). This is what guides the City's efforts.

## 1.4 ECONOMIC CONSIDERATIONS FOR CLIMATE CHANGE

The California Air Resources Board (CARB), the lead agency in implementing AB 32, projected that AB 32 would produce a net gain of 120,000 jobs in California by 2020. The CARB has also published a publicly vetted economic analysis that includes the following list related to job growth:

- California has three decades of experience in improving energy efficiency, saving the state billions of dollars and generating hundreds of thousands of jobs.

- The state's energy efficiency policies since the 1970s have saved Californians $56 billion, and are expected to save another $23 billion over the next five years – money that is reinvested back into the California economy. (Energy Efficiency: California's Highest-Priority Resource, California Public Utilities Commission and California Energy Commission)

- California's energy efficiency policies created 1.5 million jobs with a total payroll of over $45 billion. (Energy Efficiency, Innovation, and Job Creation in California)

- California's climate policies are making California a leader in green jobs and investment, drawing investment and new companies into the state.

- California entrepreneurs opened more green businesses (10,209) and created more new jobs (125,390) from 1998 to 2007 than any other state. (The Clean Energy Economy, Pew Charitable Trusts - www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf)

- While the rest of the economy struggled with job losses of 1%, the cleantech sector surged ahead in 2007-2008 with growth of 5%. The green economy could soon become the nation's fastest-growing job segment, accounting for roughly 10% of new jobs over the next 20 years – up to 4.2 million new green jobs – 500,000 in California. (Many Shades of Green: Diversity and Distribution of California's Green Jobs, Next 10; Metro Economics: Current and Potential Green Jobs in the U.S. Economy, U.S. Conference of Mayors www.nextten.org/next10/pdf/ Many_Shades_of_Green_1209.pdf)

- Three of every five dollars invested in the country's clean technology sector comes to California, five times more than our nearest competitor.

The nonprofit, nonpartisan organization **Next 10** recently published the most comprehensive accounting to date of green businesses, jobs and green job growth throughout the state. The report found that California green businesses have increased 45% in number and 36% in employment from 1995-2008, while total jobs in California expanded 13%. Additionally, as the economy slowed between 2007 and 2008, total employment in California fell 1%, but green jobs showed growth of 5%.

### Business Expansion, Attraction, and Retention

The Mayor's Office of Economic Growth Services has a proactive Business Expansion, Attraction and Retention (BEAR) Team that works directly with key businesses in targeted industries to provide assistance and incentives that result in the retention and creation of jobs and investment in San Diego.

Selected community colleges in San Diego have established Centers of Excellence (COE) that focus on economic and workforce development. A recent report, Clean Jobs in the San Diego Region, concludes that the San Diego region is consistently ranked 3rd in green job activity in California. There are an estimated 37,700 jobs where more than 50% of the work conducted is considered green. The following information identifies the key categories of green jobs in the San Diego region:

### Definitions

**Mitigation** is reducing GHG emissions now in order to slow the rate of increase in the atmosphere. Successful mitigation at local, national and international levels will reduce the impacts of a changing climate for future generations. This is the legacy we leave.

**Adaptation** is the response to the changes that are occurring because of the excessive human-induced GHGs that have been collecting in the atmosphere for the past 100 years. While mitigation strategies are similar for most areas of the United States, the way that a community chooses to adapt to a changing climate is very specific for each region.

For additional definitions, please refer to Appendix I - Glossary of Terms and Acronyms.

To better understand the domestic job potential from green buildings, the U.S. Green Building Council (USGBC) asked Booz Allen to estimate the number of jobs associated with the more resource-efficient **"green" building market**. Recent articles and studies have tried to estimate the number of **"green collar jobs"** that will be created from various national energy proposals, but few studies have focused exclusively on green building employment opportunities. The results are below:

From 2000–2008, the green construction market has:

- Generated $173 billion in GDP
- Supported over 2.4 million jobs
- Provided $123 billion in labor earnings

From 2009–2013, this study forecasts that green construction will:

- Generate an additional $554 billion in GDP
- Support over 7.9 million jobs
- Provide $396 billion in labor earnings

- Employment led by energy efficiency and green building (39% or close to 15,000 jobs)
- Treatment and conservation of water, recycling wastewater and solid waste management (more than 4,000 direct jobs in cluster)
- Producing alternative fuels, environmentally friendly practices in farming (as many as 3,700 direct jobs in natural and sustainable product manufacturing)
- Developing the technology, manufacturing, and servicing alternative fuel vehicles and transportation systems policy, management and business applications that involve reducing negative environmental impacts (more than 5,100 estimated direct jobs)

Direction from the State of California may significantly affect the cost-benefit of both mitigation and adaptation. Two key factors are "Cap and Trade" and the recent mandate by the State Insurance Commissioner.

**Cap and Trade**: This approach is a blend of regulatory "caps" on GHG levels and market mechanisms to encourage emission reductions. An overall 2020 targeted limit of 334.2 MMT of $CO_2e$ on GHG emissions from most of the California economy – the "capped sectors" – would be established by the cap-and-trade program. Businesses that cannot meet the new cap may purchase allowances from those businesses that have gone beyond what the cap requires and have an excess of "credits". These allowances may be auctioned, distributed for free, or allocated by some combination thereof. Together, direct regulation and the cap-and-trade regulation assure that emissions are cost-effectively reduced to the level of the overall cap. The cap-and-trade approach gives facility owners, electricity deliverers, and fuel deliverers more flexibility to determine the most cost-effective way to meet emissions reduction targets than a traditional regulatory approach. It also encourages the development of innovative technologies that could reduce emissions at lower costs than control measures.

**Insurance Commissioner Mandates**: Insurance commissioners in California, New York and Washington State were the first to mandate that insurance companies report on the risks from climate change to their business and customers. How do insurers plan to deal with the risks from increasingly severe storms and wildfires, rising sea levels and other consequences of climate change? California wants this traditionally backward-looking industry (that uses historical data to estimate risk) to look forward to understand the business liabilities climate change presents. Investors also want information on the risks to be able to make better decisions regarding their investments in insurers.

# CHAPTER 2 – REGULATORY AND POLICY GUIDANCE

## 2.1 STATE POLICIES

1. For nearly 30 years, California has demonstrated a steadfast resolve to remain at the cutting edge of business and community development and environmental protection. How is this possible with a population larger than any other state in the nation (approximately 37,254,000 people in 2010) and having the eighth largest economy in the world? The gross state product (GSP) was about $1.9 trillion in 2010. Without a doubt, California has demonstrated that innovative policies, codes and standards can foster economic growth and a healthy environment.

2. California has made a name for itself by keeping per capita electricity consumption flat for the last 30 years while its population was growing and demand for energy was increasing, thanks to energy efficiency standards, called the California Energy Code (Title 24), put in place in the 1970s. During this same time period, the per capita GSP has doubled. This shows that California's economy has become less reliant on energy to produce goods and services.

3. California's Low Carbon Fuel Standard (LCFS) has received an impressive outpouring of support from a diverse range of constituents. From coast to coast, seven states (Oregon, Maryland, Massachusetts, New York, Rhode Island, Vermont, and Washington) support California's LCFS.

4. While most states in the U.S. have passed policies to grow their clean energy sectors, California has easily been the most visionary. States across the country are looking to supplant California as the leader in this growing new economy. If California's clean energy policies remain in place, we can assume that leading venture-backed states like California will receive an outsized portion of market share in these large clean energy markets going forward to 2020.

**Executive Order S-3-05:** Governor Schwarzenegger's 2005 Executive Order set the first statewide GHG reduction target. By 2020, GHG emissions are to be reduced to 1990 levels, and by 2050 the reduction should be 80% below 1990 levels. By definition, the Executive Order is directed at the Executive Branch (i.e., state agencies) only.

**Global Warming Solutions Act of 2006:** This is more commonly referred to as AB 32. It requires California to reduce statewide GHG emissions to 1990 levels by 2020. The CARB adopted the "Climate Change Scoping Plan" in August 2011 to achieve compliance with AB 32. In recognition of the critical role local governments have for successful implementation of AB 32, CARB described this role and recommended a GHG reduction goal for local governments of 15% below 2008 by 2020. This will ensure that municipal and communitywide emissions match the State's reduction target (Page ES-5, California Climate Change Scoping Plan).

**Senate Bill 375 (SB 375):** SB 375 was passed in 2008 and went into effect in 2009. It seeks to reduce passenger and light truck vehicle miles traveled (VMT) and the associated GHG emissions through better coordination of land use, housing and transportation planning. The new law requires each metropolitan planning organization in California

**California's GHG emissions are large and growing**. As the second largest emitter of GHG in the United States and one of the top twenty largest in the world, the state contributes a significant quantity of GHGs to the atmosphere (1.4% of the annual global GHG output).

California's ability to slow the rate of growth of GHG emissions is largely due to the success of its energy efficiency and renewable energy programs and a commitment to clean air and clean energy. In fact, the state's programs and commitments lowered its GHG emissions rate of growth by more than half of what it would have been otherwise. Moreover, California's energy programs and policies have had multiple benefits that include not only reducing GHG emissions, but reducing energy demand and improving air quality and public health.

**The City of San Diego's CMAP is not just good public policy consistent with California's goals; it also sets a worthy example for others states and countries to emulate.**

### What is the California Renewable Portfolio Standard?

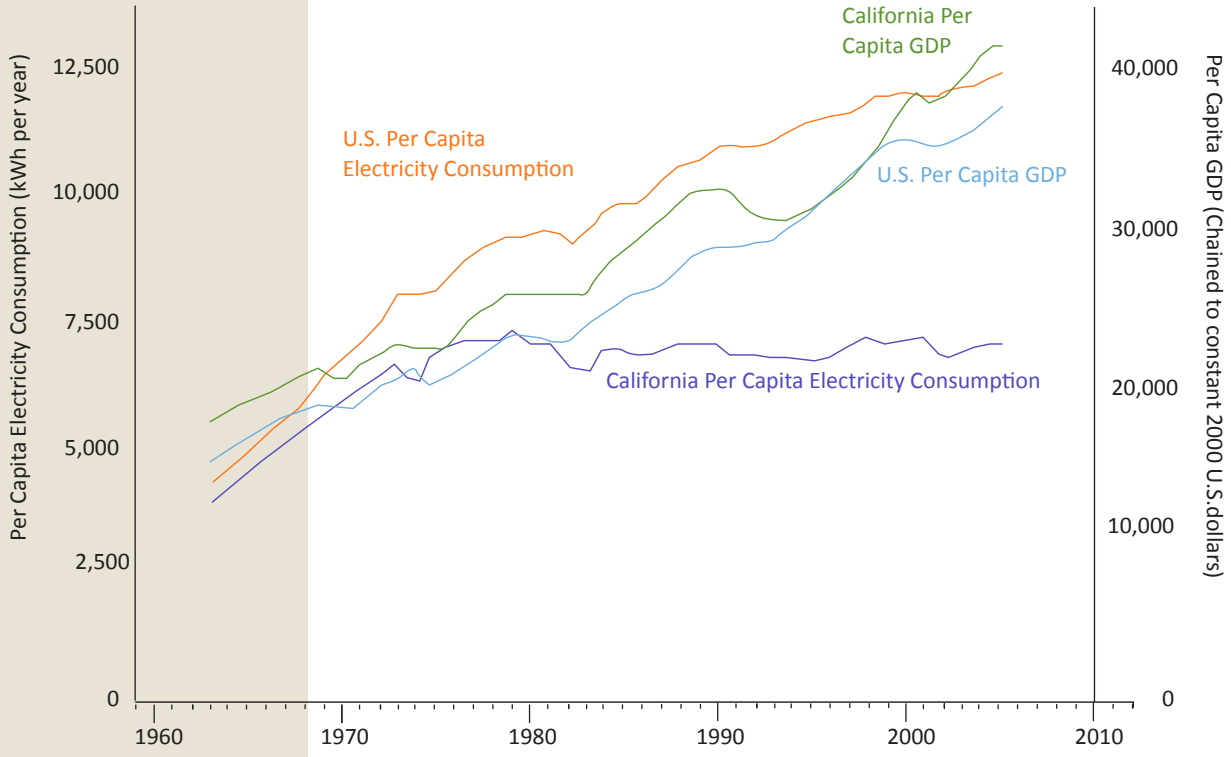
Established in 2002 under SB 1078, accelerated in 2006 under SB 107 and expanded in 2011 under SB 2, California's Renewable Portfolio Standard (RPS) is one of the most ambitious renewable energy standards in the country. The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 33% of total procurement by 2020.

to prepare a Sustainable Communities Strategy (SCS) as a part of its Regional Transportation Plan (RTP). The SCS must demonstrate how regional GHG reduction targets (related to VMT from cars and light trucks) would be met through land use patterns, transportation infrastructure investments, and other measures. The GHG targets for the San Diego region call for a 7% per capita reduction by 2020 and a 13% per capita reduction by 2035. On October 28, 2011 the San Diego Association of Governments (SANDAG) Board became the first Metropolitan Planning Organization (MPO) in the state to adopt a RTP and SCS in accordance with this law.

**Senate Bill 97 (SB 97):** SB 97 mandated an update to the California Environmental Quality Act (CEQA) Guidelines in 2010 to include provisions for determining the significance of a project's GHG emissions and mitigating significant effects. SB 97 also added CEQA Guidelines section 15183.5, which allows jurisdictions to analyze and mitigate the significant effects of GHGs at a programmatic level by adopting a "Greenhouse Gas Reduction Plan" for the reduction of GHG emissions. Therefore, the City's 2012 CMAP has been prepared in compliance with CEQA Guidelines section 15183.5 so that future project-specific environmental documents may rely on the CMAP for cumulative impacts analysis.

Figure 2.1 illustrates per capita electricity consumption versus per capita gross domestic product. This demonstrates that the codes and standards in California do not impede economic growth.

**Figure 2.1: Per Capita Electricity Consumption versus Per Capita Gross Domestic Product**




**Source: Environmental Defense**

**Long-Term California Energy Efficiency Strategic Plan:** This plan was approved by the CPUC and is referenced in Decision 07-10-032 (October 2007). The strategic plan was developed through a collaborative process involving the CPUC's regulated utilities, including SDG&E. The plan sets forth a roadmap for energy efficiency in California for 2020 and beyond, and articulates a long-term vision and goals for each economic sector, identifying specific near-term, mid-term and long-term strategies to assist in achieving those goals.

**California Climate Adaptation Strategy:** In 2009, California adopted a statewide Climate Adaptation Strategy that focuses on seven sectors: Public Health, Biodiversity and Habitat, Oceans and Coastal Resources, Water, Agriculture, Forestry, and Transportation and Energy. The state's efforts to address extreme climate events focuses on strengthening the state's planning and disaster preparedness efforts and explores reasonable and practical actions to make our communities safer and more resilient to climate change. The Governor's Office of Planning and Research is coordinating with other agencies in the state to develop guidance on how local governments can proactively prepare for extreme events, which is currently under draft advisement.

## 2.2 REGIONAL ACTIONS

**GHG Inventories:** All of the cities in San Diego County have completed GHG emissions inventories, and many have completed or are in the process of completing a Climate Action Plan. This includes the Cities of Chula Vista, National City, Encinitas, the County of San Diego and the Port of San Diego. Adding to the body of knowledge is a region-wide GHG inventory that was prepared by the Energy Policy Initiatives Center (EPIC), a research center at the University of San Diego (USD) School of Law.

**SANDAG:** SANDAG was the first MPO in the state to produce a SCS as required by SB 375. The SCS is a part of the RTP. It lays out how the region will meet VMT-related GHG reduction targets set by the California Air Resources Board (CARB). As previously noted, SB 375 sets GHG targets for the San Diego region of 7% per capita reduction by 2020, and 13% per capita reduction by 2035. SANDAG also prepared a Climate Action Strategy that provides guidance on climate change strategies and identifies a range of potential policy measures – "tools in the toolbox" – for consideration as SANDAG updates long-term planning documents. The Climate Action Strategy helped inform development of the RTP-SCS and will be used as SANDAG updates the Regional Comprehensive Plan. In addition, SANDAG has established an Energy Roadmap Program that offers energy planning assistance to local governments.

**San Diego Unified Port District:** The changing climate will affect San Diego Bay's waterfront property, recreation opportunities, and wildlife habitat. As an environmental steward of San Diego Bay, the Port of San Diego (Port) is developing a CMAP to prepare for these impacts. This will be a critical tool for future planning and development of Port tidelands and will focus on a variety of strategies pertaining to sea level rise, water reuse and conservation, beach erosion, and energy demand.

**San Diego County Water Authority (SDCWA)**: The City receives approximately 85 to 90% of its water from SDCWA, which obtains water principally from the Metropolitan Water District of Southern California (MWD) and transferred water from the Imperial Irrigation District. The SDCWA Urban Water Management Plan serves as a long-range

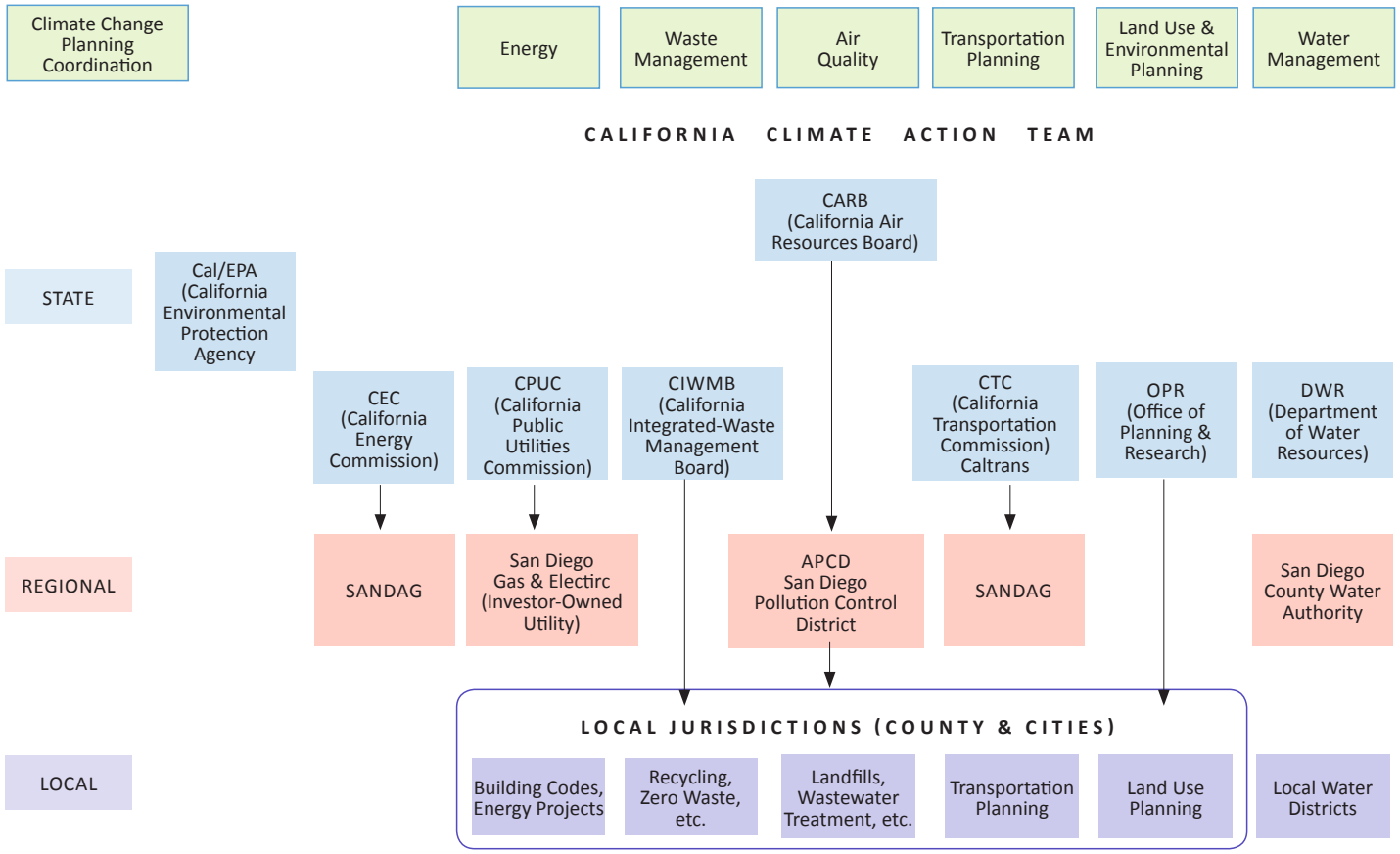
### United States Navy

The Navy's Task Force on Climate Change is a multi-layered organization that includes representatives from various Naval staff and program offices and the operational fleet, and closely collaborates with the U.S. Coast Guard and the National Oceanic and Atmospheric Administration. The Task Force developed the U.S. Navy Climate Change Roadmap, to ensure that the Navy and Marines are fully mission-capable and ready to meet training and operational needs. The Navy is examining the potential impacts from erosion threatening training areas and facilities in Marine Corps Base Camp Pendleton as well as to the Naval Base Coronado, which serves a critical service to the U.S. Pacific Fleet.

planning document for the City's water supply in accordance with the Urban Water Management Act. The plan describes the City's water supply sources, magnitudes of historical and projected water use, and compares water supply to water demands during normal, single-dry, and multiple-dry years. Additionally, the SDCWA has completed a GHG inventory, is in the process of developing a Climate Action Plan (CAP), and lastly is partnering with Scripps Institution of Oceanography (SIO) to integrate impacts of climate change into its long range planning.

**County of San Diego (County):** The County has adopted a CAP to address the issues of growth and climate change within the unincorporated areas of San Diego County. It is consistent with State law and directives, including AB 32 and CEQA Guidelines. As a supplement to the County's CAP, the County established GHG Significance Thresholds under CEQA Guidelines sections 15064.4 and 15064.7. The Significance Guidelines present a range of quantitative, qualitative, and performance levels for particular environmental effects. The purpose of these Significance Guidelines is to provide for a consistent and objective evaluation of significant effects from new projects. The Significance Guidelines were reviewed by the County of San Diego Air Pollution Control District, the local jurisdiction that enforces the Clean Air Act and CARB mandates.

**Figure 2.2: Public Agencies Addressing Climate Change in the San Diego Region**



## 2.3 CITY ACTIONS

Within the City, development and implementation of the CMAP is a continuation of the City's work to reduce GHG emissions, and is an integral part of both a federal grant as well as the City GP.

**City of San Diego 2008 General Plan:** The GP is the framework for the City's commitment to long-term conservation, sustainable growth and resource management. It addresses GHG reductions through its City of Villages growth strategy and a wide range of inter-disciplinary policies. The City of Villages strategy directs growth into compact, mixed-use, walkable centers linked by transit, which reduces the need to travel and makes alternative modes of transportation easier to use. In addition, the GP Conservation Element (Policy CE-13) calls for the City's CAP to be regularly monitored, updated, and implemented.

**City of San Diego Community Plan Updates:** There are ten community plan updates currently underway which will further implementation of the GP. As part of the scope of each plan update, the City is conducting GHG analysis and evaluating if community-specific adaptation measures are needed.

**Energy Efficiency and Conservation Block Grant (EECBG):** The U.S. Department of Energy issued the EECBG as part of the 2009 "Stimulus Funding", and the scope of work included completion of the CMAP. This was one of the projects developed by the EECBG Ad Hoc Committee in 2009 and was a component of the Energy Efficiency and Conservation Implementation Plan. The deadline for all projects to be completed under EECBG is July 2013.

**Local Government Partnership:** Under direction from the CPUC, the Independently Owned Utilities were advised to set up Local Government Partnerships with the municipalities in their service territory. The LGP was established in 2006 between the City and SDG&E. During the program cycle ending December 31, 2012, the scope of work included education and outreach for developing the CMAP.

**Environmental and Economic Sustainability Task Force (EESTF):** In November 2010, the San Diego City Council established the EESTF to provide input on the development of the CMAP. One community representative from each of the eight Council Districts and the Mayor's Office were selected and began serving on the EESTF in January 2011.

**Other Applicable City Council Policies:**

- 100-14 Procurement Policy: Recycled Products
- 200-17 Alternative Fuels
- 400-15 Comprehensive Policy for a Sustainable Water Supply in San Diego
- 600-27 Affordable/In-Fill Housing and Sustainable Buildings Expedite Program
- 600-45 Protection of Water, Agricultural, Biological and Cultural Resources within the San Pasqual Valley
- 900-02 Energy Conservation and Management, which guides City operations and supports community outreach programs

**The City of San Diego 2005 Climate Protection Action Plan (CPAP)**

The 2005 CPAP was the City's first effort to present a GHG inventory, describe climate science, and identify GHG reduction measures. It serves as a good foundation for the 2012 CMAP.

The adoption of the CMAP by the City is considered a "project" under CEQA. The overall purpose of the CMAP is to reduce the impact that the community will have on global climate change and, therefore, reduce an impact on the environment.

However, as with any proposal involving activities relating to development, implementation of the CMAP could potentially result in impacts on the physical environment. Therefore, **the City has prepared an Initial Study pursuant to CEQA** to evaluate whether there are any potential adverse environmental impacts of implementing the CMAP.

- 900-14 Sustainable Building Policy, which requires public buildings to meet green building standards
- 900-16 Construction and Demolition Material Recycling, which has significantly reduced the amount of debris being disposed at the Miramar Landfill
- 900-18 Purchase of Energy Efficient Products

### Additional City Actions Include:

- Participated with SANDAG on development of the RTP-SCS, which was developed in accordance with SB 375. The SCS demonstrates that the San Diego region will meet or exceed regional GHG targets established by the state, which call for a 7% per capita reduction in emissions resulting from vehicle miles traveled by cars and light trucks by 2020, and a 13% per capita reduction by 2035.
- Adopted building code amendments for consistency with the new California Green Building Code, also known as "CALGreen," and working toward streamlining enforcement of the mandatory requirements.
- Developed a streamlined expedite program to applicants to obtain permits for residential solar photovoltaic systems.
- Continued review of discretionary projects for conformance with GP sustainability policies.
- Participated in a multi-jurisdictional Sea Level Rise study that focused on the San Diego Bay.
- Continued progress on several water conservation and water re-use initiatives that may also result in energy savings.

## 2.4 CMAP CONSISTENCY WITH CEQA

CEQA requires the City to identify the significant environmental impacts of its discretionary actions and to avoid or mitigate those impacts, if feasible. GHG emissions are an environmental issue that requires analysis under CEQA (CEQA Guidelines section 15064.4 and Appendix G). When the City undertakes a discretionary action for a "project" under CEQA, such as approval of a proposed development project, plan, policy, or code change, the City will evaluate whether that action would result in a significant impact due to GHG emissions and climate change under CEQA.

Amendments to CEQA effective March 18, 2010 added GHG emissions to the list of environmental impacts that jurisdictions are required to examine. The CEQA amendments require that GHG significance be assessed at both a project and a cumulative level. A "Greenhouse Gas Threshold" is a metric for evaluating whether emissions from a proposed project will cross established quantitative or qualitative significance thresholds and contribute "significantly" to global emissions. Showing compliance and consistency with a CAP is one way to evaluate GHG significance. The methodology outlined below is in compliance with CEQA Guidelines section 15183.5. This process includes:

1. Completing a baseline GHG inventory and forecasting future emissions.

2. Establishing a citywide GHG reduction target.
3. Developing a CAP that creates strategies to meet the reduction target.
4. Evaluating the CAP's environmental impact.
5. Monitoring the CAP's progress.

State law allows cities to analyze and mitigate significant GHG emissions in a plan for the reduction of greenhouse gas emissions that meets certain requirements under CEQA (CEQA Guidelines section 15183.5). The CMAP was developed to serve as the City's qualified GHG reduction plan and programmatic tiering document for the purposes of CEQA for the analysis of impacts of GHG emissions and climate change. The City has determined that the 2020 Reduction Target under the CMAP will result in GHG emissions from activities covered by the CMAP to be less than cumulatively considerable under CEQA. Therefore, the CMAP can be used as a qualified GHG reduction plan for tiering purposes through 2020.

**The California Environmental Quality Act (CEQA)** is a California statute passed in 1970, shortly after the United States federal government passed the National Environmental Policy Act (NEPA), to institute a statewide policy of environmental protection. CEQA does not directly regulate land uses, but instead requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects and adopt all feasible measures to mitigate those impacts.

**San Diego Bay**

# CHAPTER 3 – EMISSIONS INVENTORY, FORECASTS, AND REDUCTION TARGETS

**The baseline for the CMAP is approximately 12,652,906 Metric Tons of $CO_2e$.** The methodology that the City used to calculate the GHG emission inventories was consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. In addition to the IPCC methodology, the City referenced documents from the U.S. Environmental Protection Agency (EPA) and CARB in order to complete specific calculations.

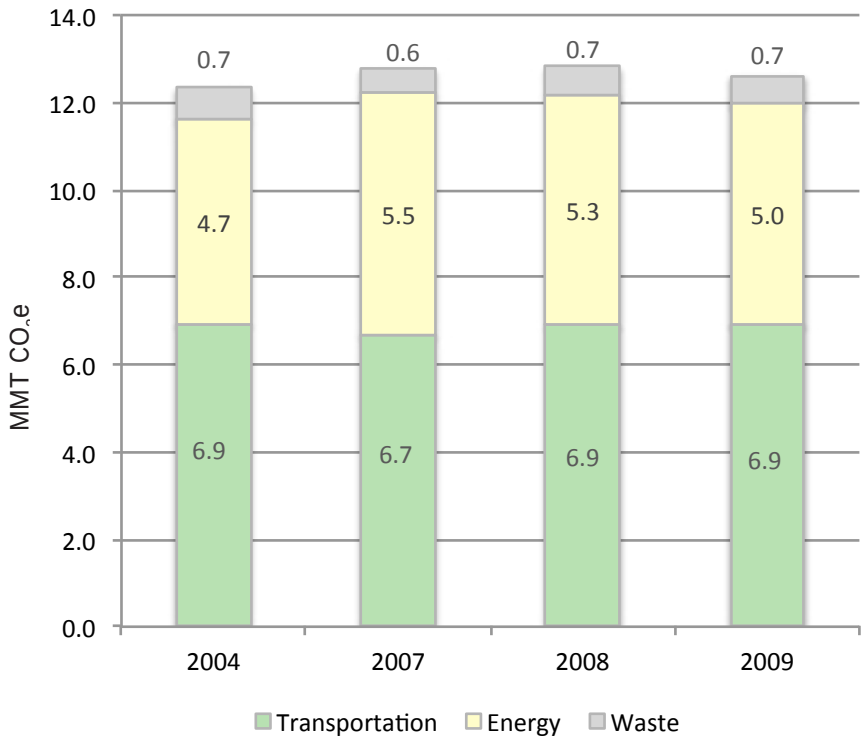
**Table 3.1: GHG Inventory for 2004, 2007, and 2008 Measured in MT of $CO_2e$**

| Year | Metric Tons $CO_2e$ | City Population |
|---|---|---|
| 2004 | 12,352,123 | 1,262,297 |
| 2007 | 12,779,000 | 1,260,905 |
| 2008 | 12,827,595 | 1,333,617 |
| Baseline (Average) | 12,652,906 | - |

## 3.1 COMMUNITY AND MUNICIPAL BASELINE EMISSIONS

The breakdown of GHG emissions in the community is very similar to that of other Southern California cities. Due to the very high frequency of single-occupancy vehicles on the road, the transportation sector results in the largest output of GHG emissions, followed by the energy sector (electricity and natural gas). Waste emissions are calculated as a combination of GHG emissions from the landfill and from the wastewater system. Figures 3.1 and 3.2 illustrate the City's communitywide and municipal baseline inventories for GHG emissions for 2004 through 2009.

**Figure 3.1: Community Emissions by Category in MMT of $CO_2e$**



Unlike other cities that are preparing CAPs, the City of San Diego is unique because GHG inventories have already been completed for 2004, 2007, 2008, and 2009. Although the City has multiple inventory years to select from, **the baseline was established by taking an average from the 2004, 2007, and 2008 inventories**. This "averaging" approach is consistent with CARB's recommendation and helps to account for the economic fluctuations during this period.

## Consumption-Based Emissions

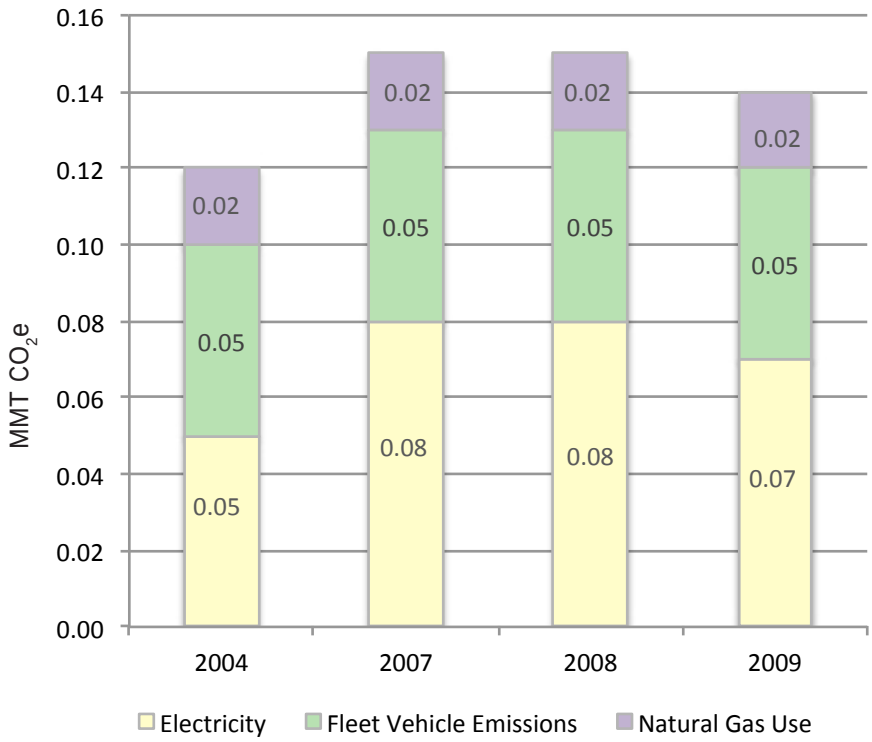
GHG inventories are most often sector-based and include energy, transportation, land use and waste management. The source of the emissions, such as those from electricity production, may be located outside of the region. Typically, however, a conventional inventory focuses on emissions that originate within a designated area, such as the City of San Diego.

A consumption-based inventory is designed to complement, not replace, traditional sector-based approaches. Its purpose is to provide a broader picture of the sources of GHG emissions. This approach has important implications, not least of which is that it provides more information for residents, businesses, and governments about the links between their own decisions as consumers and the wider climate impacts.

Understandably, the data management is much more complicated with a consumption-based approach, and there is not yet a standard methodology. The State of California is one of the few government entities to have completed a Consumption-Based Emissions Inventory (CBEI). The simple take-away message is that the creation and use of all new products and our food choices result in GHG, and most of those emissions are not captured in the sector-based inventories.

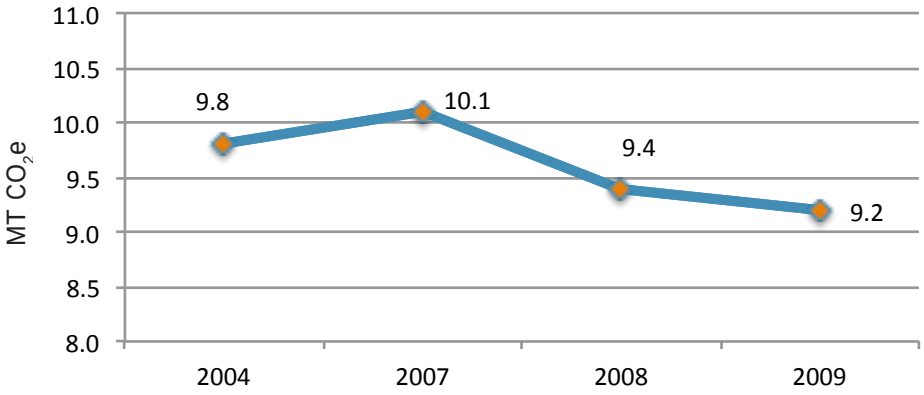
As illustrated in Figure 3.1, the community GHG emissions by category remain fairly constant between 2004 and 2009. Figure 3.2, below, illustrates the GHG emissions from City public works and operations. This contributes about 1.6% of the total GHG emissions citywide. The City's responsibilities include providing services such as water treatment and distribution, wastewater treatment, solid waste and recycling collection, landfill management, street maintenance, and data management.

**Figure 3.2: Municipal Emissions by Category in MMT of $CO_2e$**



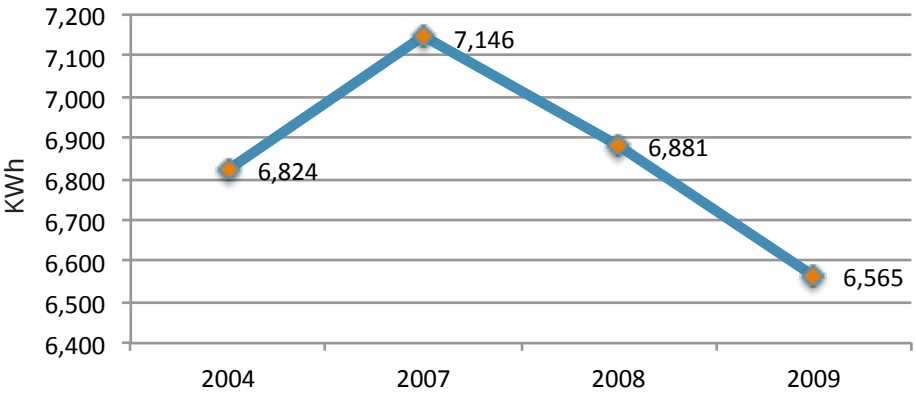

It is interesting to compare Figure 3.1 that lists the total GHG emissions and Figure 3.3, below, representing per capita emissions. Within the City, each person contributes an average of more than 9.2 metric tons per year of greenhouse gas emissions—that is the average for every man, woman and child in the City.

**Figure 3.3: Greenhouse Gas Emissions Per Capita**



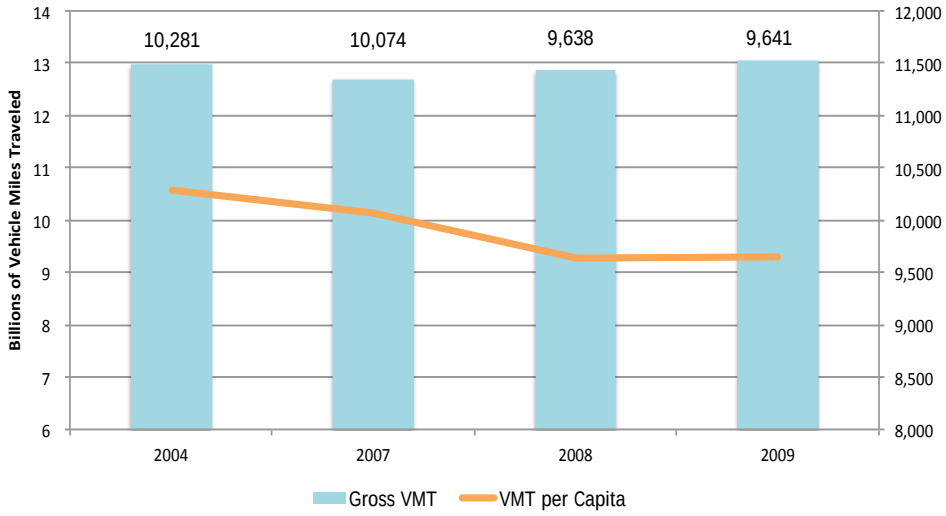

Why are GHG emissions per capita less now than in previous years? Cleaner fuels and more fuel-efficient vehicles make transportation less polluting, and the electricity we use is generated from cleaner sources. An important factor in increasing total GHG emissions is the increasing population. This continues to offset reductions in per capita emissions.

**Figure 3.4: Electricity Consumed Per Capita**




Since transportation is the leading cause of GHG emissions in San Diego, the trend in Vehicle Miles Travelled (VMT) is noteworthy. Figure 3.5 illustrates that on average the annual per capita VMT has leveled out in 2007 through 2009. However, because there are many more vehicles on the road, the cumulative VMT continues to increase.

**Figure 3.5: Gross VMT and VMT per Capita**




## 3.2 EMISSIONS FOR 2020 AND 2035

Nearly 1.4 million people live in San Diego, a 22% increase between 1990 and 2009. In 2020, the population projection is 1.5 million and in 2035, the projection is about 1.7 million. At current levels, the population growth for these target years will increase GHG emissions by 920,000 metric tons and 1,840,000 metric tons, respectively.

What is the roadmap for San Diego? Approximately 12 million metric tons of GHG, referenced as carbon dioxide equivalents ($CO_2e$), will be reduced to approximately 11 million metric tons by 2020. For the 2012 CMAP, Business As Usual (BAU) is a snapshot of 2010, including the mandates and reductions from Federal, State or local agencies, carried into the future. BAU assumes that the only circumstances that have changed between 2010-2020 are population growth and the associated energy and transportation use. Therefore, successful implementation of the CMAP will override the BAU projection and reduce GHG emissions to 15% below the 2004-2008 baseline by 2020. This is consistent with the guidelines provided by CARB.

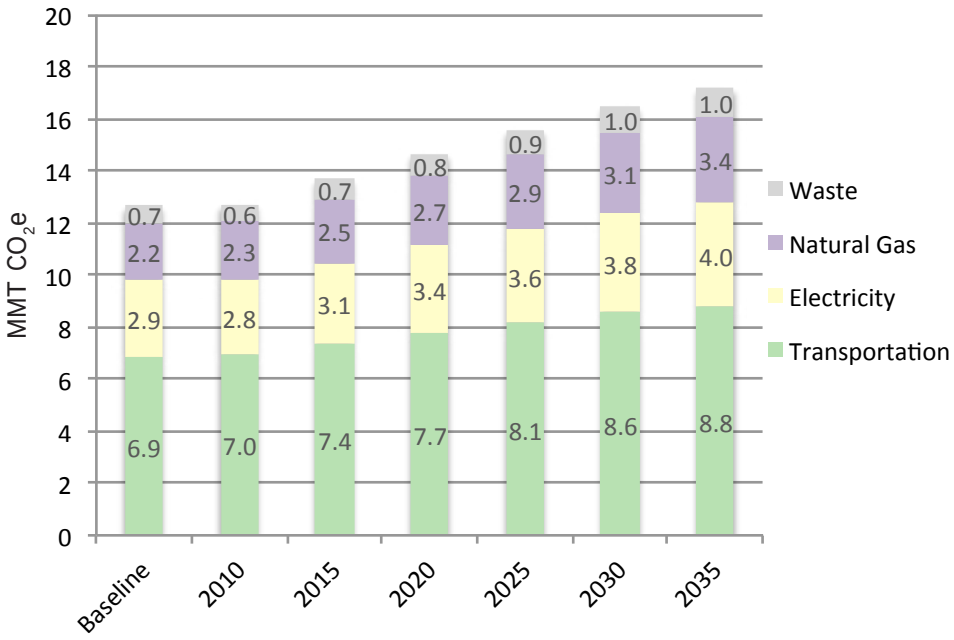
It is not surprising that cars and appliances have the most significant climate impacts. The next most significant category is food and beverages. For example, the majority of food-related emissions occur during the "pre-purchase" phase of producing, processing, and packaging the food. Not surprisingly, red meat (which includes beef, pork, and lamb) and dairy and eggs released the highest pre-purchase emissions—a fact that can be attributed to the extensive feed requirements of livestock as well as to the release of methane, a potent greenhouse gas, from the digestive tracts of ruminant animals.

The inventory suggests that the most important variable to consider when evaluating the benefits of buying local is how the item was produced, since the production phase accounts for a substantial share of consumption-based emissions. For instance, if an orange is grown locally but with high rates of chemical fertilizers or pesticides, then the climate footprint of that local orange could easily be much higher than that of an organically grown orange from miles away.

**What Can Consumers Do?**

- Shift vehicle, appliance, and food choices to more climate-friendly alternatives, such as switching from a standard sedan to a hybrid.
- Use more-efficient home appliances (and turning them off when not in use).
- Eat fewer processed foods.
- Extend the useful life of our personal and household goods, such as furnishings and clothing, to reduce the need for new products and their associated emissions.
- Purchase more durable (or secondhand) items, and delay the purchase of new items by reusing items already in use.

**Figure 3.6: Projected Community Emissions by Category**




*Average of 2004, 2007, and 2008

## 3.3 REDUCTION TARGETS FOR 2020 AND 2035

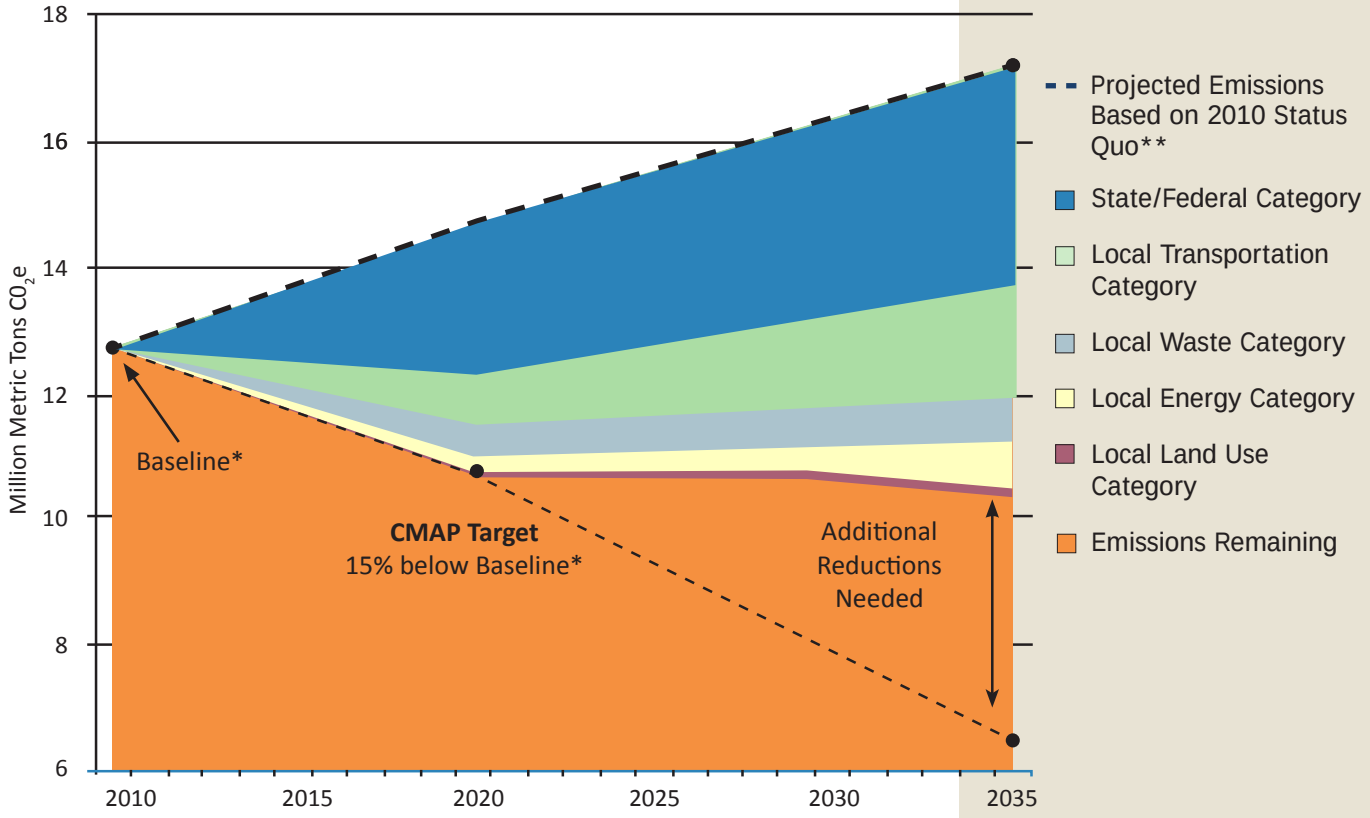
Table 3.2 lists the baseline and projected GHG emissions in MT $CO_2e$. As illustrated, the difference between the baseline and the 2020 target is about 1,900,000 MT. However, to offset the projection for BAU that includes population growth and the associated increases in energy and transportation, the 2020 target will require a reduction of approximately 3,900,000 MT. Nonetheless, with the federal, state and local measures successfully implemented, the 2020 target can be achieved.

**Table 3.2: Baseline, Projections, and Target Emissions**

| Baseline, Projections, and Target Emissions | MT $CO_2e$ |
|---|---|
| Baseline emissions (average of 2004, 2007, 2008) | 12,652,906 |
| 2020 projection (BAU assumes no federal/state strategies beyond 2010 implementation) | 14,643,089 |
| 2020 target (15% below baseline emissions) | 10,754,970 |
| 2020 projection with federal/state measures implemented | 12,254,548 |
| 2020 projection with federal/state and local measures implemented | 10,609,186 |

Since the time horizon of the CMAP carries the City forward to 2035, measures have been recommended that will continue to reduce GHG emissions after 2020. For planning and illustrative purposes, the CMAP assumes that the same GHG reduction measures used to meet the 2020 target will be implemented through 2035 with increased participation rates. However, the City also anticipates that changes to federal and state regulatory framework and advances in energy efficiency technology will occur. Therefore, the City may amend the CMAP after 2020 and allow these changes to supplement or replace some of the measures. It is clear that the collective effect of these additional state and federal mandates and emerging technologies will be needed to achieve the 2035 reduction target. Figure 3.7 illustrates the projected emissions out to 2035, the reduction trajectory, and the role of federal, state, and local reduction measures.

**Figure 3.7: City of San Diego Greenhouse Gas Emissions Projection, CMAP Target, and Estimated Contribution to Reductions by Emission Category**




* Baseline is an average of 2004, 2007, and 2008

** Status Quo includes the proportion of the Renewable Portfolio Standard and Pavley 1 that was implemented as of 2010

**Rio Vista Trolley Station**

# CHAPTER 4 - GREENHOUSE GAS EMISSIONS REDUCTION MEASURES

## 4.1 THE ROLE OF LOCAL MEASURES

The CMAP includes mandatory Greenhouse Gas (GHG) reduction measures that have been adopted by Federal and State agencies and those proposed by the City of San Diego. For those measures developed locally, there must be a nexus to the City's ability and authority to implement. When fully implemented, State and Federal mandates provide approximately 59% of the 2020 target and more than 50% of the 2035 target. For further information on the methodology of how the GHG reduction strategies were generated, please refer to Appendix II - Methodology for Estimating GHG Reductions. Table 4.1 summarizes the federal, state and local strategies' contribution to meeting both the 2020 and 2035 targets' goals assuming the proposed participation rates.

**Table 4.1: Local and State/Federal Strategies and Related GHG Emission Reductions for 2020 and 2035 to Reach Target**

| Local Strategies | 2020 MT $CO_2e$ Reduction | % of Total Reduction | 2035 MT $CO_2e$ Reduction | % of Total Reduction |
|---|---|---|---|---|
| Energy | 308,811 | 8% | 802,781 | 12% |
| Transportation | 744,399 | 18% | 1,780,745 | 26% |
| Land use and food systems | 69,062 | 2% | 65,279 | 1% |
| Waste | 523,090 | 13% | 656,668 | 10% |
| **Total local** | **1,645,362** | **41%** | **3,305,473** | **49%** |
| **State/Federal Strategies** | **2020 MT $CO_2e$ Reduction** | **% of Total Reduction** | **2035 MT $CO_2e$ Reduction** | **% of Total Reduction** |
| Energy | 593,765 | 15% | 722,734 | 11% |
| Transportation | 1,794,776 | 45% | 2,734,672 | 40% |
| **Total state/federal** | **2,388,541** | **59%** | **3,457,406** | **51%** |
| **Total GHG reductions** | **4,033,903** | **100%** | **6,762,879** | **100%** |

The CMAP includes the following four categories of GHG sources and associated reduction strategies:

1. The **Energy** strategy aims to reduce GHG emissions by improving the energy efficiency of both new and existing residential and commercial buildings, increasing renewable and efficient energy production, improving communitywide understanding of energy management, and highlighting the water-energy nexus.

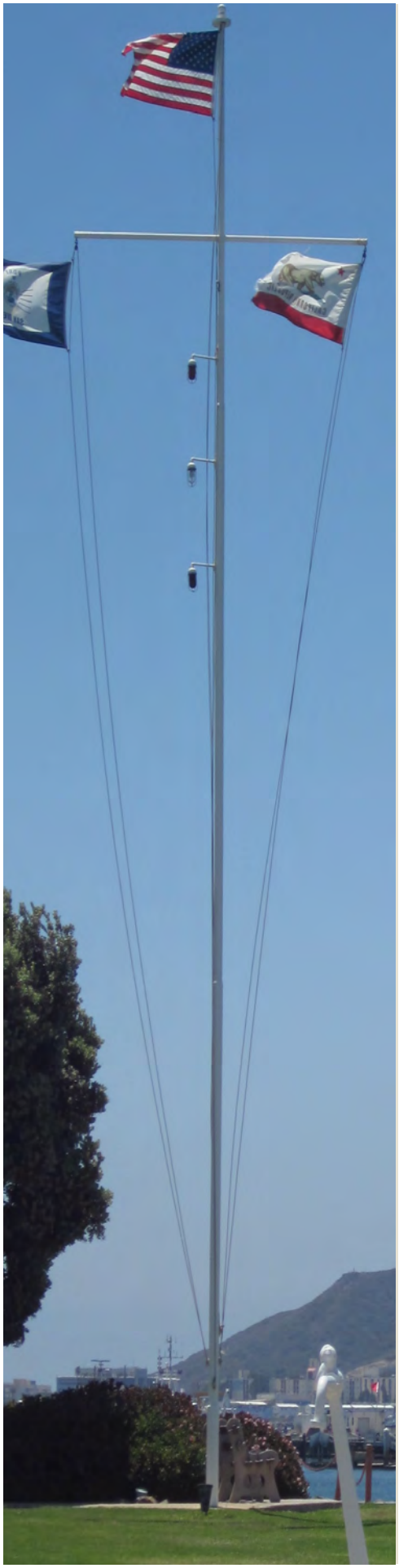
2. The **Transportation** strategy focuses on reducing emissions by reducing Vehicle Miles Traveled (VMT) through multimodal transportation options, by decreasing the energy intensity per mile traveled by reducing idling, and increasing electric vehicle use by improving the electric vehicle infrastructure.

**There are three qualifying points to consider for the CMAP GHG reduction measures:**

1. Voluntary GHG reduction measures can be recommended but were not included in the CEQA analysis of the CMAP.

2. The specific Implementation Plan for GHG reduction measures will be designed after additional coordination with external stakeholders.

3. The annual CMAP Monitoring Report will include an updated GHG Emissions Inventory and a review of the GHG reduction measures.



3. The **Land Use & Local Food System** strategy reduces emissions by supporting the City's General Plan that will result in more compact, walkable, transit-accessible neighborhoods and by strengthening the regional food system, including expanding urban agriculture activities.

4. The **Waste** strategy reduces emissions by diverting waste from landfills, and supports continual improvement in equipment and operations for wastewater treatment and landfill management.

Table 4.2 provides examples of strategies and the associated GHG reduction potential. These are the reductions expected by the measures in 2020 and 2035. It assumes that the participation rates are consistent with those listed in Appendix IV.

**Table 4.2: Greenhouse Gas Reduction Strategies for 2020 and 2035 in Metric Tons**

| Greenhouse Gas Reduction Strategy | 2020 | 2035 |
|---|---|---|
| Improve building efficiency | 143,795 | 445,060 |
| Improve water use efficiency | 46,684 | 39,469 |
| Increase renewable and efficient energy production | 118,331 | 318,252 |
| Improve multimodal transit options | 499,348 | 1,120,496 |
| Conserve fuel | 3,571 | 4,761 |
| Switch to alternative fuels | 241,481 | 655,488 |
| Advance the city general plan goals | 69,062 | 65,279 |
| Improve waste management efficiency | 523,090 | 656,668 |
| Support implementation of related state and federal policies | 2,388,541 | 3,457,406 |
| **Total Greenhouse Gas Reduction** | **4,033,903** | **6,762,879** |

Table 4.3 on the following pages is a summary of the categories of GHG reduction strategies and the initial measures identified that will lead to the targeted reductions. An expanded description is included in the narrative that follows.

**Table 4.3 – Emissions Categories and Related Strategies**

| Emissions Category | Strategy | Target | Measures Leading to Target | Status |
|---|---|---|---|---|
| Energy | Improve Building Efficiency | Retrofit existing single-family homes for 30% energy savings per unit (10% of homes by 2020, and 25% by 2035). Retrofit existing multi-family homes for 20% energy savings per unit (15% by 2020, and 30% by 2035). | Support voluntary Energy Consumption Disclosure Policy to provide home buyers with energy consumption data at the point of sale. Monitor results and phase in mandatory requirements by 2020 if necessary. | New |
| | | | Identify neighborhoods with highest energy consumption. Provide targeted outreach and incentives for energy audits and retrofits. Evaluate in 2015 with recommendations for further action. | In Progress |
| | | | Support implementation of California Solar Initiative Thermal Program for installation of 2,000 solar water heating retrofits completed by 2020. | In Progress |
| | | | Support Energy Upgrade California and other similar programs that focus on assistance for retrofitting existing residential. | In Progress |
| | | | Support implementation of state appliance standards. | In Progress |
| | | | Expand stakeholder involvement for developing an implementation plan to meet GHG reduction targets. (e.g. Retrofit Advisory Council). | In Progress |
| | | | Compile incentives available from the City of San Diego, San Diego Gas and Electric, and State of California. | In Progress |
| | | Retrofit existing commercial square footage to achieve 15% energy savings per unit (10% of units by 2020, and 25% by 2035). | Building on AB 1103, Mandatory Energy Benchmarking and Disclosure requirements for commercial buildings, identity buildings with highest energy consumption and provide targeted outreach and incentives for energy audits and retrofits. Evaluate outcome in 2015 and recommend further action. | New |
| | | | Expand stakeholder involvement for developing an implementation plan to meet GHG reduction targets. (e.g. Retrofit Advisory Council). | In Progress |
| | | | Compile incentives available from the City of San Diego, San Diego Gas and Electric, and State of California. | In Progress |
| | | Retrofit existing City facilities and infrastructure to achieve energy savings of 20% by 2020, and 30% by 2035. | Fully implement a Smart Energy Management & Monitoring System within all City facilities to monitor energy costs and consumption. Based on results, identify opportunities for greater efficiency and demand response by 2015. | In Progress |
| | | | Implement the City's Energy Strategy Goal to reduce Citywide energy consumption by 50 megawatts, using 2001 as baseline (Resolution #R-295074). | In Progress |
| | | | Seek additional funding through low-interest loans and/or grants. | In Progress |
| | | | Implement the City's Energy Strategy Objective by retrofitting all street lighting and outdoor lighting to broad spectrum by 2015. | In Progress |
| | | Retrocommission 10% of existing commercial square footage to achieve 15% energy savings per unit by 2020, and 25% of existing commercial square footage to achieve 15% energy savings per unit by 2035. | Promote the benefits for retrocommissioning through professional associations and organizations. | New |
| | | | Use the State reporting requirement (AB 1103), which requires building owners to disclose the energy consumption data of all nonresidential buildings, to inform prospective parties as part of a whole-building transaction. | New |
| | | | Adopt a voluntary retrocommissioning policy by 2014. Monitor results and phase in mandatory retrocommissioning by 2020 if necessary. | New |
| | | Improve energy efficiency of new residential and commercial buildings by 15% by 2020. | Evaluate the possibility of providing permit streamlining and other City incentives. (e.g. Council Policy 600-27) | New |
| | | | Adopt and implement a "Solar Ready" Plan that requires pre-wiring and pre-plumbing for solar hot water heating for residential and non-residential by 2015. | New |
| | Increase Water Conservation | Improve water use efficiency to achieve SB7X goal of 142 daily gallons per capita by 2020 and 116 daily gallons per capita by 2035. | Support programs and incentives for the inclusion of rain sensors in private irrigations systems. | New |
| | | | Prepare a study by 2014 that identifies the cost/benefit for requiring point-of-sale water consumption data for residential and non-residential buildings. | New |
| | | | Work closely with the City of San Diego Public Utilities Department, which is the lead agency for promoting water conservation. | In Progress |
| | | | Record the amount of reclaimed water used in the City of San Diego. | In Progress |
| | | | Record the amount of water generated from the Indirect Potable Reuse system. | In Progress |
| | Increase Use of Renewable Energy | Install solar water heaters on 5% of existing homes by 2020 and 15% by 2035. Replace 5% of commercial natural gas used to heat water by 2020 and 15% by 2035. | Compile incentives available from the City of San Diego, San Diego Gas and Electric and the State of California. | In Progress |
| | | | Expand stakeholder involvement for developing an implementation plan to meet GHG reduction targets. | In Progress |
| | | | Evaluate the possibility of providing permit streamlining and other City incentives. (e.g. Council Policy 600-27). | New |
| | | | Support implementation of the California Solar Initiative solar water heating program. | In Progress |
| | | Achieve 350 megawatts (200 MW photovoltaic, 150 MW cogeneration) of clean and efficient distributed energy generation by 2020 and 800 megawatts (550 MW photovoltaic, 250 MW cogeneration) by 2035. | Implement the City's Energy Strategy goal to increase renewable energy by 50 megawatt by 2013 using 2003 as a baseline year (Resolution #R-298412). | In Progress |
| | | | Participate in State policy processes that promote, streamline or expand cogeneration and distributed energy. | In Progress |
| | | | Implement the City's Solar Energy Implementation Plan by 2020. | In Progress |
| | | | Participate in a regional Property Assessed Clean Energy (PACE) program to support financial incentives for energy efficiency and renewable energy. | In Progress |
| | | | Compile incentives available from the City of San Diego, San Diego Gas and Electric and the State of California. | In Progress |
| | | | Expand stakeholder involvement to increase renewable energy generation and develop an implementation plan to meet GHG reduction targets. | New |
| | | | Evaluate the possibility of providing permit streamlining and other City incentives. | In Progress |
| | | | Support SB 1 requirement to offer solar technologies in new homes as a standard option. | In Progress |

**Table 4.3 (cont.) – Emissions Categories and Related Strategies**

| Emissions Category | Strategy | Target | Measures Leading to Target | Status |
|---|---|---|---|---|
| Transportation | Improve Multimodal Transportation Options | Increase mass transit by 8% by 2020 and 10% by 2035. | Support SANDAG RTP 2050 mass transit targets for 2020 and 2035. | In Progress |
| | | | Continue to support and implement the City's smart growth strategy in the General Plan. | In Progress |
| | | | Expand stakeholder involvement for developing an implementation plan that may include stronger advocacy for additional public transit projects. | New |
| | | Support SANDAG in achieving target of reducing per capita emissions from transportation 7% by 2020 and 13% by 2020. | Support SANDAG measures to meet GHG reduction targets from passenger vehicles to comply with SB 375, including telecommuting, carpooling, vanpooling, buspooling, bottleneck relief, HOV/HOT lanes, and safe routes to school. | In Progress |
| | | Increase bike lane miles per square mile to 4 by 2020 and 8 by 2035. | Continue to implement the City's Bicycle Master Plan. Work with SANDAG to publicize/promote bicycle infrastructure programs by prioritizing locations for additional bike infrastructure throughout the City, including supporting and promoting a bike-sharing program, by 2014. | In Progress |
| | | Decrease parking spaces in the San Diego Metro area 10% by 2020 and 20% by 2035. | Work with appropriate City departments and stakeholders for improving parking management. | New |
| | | | Evaluate and adjust parking requirements in areas that are highly accessible by alternative modes of transportation including public transit, biking and walking. | New |
| | | Increase downtown parking prices per day to $24 by 2020 and $30 by 2035. | Manage parking, including pricing, to reduce congestion and increase use of multi-modal transportation. Work with SANDAG on a regional approach to parking fee increases and complementary transit improvements. | New |
| | Conserve Fuel | Re-time traffic signals on 15 intersections and install roundabouts on 15 intersections by 2020 and 20 intersections by 2035. | By 2014, identify the cost/benefit for signal light re-timing and synchronization on arterial roads and expanded roundabouts with the goal of reducing vehicle idling. | In Progress |
| | | | Work with appropriate City departments to review recommendations and, if approved, develop an implementation plan. | New |
| | Switch to Alternative Fuels | Reserve 10% of parking spaces for electric vehicles by 2020 and 20% by 2035. | Require designation of preferential parking spaces to support electric vehicle charging and carpooling. | New |
| | | Increase the number of miles driven by electric vehicles to 4% by 2020 and 11% by 2035. | Fully implement the City's commitment to establish an electric vehicle charging network by 2013. | In Progress |
| | | | Track progress on the number of EV charging stations installed and the number of EVs estimated to be in San Diego. | In Progress |
| | | | Require installation of a J17-72 circuit to facilitate electric vehicles. | New |
| | | Increase zero emissions passenger and light duty trucks to 50% of the City's municipal fleet by 2020 and 100% by 2035. | Revise AR 90.73 by 2015 to require 50% zero-emissions passenger and light-duty municipal vehicles by 2020, and 100% by 2035. | New |
| | | | Coordinate with the City's Fleet Services to review consistency with City Administrative Regulations that encourage more fuel-efficient vehicle purchases and maintenance to optimize fuel efficiency of existing vehicles. | New |
| Land Use and Food Systems | Effective Land Use | Achieve better walkability and transit-supportive densities in targeted locations identified in community plans by increasing population density 12% by 2020 and 27% by 2035. | Work closely with the Planning Division to record progress on City of Villages strategy to direct growth into compact, walkable, mixed-use centers linked by transit. | In Progress |
| | | | Seek funding to prepare a Parks Master Plan by 2014; continue park planning efforts through community plan updates and focused planning efforts. | New |
| | | Implement strategies to reduce the urban heat island effect. | Research best practices and work closely with appropriate City departments to increase implementation of measures to reduce urban heat island effect. | New |
| | | | Support conversion of impermeable hardscapes to permeable softscapes using native or drought tolerant planting in public and private projects by 2020. Revise design guidelines and standards as needed. | New |
| | | Advocate for sequestration of GHG through land use practices. | Research best practices and work with appropriate City departments to determine feasibility of expanding wetlands to sequester carbon. | New |
| | | | Research best practices and work with appropriate City departments to determine feasibility of expanding the urban forest in commercial and residential areas. | New |
| | | | Research other land use practices that have successfully sequestered GHG. | New |
| | Expand Development of Local Food Systems | Increase availability of local food options 50% by 2020. | Support food system planning that increases food security and infrastructure, links local producers to local markets, creates jobs, and re-circulates food dollars in the local economy. Incentivize local food production and distribution through municipal purchasing policies, establishment of local distribution centers and permanent public markets. | New |
| | | | Report on existing stakeholder groups' efforts to expand local food production and distribution. | In Progress |
| | | | Monitor effectiveness of code and process amendments designed to facilitate the establishment and operation of community gardens and urban agriculture. | In Progress |
| | | | Create City and County partnerships with healthcare, schools, and other organizations to promote healthy, low-carbon diets. | New |

**Table 4.3 (cont.) – Emissions Categories and Related Strategies**

| Emissions Category | Strategy | Target | Measures Leading to Target | Status |
|---|---|---|---|---|
| Waste | Improve waste management efficiency | Divert 75% of trash from landfill disposal by 2020. | Expand organic waste diversion programs to meet goals of 70,000 tons by 2020 and 140,000 tons by 2035. | In Progress |
| | | | Continue to update the City waste management strategy and prioritize the most successful technologies. | In Progress |
| | | | Complete and adopt the City's Long Term Resource Management Strategic Plan. | New |
| | | | Require construction/building/remodeling projects to use 20% recycled construction materials by 2035. | New |
| | | | By 2017, develop a Resource Recovery Center at Miramar Landfill to maximize waste diversion. | New |
| | | | Support legislation at the national, state and local level that will require extended producer responsibility and improve the recyclability of products and packaging by 2015. | In Progress |
| | | | Adopt a zero waste resolution by 2015. | New |
| | | | Adopt a plastic bag ordinance by 2015. | New |
| | | Capture 80% of methane from landfills in 2020 and 2035. | Increase landfill gas monitoring wells consistent with AB 32, ensure ongoing compliance, and report on effectiveness of gas collection system. | In Progress |
| | | | In concert with private sector partners, continue to improve utilization of gas in energy generation through fuel cells, co-generation, and other technologies. | In Progress |
| | | Capture 98% of wastewater treatment gas in 2020 and 2035. | Report on the effectiveness of digesters' gas collection system. | In Progress |
| | | | In concert with private sector partners, continue to improve utilization of gas in energy generation through fuel cells, co-generation, and other technologies. | In Progress |
| State and Federal | Support implementation of related state and federal policies | Achieve a 33% Renewable Portfolio Standard by 2020. | No Additional Local Action | |
| | | CAFE/Pavley I: achieve 39 mpg for new passenger cars and 34 mpg for light duty trucks by 2016. | | |
| | | Low Carbon Fuel Standard: achieve 10% reduction in carbon intensity of transportation fuels by 2020. | | |
| | | CARB Tire Pressure Program. | | |
| | | CARB Heavy Duty Vehicle Regulation. | | |

## 4.2 ENERGY

Buildings account for about 40% of total U.S. energy consumption and greenhouse gas emissions (Lawrence Berkeley National Laboratory, 2009), and the same holds true for the City. In California, minimum efficiency standards for buildings and appliances that are updated on a regular basis have driven guaranteed progressive energy savings over the past three decades.

One of the visions of the 2008 California Long-Term Strategic Energy Plan is that "residential energy use will be transformed to ultra-high levels of energy efficiency resulting in Zero Net Energy new buildings by 2020. All cost-effective potential for energy efficiency, demand response and clean energy production will be routinely realized for all dwellings on a fully integrated, site-specific basis". These goals and subsequent policy changes will drive new construction practices. However, retrofitting existing residential and non-residential buildings, especially those that were built before 1980, will result in the greatest reduction in GHG emissions for San Diego. Additionally, changes in the building "envelope" need to be coupled with changes in how people use electricity and natural gas. "Energy Upgrade California" is a coordinated statewide public education campaign with targeted incentive programs to encourage people to make their homes more energy efficient. State and local governments are also working with the financial community to develop innovative and affordable financing options for energy-efficient buildings and retrofits.

### GOAL:

Reduce the GHG emissions associated with the consumption of electricity and natural gas by 308,800 MT by 2020 and by at least 802,800 MT by 2035 through local measures.

### CO-BENEFITS:

1. Reduced energy costs
2. Increased jobs
3. Improved air quality and health
4. Water conserved
5. Improved quality of life
6. Adaptation

**Definitions:**

**Energy Efficiency** means that the same function can be accomplished with less electricity. This usually requires newer equipment (such as televisions), different types of lighting (such as CFL bulbs) and other technology changes.

**Energy Conservation** is typically using what you have more efficiently, such as shutting off the light or only using the dishwasher when it is full.

**San Diego Gas and Electric and the State of California** have developed programs and regulations to help consumers use electricity more efficiently - doing the same with less. (http://www.energy.ca.gov/efficiency/)

## STRATEGIES AND MEASURES:

### Table 4.4: Energy Measures

| Energy Measures | 2020 MT $CO_2e$ Reduction | % of Total Reduction | 2035 MT $CO_2e$ Reduction | % of Total Reduction |
|---|---|---|---|---|
| **A. Improve Building Efficiency** | | | | |
| Residential efficiency retrofits | 52,464 | 1% | 132,386 | 4% |
| Commercial efficiency retrofits | 20,646 | 1% | 196,118 | 4% |
| City facility efficiency retrofits | 13,222 | 0% | 18,634 | 0% |
| Commercial retrocommissioning | 20,646 | 1% | 58,835 | 1% |
| New construction efficiency | 23,895 | 1% | - | 0% |
| **B. Increase Water Conservation** | | | | |
| Water use efficiency conservation | 46,684 | 1% | 39,469 | 3% |
| **C. Increase Use of Renewable Energy** | | | | |
| Residential solar water heaters | 9,596 | 0% | 26,652 | 1% |
| Commercial solar water heating | 3,327 | 0% | 12,434 | 0% |
| Distributed generation and on-site renewable energy | 118,331 | 3% | 318,252 | 5% |

### A. STRATEGY: Improve Building Efficiency

Increase the energy efficiency of new and existing residential, commercial, and municipal buildings through retrofits, retrocommissioning, incentives, and policies.

### Table 4.5: Residential Building Retrofit Targets

| Residential Efficiency Retrofit Single Family | 2020 | 2035 |
|---|---|---|
| Energy reduction (percentage/unit) | 30% | 30% |
| Number of units retrofit (percentage of total units) | 10% | 25% |
| **Residential Efficiency Retrofit Multi Family** | **2020** | **2035** |
| Energy reduction (percentage/unit) | 20% | 20% |
| Number of units retrofit (percentage of total units) | 15% | 30% |

**Measures Leading to Target:**

- Compile the incentives available from the City, SDG&E and the State of California.

- Expand stakeholder involvement and develop an implementation plan to meet GHG reduction targets (e.g., Retrofit Advisory Council).
- Support implementation of the California Solar Initiative thermal program for installation of 2,000 solar water heating retrofits by 2020.
- Support a voluntary Energy Consumption Disclosure Policy with the intent of providing home buyers with energy consumption data at the point of sale. Monitor results and if voluntary participation is found to be ineffective by 2015, phase in mandatory guidelines by 2020. Consider use of a third-party national database such as the Multiple Listing Service (MLS) as implementation mechanism.
- In conjunction with utilities and other public entities, identify neighborhoods within the City with the highest energy consumption. Provide targeted outreach and incentives for energy audits (Home Energy Rating System (HERS) certification or equivalent) and retrofits. Evaluate the outcome of measures in 2015, with recommendations for further action.
- Support Energy Upgrade California and other similar programs that focus on assistance for retrofitting existing residential.
- Support implementation of state appliance standards.

### Table 4.6: Commercial Building Retrofit Targets

| Commercial Efficiency Retrofits | 2020 | 2035 |
|---|---|---|
| Energy reduction (percentage/unit) | 15% | 15% |
| Area retrofit (percentage of square foot) | 10% | 25% |

### Measures Leading to Target:

- Compile incentives available from the City of San Diego, SDG&E, and the State of California.
- Expand stakeholder involvement and develop an implementation plan to meet GHG reduction targets.
- Building on AB 1103, Mandatory Energy Benchmarking and Disclosure requirements for commercial buildings, identify buildings with highest energy consumption and provide targeted outreach and incentives for energy audits and retrofits. Evaluate outcome in 2015 and recommend further action.

### Table 4.7: City Facility Retrofit Targets

| City Building Efficiency | 2020 | 2035 |
|---|---|---|
| % reduction in total energy consumption | 20% | 30% |
| Participation rate by 2020 | 100% | 100% |

### AB 1103 - Commercial Building Energy Use Disclosure

Commercial buildings account for more than 35% of electricity consumption in California and are significant contributors to the state's greenhouse gas emissions.

AB 1103 is one of the ways the California State legislature is working to help achieve the greenhouse gas emission reductions mandated by the California Global Warming Solutions Act of 2006, also known as AB 32.

Unlike Title 24 building energy efficiency codes that regulate standards for commercial construction and renovations, AB 1103 comes into play when a building is sold, leased in whole or refinanced.

Along with the usual financial and transaction disclosures, AB 1103 requires that building owners provide 12 months of energy-use information using the U.S. Environmental Protection Agency's ENERGY STAR Portfolio Manager.

The purpose of AB 1103 is to drive commercial building owners to not only track but to also improve their ENERGY STAR rating by optimizing the energy performance of existing systems and installing new energy-efficient upgrades and renewable energy technologies. A higher rating means lower energy costs, decreased occupancy costs and, potentially, increased building valuation. (http://energycenter.org/index.php/news-a-media/latest-news/2137-getting-ready-for-ab-1103)

### CalGreen Code for California

The Green Building Standards Code, otherwise known as CalGreen, is Part 11 of the California Energy Code, or Title 24, of the California Code of Regulations, and also is the first statewide green building code in the nation. For residential construction, CalGreen addresses five main areas: planning and design; energy efficiency (whose code requirements are set by the California Energy Commission); water efficiency and conservation; material conservation and resource efficiency; and environmental quality (which is aimed at "reducing the quantity of air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of a building's installers, occupants and neighbors"). For water efficiency, CalGreen is designed to reduce overall use of potable water by at least 20%, as measured by specified plumbing fixture flow rates. Addressing material conservation and resource efficiency, CalGreen requires that at least 50% of a project's nonhazardous construction and demolition debris be recycled or salvaged for reuse (except for excavated soil and land-clearing debris, or when local recycling facilities do not exist).

**Measures Leading to Target:**

- Implement the City of San Diego Energy Strategy for a Sustainable Future (2009), which includes a goal to reduce citywide energy consumption by 50 MW, using 2001 as a baseline year (Resolution #R-295074).
- Seek additional funding through low-interest loans and/or grants.
- Fully implement a Smart Energy Management & Monitoring System (SEMMS) within all City facilities to monitor and track energy cost and consumption. Based upon results, identify opportunities for greater efficiency and demand response by 2015.
- Implement the City's Energy Strategy Objective by retrofitting all street lighting and outdoor lighting by 2015.

**Table 4.8: Commercial Retrocommissioning Targets**

| Commercial Retrocommissioning | 2020 | 2035 |
|---|---|---|
| Average energy reduction percentage | 15% | 15% |
| Percentage commercial square foot | 10% | 25% |

**Measures Leading to Target:**

- Promote the benefits of retrocommissioning through professional associations and other organizations.
- Use the State reporting requirement (AB 1103), which requires building owners to disclose the energy consumption data of all nonresidential buildings, to inform prospective parties as part of a whole-building transaction.
- Adopt a voluntary retrocommissioning policy by 2014. Monitor results and if voluntary participation is found to be ineffective, phase in mandatory retrocommissioning by 2020.

**Table 4.9: New Construction Efficiency Targets**

| Residential New Construction | 2020 | 2035 |
|---|---|---|
| Percentage better than Title 24 | 15% | N/A |
| Participation rate after 2015 | 100% | N/A |
| **Commercial New Construction** | **2020** | **2035** |
| Percentage better than Title 24 | 15% | N/A |
| Participation rate after 2015 | 100% | N/A |

**Measures Leading to Target:**

- Evaluate the possibility of providing permit streamlining and other City incentives. (e.g., Council Policy 600-27)
- Adopt and implement a "Solar Ready" Plan that requires pre-wiring and pre-plumbing for solar hot water heating for residential and non-residential by 2015.

## B. STRATEGY: Increase Water Conservation

A significant amount of energy is required for the procurement, treatment, and conveyance of water. The City of San Diego's 2010 Urban Water Management Plan (UWMP), approved by the City Council, requires a 20% reduction in water use by 2020. The water use goal was established by Senate Bill (SB) 7X-7, and there is no water-use efficiency goal past 2020. The CMAP establishes a 2035 goal of 116 gallons per capita per day (GPCPD). The CMAP target pertains specifically to imported water from outside of the region, and will not include the water generated in the City of San Diego from various reclamation pro-

cesses. Examples include reclaimed/recycled water currently distributed through purple pipes for irrigation only, water reuse/reservoir augmentation, and expanded greywater use.

### Table 4.10: Water Efficiency Targets

| Water Use Efficiency | 2020 | 2035 |
|---|---|---|
| Gal/person/day for imported water | 142 | 116 |

### Measures Leading to Target:

- Work closely with the City of San Diego Public Utilities Department, which is the lead agency for promoting water conservation.
- Record the amount of reclaimed water used in the City of San Diego.
- Record the amount of water generated from the Indirect Potable Reuse system.
- Support programs and incentives that result in the inclusion of rain-sensor systems in private irrigation systems.
- Prepare a study by 2014 that identifies the cost/benefit for requiring point-of-sale water consumption data for residential and non-residential buildings.

## C. STRATEGY: Increase the Use of Renewable Energy

Clean, renewable energy is essential to achieve the overall GHG reduction targets. With technologies rapidly improving, a small on-site power plant today can often produce energy more efficiently than central power plants. Distributed generation can serve one building, a campus, or a neighborhood.

### Table 4.11: Residential Solar Water Heating Targets

| Residential Solar Water Heating Retrofit Single Family | 2020 | 2035 |
|---|---|---|
| Number of units ( percentage of total units) | 5% | 15% |

### Measures Leading to Target:

- Compile incentives available for installation of solar hot water heating in existing buildings from the City, SDG&E and the State of California.
- Expand stakeholder involvement and develop an implementation plan to meet GHG reduction targets.
- Evaluate the possibility of providing permit streamlining and other City incentives to increase installation of solar hot water heating.
- Support implementation of the California Solar Initiative solar water heating program.

### Table 4.12: Commercial Solar Water Heating Targets

| Commercial Solar Water Heating Retrofit | 2020 | 2035 |
|---|---|---|
| Reduction in water heating energy | 50% | 50% |
| Percentage commercial water heating energy affected | 5% | 15% |

### Water Conservation and its Relationship to Energy Use

Embodied energy refers to the quantity of energy required to manufacture and supply a product, material, or service to the point of use. In the water utility sector, embodied energy is the total amount of energy associated with the use of a given amount of water in a specific location. It is the amount of energy consumed by all the processes associated with the production, delivery, consumption, and disposal of water. Increased water conservation reduces embodied energy and as a result, GHG emissions.

### The Otay Water Treatment Plan Harnessing the Sun

The Otay Water Treatment Plant (WTP) supplies one of the City of San Diego's three major water service areas, providing up to 34 million gallons per day of potable water to customers primarily in the southern reaches of the City. The treatment plant gets its water from the Morena, Barrett and Lower Otay Reservoirs.

In April 2010, workers activated a 945-kW solar photovoltaic (PV) energy system on top of the plant's water tanks. The PV system is expected to generate 1.5 million kWh of clean solar energy annually — more than enough to power the facility. In addition, the renewable energy system will avoid the release of an estimated 29 million pounds of carbon dioxide emissions over 20 years. This project is a demonstrative case study that meets the City of San Diego's long-term goal: establishing 5 MW of solar energy capacity for city facilities by 2013. The Otay project is actually the second solar system installed on a city-owned water treatment plant; the first is a 1.1-MW array at the larger Alvarado Water Treatment Facility. Another PV system is planned for a third water treatment plant.

Contractor SunEdison built the systems at Otay and Alvarado. San Diego has agreed to buy all of the power generated for the next 20 years; SunEdison owns and maintains the systems. This arrangement allows the systems to be built with no upfront cost to the city. In fact, the systems help the city save money, with rates for the solar power set below the price of conventional power. San Diego can even sell a little extra power back to its utility during peak hours.

**Measures Leading to Target:**

- Compile incentives available for installation of solar hot water heating in existing buildings from the City, SDG&E and the State of California.
- Expand stakeholder involvement and develop an implementation plan to meet GHG reduction targets.
- Evaluate the possibility of providing permit streamlining and other City incentives to increase installation of solar hot water heating.
- Support implementation of the California Solar Initiative solar water heating program.

**Table 4.13: Clean and Efficient Distributed Generation Targets**

| Cogeneration (MW) | 2020 | 2035 |
|---|---|---|
| Total capacity (MW) | 150 | 250 |

**Measures Leading to Target:**

- Expand stakeholder involvement to increase renewable generation and develop an implementation plan to meet GHG reduction targets.
- Participate in State policy processes that promote, streamline or expand cogeneration and distributed energy.
- Implement the City's Energy Strategy goal to achieve a 50 MW increase in renewable energy by 2013 using 2003 as a baseline year (Resolution #R-298412).

**Table 4.14: On-Site Renewable Energy Generation Targets**

| Residential PV | 2020 | 2035 |
|---|---|---|
| Total capacity (MW) | 50 | 200 |
| **Commercial PV and Fuel Cell** | **2020** | **2035** |
| Total capacity (MW) | 150 | 350 |

**Measures Leading to Target:**

- Participate in a regional Property Assessed Clean Energy (PACE) program citywide to support financial incentives to energy efficiency and renewable energy.
- Compile incentives available from the City of San Diego, SDG&E, and the State of California.
- Expand stakeholder involvement and develop an implementation plan to meet GHG reduction targets.
- Evaluate the possibility of providing permit streamlining and other City incentives.
- Implement the City's Energy Strategy goal to achieve a 50 MW increase in renewable energy by 2013 using 2003 as a baseline year (Resolution #R-298412).
- Implement the City's Solar Energy Implementation Plan by 2020.
- Support implementation of state Renewable Portfolio Standards (33% renewable by 2020).
- Support implementation of California Solar Electric Incentive Program (SB 1) requirement to offer solar technologies in new homes as a standard option.

## 4.3 TRANSPORTATION

A by-product of the combustion of fuels is GHG emissions, and the transportation sector accounts for 40% of the GHG in California and 54% in the City. There are two approaches to reduce GHG in the transportation sector: 1) reduce the intensity of GHG emissions per gallon of fuel; and 2) reduce the VMT. For the first approach, the CARB adopted a regulation that implements the LCFS. The standard is designed to reduce carbon emissions from California's transportation fuels 10% by 2020 by diversifying the variety of fuels used to power vehicles. When fully implemented, application of the standard is expected to replace 20% of the petroleum fuels burned by cars in California with cleaner alternative fuels and electric vehicles. The second approach, reducing VMT, is more complex.

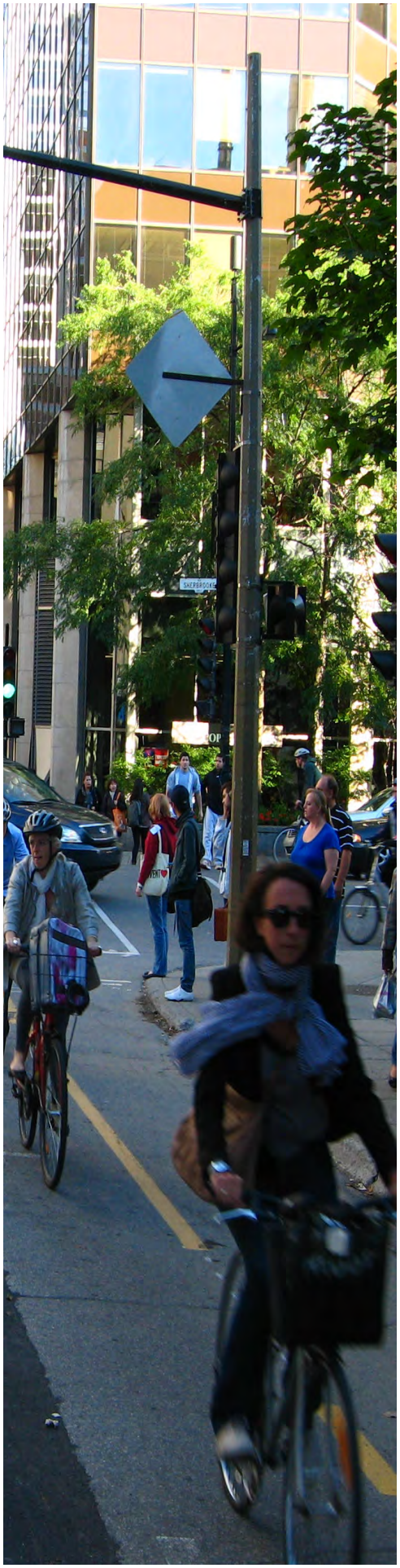
There is near consensus among experts that this should be the highest priority for meeting AB 32 requirements. The strategies most commonly cited by experts to reduce VMT include smart growth, transit-oriented development, pricing, and encouraging the development of "best practice" blueprint planning. Pricing and improving public transit are viewed as short-term strategies (although funding and political support may be challenging), while land use changes are cited by nearly every expert as the most important approach for meeting the 2050 target. Experts identified behavioral change, pricing, reducing VMT, and smart growth as the strategies that are the most difficult to implement (University of California at Davis, 2009).

### GOAL:

Reduce GHG emissions associated with the internal combustion engines by 744,400 MT by 2020 and by at least 1,780,700 MT by 2035 through local measures.

### CO-BENEFITS:

1. Reduced energy costs
2. Increased jobs
3. Improved air quality and health
4. Improved quality of life



### Why is the Measurement of Vehicle Miles Traveled (VMT) so Important?

The transportation sector is the top GHG emitter in California, contributing roughly 40% of all California emissions. Poor fuel efficiency and high vehicle miles traveled (VMT) are primary contributors to transportation sector GHG emissions. Meeting California's GHG emissions reduction goals requires reductions in both per-mile emissions (often measured in as a vehicle's miles per gallon performance) and vehicle miles traveled. Fuel efficiency has been addressed historically by the federal Corporate Average Fuel Economy (CAFE) standards, and California has passed its own legislation regulating GHG emissions from vehicles. The number of miles traveled has ramifications on insurance premiums, but there has not been and likely will not be any legislative action to curb VMT even though it is growing at a much faster rate than population or the economy.

## STRATEGIES AND MEASURES:

### Table 4.15: Transportation Measures

| Transportation Measures | 2020 MT $CO_2e$ Reduction | % of Total Reduction | 2035 MT $CO_2e$ Reduction | % of Total Reduction |
|---|---|---|---|---|
| **A. Improve Multi-Modal Transportation Options** | | | | |
| Mass transit | 105,613 | 3% | 119,649 | 3% |
| SB 375 (telecommute, carpool, vanpool, buspool, bottleneck relief, HOV/HOT lanes) | 192,663 | 5% | 710,413 | 6% |
| Bicycle infrastructure | 17,194 | 0% | 38,522 | 1% |
| Parking management and distribution | 30,782 | 1% | 51,058 | 1% |
| Increase parking fee | 110,474 | 3% | 130,158 | 2% |
| **B. Conserve Fuel** | | | | |
| Signal timing and roundabouts | 3,571 | 0% | 4,761 | 0% |
| **C. Switch to Alternative Fuels** | | | | |
| Electric vehicle use | 228,321 | 6% | 631,799 | 5% |
| Convert municipal fleet to electric vehicle | 13,160 | 0% | 23,688 | 0% |
| Parking - preferred parking for electric vehicles | 42,621 | 1% | 70,696 | 1% |

### A. STRATEGY: Improve Multi-Modal Transportation Options

This strategy aims to decrease the number of single-occupancy vehicles by increasing the number and types of transportation alternatives.

### Table 4.16: Single-Occupancy Vehicle Reduction Targets

| Mode Share | 2020 | 2035 |
|---|---|---|
| Percentage increase in mass transit | 8% | 10% |
| Percentage of target achieved for SB 375 - telecommute, carpool, vanpool, buspool, bottleneck relief, HOV/HOT lanes, and safe routes to school only. | 100% | 100% |

### Measures Leading to Target:

- Continue to support and implement the City's smart growth strategy in the General Plan.
- Expand stakeholder involvement and develop an implementation plan that may include stronger advocacy for additional public transit projects.
- Collaborate with SANDAG and other regional entities to promote and incentivize full implementation of the Sustainable Communities and Climate Protection Act of 2008 (SB 375).

### Table 4.17: Expanded Bicycle Infrastructure Targets

| Bicycle Infrastructure | 2020 | 2035 |
|---|---|---|
| Bicycle lanes per square mile | 4 | 8 |

**Measures Leading to Target:**

- Continue to implement the City's Bicycle Master Plan.
- Work with SANDAG to publicize/promote bicycle infrastructure programs by prioritizing locations for additional bike infrastructure throughout the City, including supporting and promoting a bike-sharing program, by 2014.

### Table 4.18: Parking Management Targets

| Improve Management and Distribution of Parking | 2020 | 2035 |
|---|---|---|
| Percentage of total reduced metro area | 10% | 20% |
| **Parking - Increased fees** | **2020** | **2035** |
| Dollars per day | 24 | 30 |

This includes: 1) managing spaces; 2) establishing a reasonable cost; and 3) supporting SANDAG's attainment of SB 375 targets. Actual parking fees would vary by market demand and geographic area. A goal would be to spread fees over a wide area to avoid putting downtown or other centers at a competitive disadvantage.

**Measures Leading to Target:**

- Work with appropriate City departments and stakeholders for improving parking management.
- Evaluate and adjust parking requirements in areas that are highly accessible by alternative modes of transportation including public transit, biking and walking.
- Manage parking, including parking pricing, to reduce congestion and increase use of multi-modal transportation. Work with SANDAG on a regional approach to parking fee increases and complementary transit improvements.

## B. STRATEGY: Reduce Vehicle Idling to Conserve Fuel

This strategy includes re-timing traffic signals and installing roundabouts to decrease the duration of vehicle idling in order to conserve fuel and the resultant emissions.

### Table 4.19: Traffic Signal and Roundabout Targets

| Signal Timing and Roundabouts | 2020 | 2035 |
|---|---|---|
| Number of signals and roundabouts, each | 15 | 20 |

**Measures Leading to Target:**

- By 2014, identify the cost benefit for signal light re-timing and synchronization on arterial routes and expanded roundabouts with the goal of reducing vehicle idling and the associated fuel use and vehicle emissions.
- Work with the appropriate City departments to review recommendations and, if approved, develop an implementation plan.

**Bicycle Infrastructure for the City of San Diego:**

Great weather year-round and terrain that ranges from flat to mountainous make San Diego a great place for cycling. The City of San Diego has approximately 510 miles of exiting bike paths, lanes and routes. The SANDAG Board of Directors has adopted "Riding to 2050, The San Diego Regional Bike Plan." It outlines the vision for the regional bicycle system through 2050.

**iCommute** is San Diego's online resource for commuter choices, like biking to work, in the San Diego region. The program is managed by SANDAG as part of the regional 511 transportation information program. The goal of the iCommute program is to reduce traffic congestion during peak-times, as well as reduce greenhouse gas emissions and other environmental pollutants that result from commuters driving to work each day.

**Bike Lockers.** There are currently more than 60 locations that feature bike lockers, with more added annually. The locations include Trolley stations, all COASTER and SPRINTER stations, I-15 Bus Rapid Transit stations, and some Park & Ride lots. All sites are shown on the San Diego Regional Bike Map.

**Electric Vehicles: Charging the Future for San Diego**

On June 16, 2011, the City of San Diego and Blink® Pedestal celebrated the first installation of electric charging stations for the City. The site of the new charging station is the Reuben H. Fleet Science Center in Balboa Park, one of five in a series of events that celebrate installations of commercial and publicly available charging stations in EV Project markets.

"A well-planned charging network tears down a significant barrier to adopting electric vehicles," Mayor Jerry Sanders said. "I'm proud San Diego will be one of the first cities in the nation to encourage residents to purchase EVs, and that we'll serve as a model for other cities as they look to deploy their charging infrastructures."

"This is another example of how San Diego is leading the way when it comes to energy innovation," said U.S. Rep. Susan Davis. "Electric vehicles provide a lower cost, cleaner alternative to transportation powered with expensive oil."

Ecotality, June 2011.

### C. STRATEGY: Switch to Alternative Fuels

Expand the infrastructure for electric vehicles and incentivize their use.

**Table 4.20: Electric Vehicle Targets**

| Electric Vehicles (EV) | 2020 | 2035 |
|---|---|---|
| Percentage miles driven of personal miles | 4% | 11% |
| **Preferred Parking for EV** | **2020** | **2035** |
| Percentage reserved for electric vehicles | 10% | 20% |

**Measures Leading to Target:**

- Coordinate with the City's Cleantech Initiative to track progress on the number of EV charging stations installed and the number of EVs estimated to be in San Diego.
- Require installation of a J17-72 circuit in new commercial and residential construction in proximity to where the automobile(s) will be in order to make it easier for electric vehicle charging.
- Fully implement the City's commitment to establish an electric vehicle charging network by 2013.
- Require designation of preferential parking spaces to support electric vehicle charging and carpooling.

**Table 4.21: City Fleet Zero Emissions Vehicle Targets**

| Convert Municipal Fleet to EV | 2020 | 2035 |
|---|---|---|
| Percentage zero-emissions passenger and light-duty vehicles | 50% | 100% |

**Measures Leading to Target:**

- Coordinate with the City's Fleet Services to review consistency with City Administrative Regulations that encourage more fuel-efficient vehicle purchases and maintenance to optimize fuel efficiency of existing vehicles.
- Revise AR 90.73 by 2015 to require 50% zero-emissions passenger and light-duty municipal vehicles by 2020, and 100% by 2035.

## 4.4 LAND USE AND FOOD SYSTEMS

Land use patterns dictate the built environment in which we live and travel. As people and businesses spread out over the landscape, people have a harder time walking or bicycling to their destinations and communities lack the efficiencies of density necessary to financially support public transportation infrastructure, such as buses, trolleys or trains. Land use patterns and transportation have historically been closely linked. Smart Growth, a land use concept emphasizing compact, mixed-use development, open-space conservation, expanded mobility, and efficient infrastructure management, is essential for influencing land use patterns in a way that might reduce GHG emissions. The Sustainable Communities and Climate Protection Act of 2008 (SB 375) requires that each of California's metropolitan regions develop a binding land use and transportation investment plan that accommodates anticipated growth while meeting carbon emissions reduction targets. Transportation funding is tied to the plans, and development projects consistent with the plans will receive expedited approvals.
The Worldwatch Institute states that urban agriculture helps the envi-

ronment because they are closer to markets, which means that the food does not have to be transported as far, thus reducing GHG emissions from vehicle exhausts. Also, according to the Institute, because urban farmers often recycle waste for compost, there is less waste going to landfill, which can create vast amounts of methane.

**GOAL:**
Reduce the GHG emissions associated with land use by 69,100 MT by 2020 and by at least 65,300 MT by 2035 through local measures.

**CO-BENEFITS:**

1. Reduced energy costs
2. Increased jobs
3. Improved air quality and health
4. Water conserved
5. Improved quality of life
6. Adaptation

**STRATEGIES AND MEASURES:**

**Table 4.22: Land Use and Food Systems Measures**

| Land Use and Food Systems Measures | 2020 MT $CO_2e$ Reduction | % of Total Reduction | 2035 MT $CO_2e$ Reduction | % of Total Reduction |
|---|---|---|---|---|
| **A. Effective land use** | 69,062 | 2% | 65,279 | 2% |
| Smart growth | | | | |
| Reduce urban heat island | | | | |
| GHG sequestration | | | | |
| **B. Expand local food systems** | | | | |
| Increase local food production | | | | |

**A. STRATEGY: Effective Land Use**

Support the City's General Plan City of Villages strategy and individual community plan recommendations to direct growth into compact, walkable, mixed-use centers linked by transit.

**Table 4.23: Smart Growth Targets**

| Smart Growth | 2020 | 2035 |
|---|---|---|
| Percentage increase in population density in targeted areas from 2010 | 12% | 27% |

**Measures Leading to Target:**

- Work closely with the Planning Division of Development Services Department to record progress on City of Villages strategy to direct growth into compact, walkable, mixed-use centers linked by transit.

**What is a Low-Carbon Diet?**

A low carbon diet refers to making lifestyle choices to reduce the greenhouse gas emissions (GHG) resulting from energy use. A low carbon diet minimizes the emissions released from the production, packaging, processing, transport, preparation and waste of food. Major tenets of a low carbon diet include eating less industrial meat and dairy, eating less industrially produced food in general, eating food grown locally and seasonally, eating less processed and packaged foods and reducing waste from food by proper portion size, recycling or composting.

**What is Smart Growth?**

Smart growth is a compact, efficient, and environmentally-sensitive urban development pattern. It focuses future growth and infill development close to jobs, services, and public facilities to maximize the use of existing infrastructure and preserve open space and natural resources. Smart growth is characterized by more compact, higher density development in key areas throughout the region that is walkable, near public transit, and promotes good community design. Smart growth results in more housing and transportation choices for those who live and work in smart growth areas.

### City of Villages

The 2008 General Plan is principled upon a City of Villages smart growth strategy that demonstrates a strong commitment to sustainable land use practices. The City of Village's strategy focuses growth into mixed-use villages, of different scales, that are linked to the transit system, while respecting San Diego's natural environment and wealth of distinctive neighborhoods. Villages provide a variety of housing types, and allow for pedestrian and bicycle connectivity, with easy transit access to job centers and other more distant destinations. Village locations are consistent with smart growth areas identified in the San Diego Association of Governments (SANDAG) Regional Comprehensive Plan.

### City of San Diego Urban Agriculture Amendments

On January 31, 2012, by Resolution 307262, the San Diego City Council approved amendments to the General Plan Conservation Element to provide policy support for expansion of urban agriculture to realize environmental, economic, and public health benefits including: increasing access to fresh local food; reducing energy used for food transportation and distribution; and increasing opportunities for economic development and local enterprise.

- Seek funding to prepare a Public Park Master Plan (2014) and continue to make progress in park planning efforts through community plan updates and focused planning efforts.

### Implement strategies to reduce the urban heat island effect

#### Measures Leading to Target:

- Work closely with the appropriate City departments to increase implementation of best practices for reducing the urban heat island effect, such as using white roofs and expanding the urban forest in San Diego's urban areas.
- Support the conversion of impermeable hardscapes to permeable softscapes using native or drought-tolerant planting in public and private projects by 2020. Revise design guidelines and standards as needed.

### Advocate for sequestration of GHG through land use practices

#### Measures Leading to Target:

- Research best practices, and work with appropriate City departments to determine the feasibility for expanding wetlands as a means to carbon sequestration.
- Research best practices, and work with appropriate City departments to determine the feasibility for expanding the urban forest in San Diego's commercial and residential areas.
- Research other land use practices that have successfully sequestered GHG.

## B. STRATEGY: Expand Local Food Systems

Support food system planning that increases food security and infrastructure, links local producers to local markets, creates jobs, and re-circulates food dollars in the local economy.

### Table 4.24: Local Food Production and Availability Targets

| Food Production | 2020 | 2035 |
|---|---|---|
| Percentage increase food production and availability | 50% | 50% |

#### Measures Leading to Target:

- Encourage implementation of community gardens in accordance with regulatory reforms approved in 2011 and early 2012
- Report on the existing stakeholder groups' efforts to expand local food production and distribution. Continue public education regarding new urban agriculture opportunities made possible by Land Development Code amendments approved by the City Council in early 2012.
- Report on the existing stakeholder groups' support and action on food system planning and seek out opportunities to incentivize the local production and distribution of food by way of municipal purchasing policies, establishment of local distribution centers and permanent public markets, and other means.
- Create City and County partnerships with healthcare, schools, and other organizations to promote healthy, low-carbon diets.

## 4.5 WASTE MANAGEMENT

There are several different options for managing waste, such as source reduction, recycling, and disposal, all of which affect GHG emissions differently. Methane gas is a by-product from the decomposition of organic material, and it is a powerful GHG that has about 20 times the effect as carbon dioxide. For this reason, landfills and wastewater treatment plants were among the first facilities required to report emissions under AB 32. In 2010, the City's waste diversion rate was 68%, and the goal is to achieve 75% by 2020. This reduction of waste entering the landfill significantly reduces GHG emissions. Methane gas can also be refined and used as a fuel. The City strives to maximize the capture of methane gas from landfills and sewage treatment facilities not just to be in compliance with regulations, but also to increase production of energy. The City's landfill and sewage treatment plants produce a combined total of nearly 17 MW of electricity, equivalent to what is used by approximately 10,000 homes. The result from implementing the waste management strategies is equivalent to removing approximately 102,500 cars from the road or emissions from electricity generation for 65,200 homes.

**Waste Statistics for the City of San Diego:**

- Percent of waste that was diverted from landfill disposal in 2011: 66%
- Average daily waste that was disposed in 2011: 5.9 pounds/person/day

### GOAL:

Reduce the GHG emissions associated with the methane gas releases from landfill and from wastewater treatment by 523,100 MT by 2020 and by at least 656,700 MT by 2035 through local measures.

### CO-BENEFITS:

1. Reduced energy costs
2. Improved air quality and health
3. Adaptation

### STRATEGIES AND MEASURES:

**Table 4.25: Waste Management Local Measures**

| Waste Management Measures | 2020 MT $CO_2e$ Reduction | % of Total Reduction | 2035 MT $CO_2e$ Reduction | % of Total Reduction |
|---|---|---|---|---|
| **A. Improve Waste Management Efficiency** | | | | |
| Divert trash | 523,090 | 13% | 656,668 | 13% |
| Capture and utilize landfill gas | | | | |
| Capture and utilize sewage treatment gas | | | | |

### A. STRATEGY: Improve Waste Management Efficiency

Increase the diversion of trash from landfill disposal, increase the capture and use of landfill gas, increase the capture and use of sewage digester gas, and support other policies that promote the efficient use and recyclability of resources.

### Gas Capture (Methane) in Landfills

Methane ($CH_4$) constituted approximately 8% of U.S. GHG emissions (2007). Methane is emitted from a number of sources including wastewater treatment plants, sewers, and landfills. Landfills were the second-largest U.S. source of methane emissions. Efforts to reduce emissions of methane from natural and anthropogenic sources could play a significant role in climate change mitigation. Both landfills and sewage treatment operations have new State and Federal laws and regulations that require capturing the methane generated from anaerobic decomposition of organic material. The City of San Diego uses much of the captured methane for the production of electricity.

**Table 4.26: Trash Diversion Targets**

| Divert Trash | 2020 | 2035 |
|---|---|---|
| Percentage of trash diverted from landfill | 75% | 75% |

**Measures Leading to Target:**

- Expand organic waste diversion programs to 70,000 tons by 2020 and 140,000 tons by 2035.
- Continue to update the City waste management strategy and prioritize the most successful technologies.
- Adopt the City's Long Term Resource Management Strategic Plan.
- Require construction/building/remodeling projects to use 20% recycled construction materials by 2035.
- By 2017, develop a Resource Recovery Center at Miramar Landfill to maximize waste diversion.
- Support legislation and policy at the national, state and local level that will require extended producer responsibility and improve the recyclability of products and packaging by 2015.
- Adopt a zero waste resolution by 2015.
- Adopt a plastic bag ordinance by 2015.

**Table 4.27: Landfill Gas Capture Targets**

| Capture Landfill Gas | 2020 | 2035 |
|---|---|---|
| Percentage of landfill gas capture | 80% | 80% |

**Measures Leading to Target:**

- Increase landfill gas monitoring wells, consistent with AB 32 guidelines, ensure ongoing compliance, and report on effectiveness of landfills' methane gas collection system.
- In concert with private sector partners, continue to improve utilization of gas in energy generation through fuel cells, co-generation, and other technologies.

**Table 4.28: Sewage Treatment Gas Targets**

| Capture Sewage Digester Gas | 2020 | 2035 |
|---|---|---|
| Percentage of wastewater gas capture | 98% | 98% |

**Measures Leading to Target:**

- Report on the effectiveness of digesters' gas collection system.
- In concert with private sector partners, continue to improve utilization of gas in energy generation through fuel cells, co-generation, and other technologies.

## 4.6 STATE AND FEDERAL ACTIONS

### Support Implementation of Related State and Federal Policies:

**Federal Corporate Average Fuel Economy:** U.S. EPA and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) joint rule established a national program consisting of new standards for model year 2012 through 2016 light-duty vehicles that will reduce GHG emissions and improve fuel economy. EPA is finalizing the first-ever national GHG emissions standards under the Clean Air Act, and NHTSA is finalizing Corporate Average Fuel Economy (CAFE) standards under the Energy Policy and Conservation Act.

**Federal Alternative Fuels Strategies:** Based on current GHG emission reporting guidelines, the transportation sector directly accounted for about 28% of total U.S. GHG emissions in 2006, making it the second-largest source of GHG emissions, behind only electricity generation (34%). An alternative fuel, most generally defined, is any fuel other than the traditional selections, gasoline and diesel, used to produce energy or power. The emissions impact and energy output provided by alternative fuels varies, depending on the fuel source. Examples of alternative fuels include biodiesel, ethanol, electricity, propane, compressed natural gas, and hydrogen.

**California Renewables Portfolio Standard:** Established in 2002 under Senate Bill 1078, accelerated in 2006 under Senate Bill 107 and expanded in 2011 under Senate Bill 2, California's Renewables Portfolio Standard (RPS) requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 33% of total procurement by 2020.

**California Low Carbon Fuel Standards:** Executive Order S-1-07, the Low Carbon Fuel Standard (LCFS) calls for a reduction of at least 10% in the carbon intensity of California's transportation fuels by 2020.

**California Energy Commission and California Air Resources Board Vehicle Maintenance Recommendations:** The California Legislature required a California strategy to reduce petroleum dependence, including increasing transportation energy efficiency by adhering to specific vehicle use and maintenance recommendations.

**California Air Resources Board Heavy Duty Vehicle Regulations:** Adopted in December 2008, this new regulation requires improvements in heavy-duty vehicles. The regulation is expected to reduce greenhouse gas emissions by approximately 1 million metric tons of $CO_2e$ by 2020, statewide. Between now and the end of 2020, after the rule has been in effect, it is estimated that truckers and trucking companies will save about $8.6 billion because diesel fuel consumption will be reduced by as much as 750 million gallons in California and 5 billion gallons across the nation.

## 4.7 COST-EFFECTIVENESS OF STRATEGIES

While economic quantification of each measure was not feasible, the CMAP measures are designed to be advantageous to San Diego businesses, residents, and government. For example, many of the CMAP measures decrease energy costs for consumers. Through investments in energy efficiency and renewable energy, individuals, households and businesses will reduce costs and achieve long-term savings for operations and maintenance budgets. Similarly, the water conservation and efficiency activities will increase citywide water security and decrease reliance on imported sources. Given these benefits, implementation of the CMAP is predicted to positively impact the San Diego economy.

Evaluating the cost-benefit of a project is complex and requires transparency about the assumptions that were made. Table 4.29 provides a summary of the costs, which are shown in the net present value in 2010 dollars per metric ton of carbon dioxide equivalent ($2010/MT $CO_2e$) for the measures analyzed. The methodology for establishing the costs can be found in Appendix III.

### Solar Photovoltaics Sensitivity Analysis

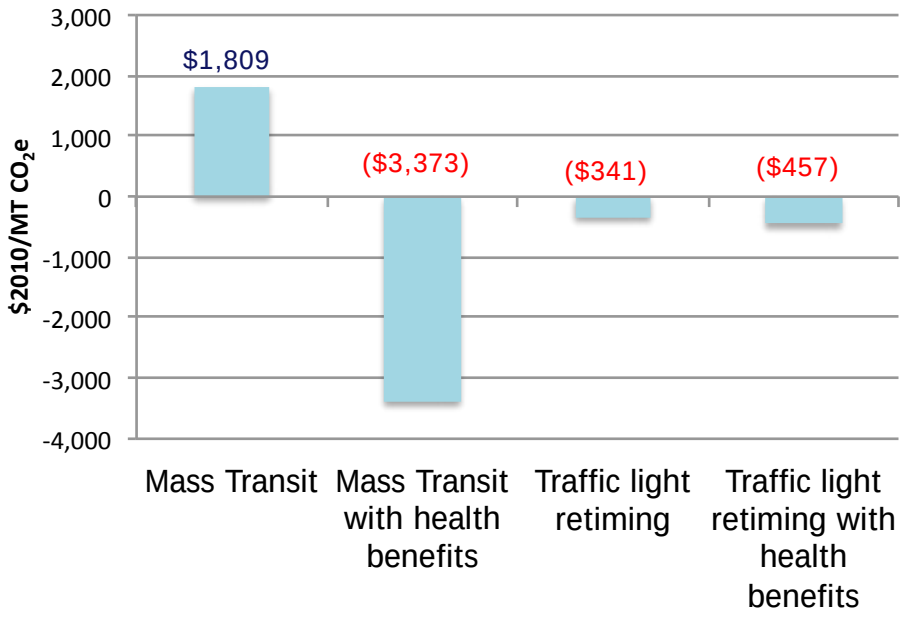
The cost of photovoltaics has been declining over the past decade, more quickly in recent years. It is likely these trends will continue but there is some uncertainty associated with future installed costs of photovoltaics, including availability of federal tax credits, funding for extending the California Solar Initiative, and other market forces like the significant drop in natural gas prices due to an increase in hydraulic fracturing (fracking) in North America. To show how a drop in installed costs would affect the overall cost-effectiveness of residential and commercial photovoltaics, the cost was calculated per metric ton of $CO_2e$ for prices ranging from $1.00 per Watt to $7.00 per Watt both in 2010 and 2020.

In this case, the year 2010 should be regarded as a proxy for today (2012). For the purposes of this analysis, installed costs represent the full cost of installation and do not take into account subsidies. This represents the cost to society, not to the end user.

**Table 4.29: Summary Table of Strategies Cost Effectiveness ($2010/MT $CO_2e$)**

| Cost Effectiveness of CMAP Measures ($2010/MT $CO_2e$) | |
|---|---|
| **Electric/Natural Gas Measures** | **2020** |
| Commercial retrocommissioning | ($193) |
| Commercial efficiency retrofits | $42 |
| Residential solar water heating retrofit - single family | $72 |
| Residential efficiency retrofit - multi-family | $100 |
| Residential photovoltaics | $175 |
| Commercial photovoltaics | $327 |
| Residential efficiency retrofit - single family | $596 |
| **Transportation Measures** | **2020** |
| Mass transit with health benefits | ($3,373) |
| Traffic light retiming with health benefits | ($457) |
| Traffic light retiming | ($341) |
| Roundabouts | ($340) |
| Parking fee strategy | $9 |
| Preferred parking for electric vehicles | $15 |
| Mass transit | $1,809 |
| Bicycle strategy | $40,864 |

**Figure 4.2: Cost of Transportation Measures for 2020 - Effects of Health Benefits on Selected Measures**



# CHAPTER 5 – CLIMATE ADAPTATION

## 5.1 INTRODUCTION

Climate change presents numerous risks for cities around the world that range in type, timing and severity. A recent assessment of climate change impacts for the San Diego region identified exacerbated conditions for heat waves, drought, wildfires, intense rainfall events and coastal inundation due to storm surge and sea level rise (San Diego Foundation 2007). This regional study provides the first step in assessing the City of San Diego's specific vulnerability. Resiliency is dependent upon both a retrospective review of climate change impacts and, to a greater extent, a prospective analysis of current climate change models, such as those provided by the IPCC.

The City of San Diego has identified vulnerabilities associated with a changing climate and possible responses; however, a more detailed analysis is needed. A vulnerability assessment is recommended in order to fully understand the risks, impacts and possible solutions. This is essential in order to take effective and timely action to alleviate the range of consequences. The purpose of this chapter is to highlight work currently underway and provide basic information about: 1) vulnerabilities and potential impacts; 2) adaptation strategies; and 3) the cost and benefits of taking action sooner rather than later.

### Step one is prioritizing risks.

Not all issues can or should be addressed at once, so the risks will be prioritized to maximize the use of the City's resources while ensuring a timely and effective response. Factors to consider when prioritizing projects include: public health and safety, available funding sources, legal mandates, planning consistency, capacity and level of service, cost-benefit relationship, and public support. Risks that present the most serious consequences and are projected to occur first will raise a project's level of priority; however, it is also important to initiate responses to serious longer-term risks if their response requires substantial time to implement.

### Step two is evaluating possible solutions.

Risks can be addressed by reducing vulnerability or exposure. This can be accomplished by increasing infrastructure resilience, transferring the risk through insurance, negating the risk through technological change or retreat, and through behavior change.

### Step three is reviewing and initiating public policy and protocols.

Reviewing current City policies, protocols and/or programs associated with potential climate risks allow for adjustments and actions that can alleviate the impacts. The CMAP builds the base of knowledge to inform future decisions so that they minimize vulnerabilities and/or liabilities.

Of utmost importance to the successful implementation of an adaptation strategy is to communicate the issues and engage the community in the proposed responses. Studies repeatedly show that a knowledgeable community that understands how to respond to extreme events is far more resilient to the impacts. Informed people are also more likely to make personal decisions that contribute to developing a prosperous, livable and affordable city in the face of climate change.

The State of California addresses adaptation to climate change through its California Climate Adaptation Strategy. The State also prepared an Adaptation Policy Guide to provide a decision-making framework intended for use by local and regional stakeholders to aid in the interpretation of climate science and to develop a systematic rationale for reducing risks caused, or exacerbated, by climate change. The California Natural Resources Agency and the California Energy Commission have released Cal-Adapt, a web-based tool that enables city and county planners, government agencies, and the public to identify potential climate change risks in specific areas throughout California.

**West Nile outbreak largest ever in U.S.**

CNN - August 23, 2012

The recent West Nile virus outbreak is the largest ever seen in the United States, according to new numbers from the Centers for Disease Control and Prevention.

The number of cases so far this year is the highest recorded since the disease was first detected in the United States in 1999. As of August 21, 38 states had reported human infections. The cases reported to the CDC total 1,118, including 41 deaths

**High priority public health risks include:**

- Flooding can inundate stormwater and wastewater systems, contaminating recreational water sources, and creating health risks
- Potential increase in vector borne disease
- Potential respiratory illness, injury or death due to wildfires
- Potential water quality issues due to wildfires in water catchments, which can also significantly reduce runoff and affect water supply availability
- Potential increased incidence of heat stress illness and death in the community during heat waves
- Increased accidents due to flooding or windstorm events

## 5.2 VULNERABILITIES, POTENTIAL IMPACTS, AND ADAPTATION RECOMMENDATIONS

Based on research from Scripps Institute of Oceanographcy (SIO), as well as a number of other national, State and local researchers, San Diego faces serious regional vulnerabilities from a changing climate. The San Diego Foundation commissioned a landmark study titled "Focus 2050 Study for the San Diego Region," in which many of the vulnerabilities were identified:

- The City will see hotter days and more prolonged heat waves.
- Hotter days create more air pollution by raising ozone levels and this can exacerbate asthma and other respiratory and cardiovascular diseases.
- Warmer temperatures year-round could lead to growing mosquito populations, increasing the regional occurrence of West Nile virus and potentially introducing tropical diseases such as Malaria and Dengue Fever to the San Diego region.
- Water and energy demand will increase while the potential supply diminishes.
- Drier weather may increase the frequency and size of wildfires.
- Projected sea level rise, coastal erosion, and increasing storm surges may be significant issues for low-lying coastal districts.

### Protecting Public Health

Public health is arguably the most important concern and multidimensional issue to address in response to climate change. Understanding how extreme events may affect human health and possible solutions or mitigation to protect vulnerable populations is essential. These risks include health impacts associated with diminished air quality from wildfires or excessive ozone; hotter temperatures causing heat stress and death; flooding or wind storm events causing injury and death; and the introduction of new vector-borne diseases to the region.

### General Recommendations:

- Review current alert systems with health services and/or Centers for Disease Control and Prevention to identify effective improvements; work with health services to develop a communications campaign to educate the community about risks, precautions and symptoms; engage environmental health workers to identify and monitor known or potential breeding sites of vectors.
- Review current water treatment and monitoring programs; assess impact of rising temperatures on water quality and potential associated impacts to public health.
- Collaborate with wildfire authorities, health services and regional districts to identify shared vulnerabilities and responses; review current air quality warning system and revise if necessary; develop school education program and protocols with regard to wildfire affected air quality days.
- Consider potential water restrictions policy related to wildfire incidents.
- Review current heat wave response plans and revise if necessary; consult with health and emergency services to ensure alignment; involve event sector to maximize compliance.
- Work with elderly care, children and social welfare services and health providers to create collaborative prevention awareness campaign. Coordinate and promote 'cool-safe' venues with proprietors and health services; review city policy for outdoor workers and prepare regionally aligned heat wave plan; promote early in the season to maximize community preparedness; require health services to record and report heat stress related illness and death to monitor impacts and results.
- Review current food preparation and storage requirements for outdoor events or temporary stalls and revise accordingly; include health issue advice in any relevant event permit applications to ensure awareness of issue; work with health providers to develop public awareness campaign.
- Review and revise, if necessary, public education programs, early warning systems and protective measures to help alleviate impacts.

### Maintaining Water Supply and Services

Adequate water supply is a fundamental requirement for every community. Like many other California cities, San Diego's water challenge is meeting ever-increasing demand with a projected declining supply. By 2030 the San Diego County Water Authority projects an increase in water demand of 24%, including the expected realization of a 12% per capita demand reduction. Approximately 70% of the 2030 demand is expected to be met by imports. By 2050, the expected increase in demand is 37% over 2005 levels. This does not take into account the projected supply reductions by 2050 due to climate change that currently shows a shortfall of approximately 20%. This is a serious concern to San Diego.

**Wildfires raging in 13 western states**

CNN - August 16th, 2012

At least 70 large fires were burning across 13 states west of the Mississippi River, according to the National Interagency Coordination Center. California had the most with 13, followed by Nevada with 12 and Idaho with 10, the center said. In California alone, 8,000 firefighters were fighting a dozen fires, the state Department of Forestry and Fire Protection said Wednesday. The state issued a burn ban, saying only some campfires are allowed.

**The high priority water supply risks include:**

Potential reduction in available water supply. With drought years expected to double from now until 2050 and supplies in the Colorado River and Delta Basin expected to significantly decline, the consequence of inadequate or unaffordable water is serious.

**Drought sends 'mighty Mississippi' river levels near record lows**

CNN - July 19, 2012

The "mighty Mississippi" has lost some of its might with the season's epic drought taking its toll on river levels, which are falling to near historic lows. The U.S. Army Corps of Engineers will spend nearly $7 million dredging in an attempt to keep ports operational and keep the river open for barge traffic in the coming weeks.

**The high priority infrastructure risks include:**

Roads, sidewalks, bridges, communications networks, sewer systems, transit systems and energy grids will all be affected by climate change impacts in different ways.

### General Recommendations:

- In San Diego, 58% of water is used for residential purposes, which is expected to increase to approximately 66% by 2050. A significant amount of that water is used for landscaping. Therefore, water efficient landscaping is clearly a priority consideration for San Diego to adapt to climate change in this area and ensure sufficient water supply. Such a challenge requires the coordinated efforts of many stakeholders at government, industry and community levels. For the commercial and industrial sector, which consumes approximately a third of the supply, conservation and efficiency efforts should focus on the largest users to gain the most significant results.

- Short- to medium-term strategies include: Continued implementation of the City's Long-Range Water Resources Plan (LRWRP) and 2010 Urban Water Management Plan (UWMP). The LRWRP defines a plan to reduce reliance on water supply imports and develop and maximize the City's water resources. The 2010 UWMP provides a 25-year estimate of water supplies and demand, and is updated every five years. The UWMP discusses potential climate change impacts to water supply and documents how the City meets the Water Conservation Act of 2009 goal to achieve a 20% reduction in urban per capita water use. The plans discuss numerous initiatives currently underway that address future water supplies including implementing a Water Purification Demonstration Project, undertaking a Recycled Water Study, implementing a Water Efficient Landscape Ordinance (includes requirement for projects to meet a water budget), and public outreach and education measures, among other actions.

- Take immediate steps to reduce reliance on imports; price increases should consider social equity; public communication programs identifying district, sector and high users have potential to shift values and make price increases and water restrictions more acceptable.

## Protecting Urban Infrastructure and Services

Urban infrastructure forms the structural and functional backbone of the City. A breakdown in that structural or functional integrity can cause a range of cascading consequences for residents, businesses and/or tourists. It is important to identify where the risks are most significant and which critical assets are most vulnerable. This will aid in prioritizing assets and actions to maintain service resilience.

### General Recommendations:

- For critical assets at significant risk, implementing climate resilient asset management strategies early will ultimately decrease the risk of asset damage and failure that in turn reduces or minimizes the recovery costs resulting from an extreme event.

- Where response measures are considered important but not urgent, aligning the implementation of the measures with asset management, maintenance and renewal cycles means costs can be streamlined. While there may be additional costs for the resilience measures, these costs are minimized when incorporated with already budgeted replacement and renewal initiatives.

- It is also important that adaptation measures be planned in the context of the expected life span of the asset and the timing of the projected impacts of climate change. This allows resilience measures to be staged as climate becomes more extreme as well as builds in flexibility to allow variations to the response measures that reflects updated science, revised risk ratings or observed trends.

Adaptation measures to be undertaken by the City to address infrastructure issues of high and medium priority in the short term include:

- Address potential subsidence and erosion affecting stability and safety of roads in drought conditions by aligning assessments with road maintenance schedules.
- Consider potential damage to, or destruction of, public and private infrastructure due to wildfires by identifying key service vulnerabilities and redundancy options.
- Consider potential power outages in heat waves due to demand exceeding supply and the impacts for water and wastewater infrastructure, building tenants and other critical infrastructure.
- Assess potential for blocked access in low-lying areas due to flash-flooding impacting residents, emergency services, local businesses, distribution networks, and through traffic causing mass delays. Consider seasonal drainage issues, additional pumping capacity and protocols in critical areas, highlight alternative routes and review emergency warning systems and traffic management.
- Address potential building and asset damage due to flash flooding in low-lying areas surpassing drainage capacity by reviewing flood preparedness programs, review drainage capacity and climate projections, promote flood preparedness in development approvals, and assess stormwater harvesting potential to alleviate drainage issues and water supply pressures.
- Consider potential heat stress and damage to infrastructure in heat waves, including thresholds for warping of electricity network, bridge supports and train tracks, by relevant asset owners and authorities to identify risks and extreme event protocols.

## Protecting Environmental Health

Environmental health is of significant importance to the community. Healthy natural water systems, vegetation areas, wetlands, estuaries and the biodiversity that lives there, as well as air quality, all provide important ecosystem services to the surrounding districts and residents. In San Diego, environmental health also contributes to tourism, water sport industries, recreational and commercial fishing, marine industries and public events. Any decline in environmental health will likely also result in a negative effect on these social and economic activities. Balancing the needs of the environment with the needs of the community is of critical importance and climate change may further challenge that balance. There is a need to identify key issues and prioritize climate adaptation actions in a manner that best meets community goals.

**The high priority environmental health risks include:**

- Changes to pest and weed prevalence may be a key issue with rising temperatures and reduced water availability; this can have considerable ripple effects for indigenous flora and fauna species.
- Rising temperatures threaten the viability of certain plant and tree species and temperature-sensitive animal species such as birds, frogs and butterflies.
- Increased risk of pollution from intense rainfall events in storm drains, waterways, and local beaches.
- Economic impact from decreased tourism due to contaminated beaches.

**The high priority risks associated with parks and recreation include:**

- Drought can stress trees causing branches to fall with potential risk of injury.
- Dried park areas can result in a reduction of community use and pride and tourism losses.

"In times of tight budgetary constraints, state and national level policy leaders must remember the need for long term strategies that will be essential to answer practical resource management questions of today and for future generations."

James Boyd, Vice-Chair, California Energy Commission (2011).

### General Recommendations:

- Working with local agencies region-wide to develop monitoring programs to address the problem and develop innovative solutions tailored to the emerging issues.
- Undertake climate change risk assessment and incorporate into City risk profile; review all processes and protocols to incorporate climate change considerations.

Adaptation measures to protect our environmental health in the short- to medium-term will include:

- Review, and if necessary revise, current invasive weed and pest management plans to address projected changed conditions; consider potential increased maintenance and resource requirements.
- Identify potential pollution channels and steps to prevent contamination; promote good waste practices upstream in the community.

## Maintaining Open Space, Parks and Recreation

It is important to understand that impacts to recreational space or activities can have a significant impact on lifestyle and wellbeing for many San Diegans. Parks and open space are a key attribute of the culture and character of the City. The urban green spaces provide recreational and tourism appeal as well as alleviate the heat island effect and provide some level of mitigation for intense flooding events. Extreme temperatures create health risks for outdoor sports activities and harden sporting fields, causing more frequent and significant injuries. Losing our sporting activities at certain times of the year would also lose the community cohesion and health benefits that they create.

### General Recommendations:

- Recreational alternatives or protection strategies can help to maintain the integrity of the park and recreation system; therefore, adequate training of City staff about adaptation measures is important.
- Providing public education and outreach can ensure that the community is aware of the safeguards and measures in place.

## Coastal Management and Protection

The prospect of sea level rise, as well as coastal erosion and storm surge as it advances, is a significant issue for all low-lying, soft shore coastal districts. This complex issue is challenging to address. The competing demands of coastal development and community protection provide an ongoing tension that features diverse interests and objectives.

In 2009, the California State Lands Commission confirmed that the 'gradual and imperceptible' increase in sea level rise would see the shifting shoreline also move the sovereign land boundaries in the eyes of California law. How this will translate to property ownership or evacuation obligations has not been defined.

Detailed adaptation studies pertaining to climate change are relatively new. The first detailed analysis for the San Diego region was funded by

The San Diego Foundation and completed by the nonprofit organization ICLEI- Local Governments for Sustainability in January 2012. The study focused specifically on the land bordering San Diego Bay, which includes the City of San Diego. The primary vulnerabilities by sector listed below are derived from the "Sea Level Rise Adaptation Strategy for San Diego Bay" (January 2012). They are as follows:

**Ecosystems and Critical Species**

- Bay ecosystems, which provide habitat for many endangered and threatened species, are extremely vulnerable to inundation that is expected to result in habitat shift. These shifts could cause the loss of irreplaceable habitats for critical species in many areas.

- Upland areas are vulnerable to erosion, and subtidal ecosystems are threatened by erosion of upland areas and degraded water quality.

**Contaminated Sites**

- Hazardous waste sites are highly vulnerable to flooding and inundation as storage tanks in the area could be opened or moved, or motors and pumps could be impaired thus releasing contamination into floodwaters or area soils.

**Stormwater Management**

- Storm sewers are highly vulnerable to flooding and inundation in the Bay due to higher sea levels, a condition that would result in localized flooding in very low-lying inland areas.

**Wastewater**

- Sanity sewers in low-lying locations will be vulnerable to floodwater inflow that could exceed their capacity, potentially in discharge of wastewater to the Bay.

- The entire wastewater collection system in the planning area will be vulnerable to inundation impacts.

**Potable Water**

- Aboveground water distribution components such as valves, meters, and service points will be vulnerable to flooding and inundation.

**Energy Facilities**

- Aboveground electricity transmission and distribution in limited areas will be vulnerable to erosion, particularly after 2050 and during major storm events. Erosion could undermine infrastructure, causing outages or safety issues.

- Aboveground electricity transmission and distribution will be moderately vulnerable to flooding and inundation, particularly in the 2100 time frame when more components are likely to be exposed to regularly occurring flood events.

**Local Transportation Facilities**

- Access provided by local transportation facilities will be vulnerable to flooding and inundation, particularly in the 2100 time frame when more components are likely to be exposed to regularly occurring inundation.

- Roads and other facilities could also be vulnerable to flooding and inundation due to saturated soils and impacts on road substructure and pavement degradation.

**Definitions:**

**Risk**

Denotes the result of the interaction of physically defined hazards with the properties of the exposed systems - i.e., their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences - i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability.

**Resiliency**

When referring to natural systems, the amount of change a system can undergo without changing state. When referring to human systems, the term "resiliency" can be considered as a synonym of adaptive capacity. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

**Vulnerability**

The degree to which systems affected by climate change are susceptible to and unable to cope with adverse impacts.

**Building Stock**

- Residential buildings have low vulnerability to flooding in the 2050 scenario due to limited exposure. They are highly vulnerable to flooding and inundation in the 2100 scenarios as exposure expands to large portions of residential neighborhoods and major commercial facilities.

**Emergency Response Facilities**

- Fire stations in San Diego and Coronado are moderately vulnerable to flooding in the 2100 Extreme Event scenario.

**Parks, Recreation, and Public Access**

- Shoreline parks and recreational facilities are extremely vulnerable to regular inundation due to extensive exposure around the Bay and high sensitivity to inundation impacts.
- The system is highly vulnerable to flooding because of extensive exposure and high sensitivity, but adaptive capacity to cope with flooding is higher than for most other systems.

**Regional Airport Operations**

- Parts of the Airport site will be vulnerable to localized flooding from blocked storm outfalls in the Bay.
- In the 2100 scenarios, Airport operations will be extremely vulnerable to Bay flooding and inundation, particularly from impacts on access roads, future terminal areas, and portions of the runway/airfield.

**Vulnerable Populations**

- Many groups that are currently vulnerable – such as low-income residents, the homeless, elderly, and ethnic minorities – will face even greater threats from future flooding, particularly in the 2100 time frame.
- Residents that work in sectors that could be adversely impacted by future flooding are also a key vulnerability for the region.

**General Recommendations:**

- While protection measures can be somewhat gradual or progressive, ensuring that no unsuitable development is undertaken in known vulnerable areas should be a key priority to limit future damages and public risk.
- Estuaries and wetlands at risk of inundation threaten both the local species as well as the ecosystem services the area provides.
- Address potential inundation and erosion of soft shore, low-lying coastal residential and recreation areas that will damage assets and displace residents; consider potential coastal protection measures and associated impacts.
- Consider potential inundation and erosion of soft shore low-lying coastal business and tourism areas and evaluate resulting economic losses; consider potential coastal protection measures and associated impacts; work with local businesses to identify opportunities for retreat; develop progressive shift strategy to alleviate future damage and ensure preservation of future community identity and appeal.

- Consider potential inundation and erosion of soft shore, low-lying coastal estuaries and wetland areas which will endanger local biodiversity and ecosystem services by working with relevant agencies to establish assessment and protection principles and protocols; ensure consideration of ecosystem services in assessing vulnerability and values.

- Identify key issues and vulnerable species in the short, medium and long term; collaborate with other districts sharing resources and maximizing effective opportunities for species and habitat protection.

- Identify vulnerable properties and work to ensure collaborative solutions and minimize future liability; identify range of potential response measures that together create a planned and progressive solution, minimizing social and economic damages.

### Land Use Planning

The City's General Plan (2008) and Community Plans have important roles in adaptation planning. The General Plan lays out the policy framework for addressing climate change and the Community Plans have the purview to make site-specific land use and design recommendations. These recommendations, along with implementing ordinances, can influence the level of consequence from climate change impacts. Examples of planning-related adaptation strategies include:

- Designating land for a full range of uses, including open spaces and high density areas where appropriate.

- Designing a multi-modal mobility system with multiple routes in and out of communities.

- Fostering urban agriculture to increase food system security.

- Implementing tree planting incentives, ordinances and programs to save energy, sequester carbon, and reduce the urban heat island effect.

- Requiring appropriate setbacks from the coast in areas subject to sea level rise.

- Requiring development to incorporate natural drainage basins and water features to capture storm water in areas vulnerable to increased flood risk.

- Implementing brush management programs to reduce wildfire risk in fire-prone areas.

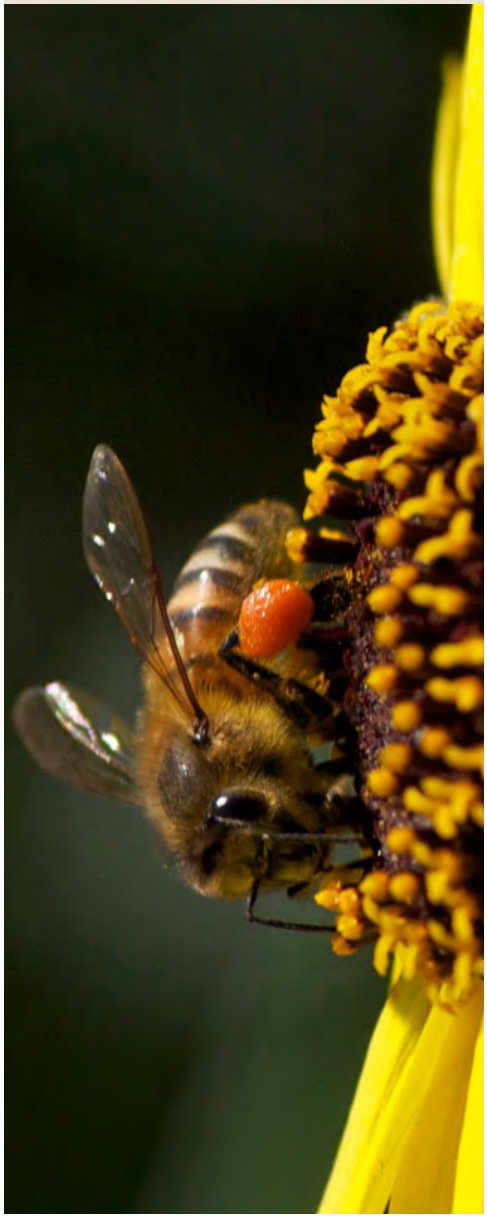
- Increasing conservation and efficiency in water use to reduce reliance on imported water.

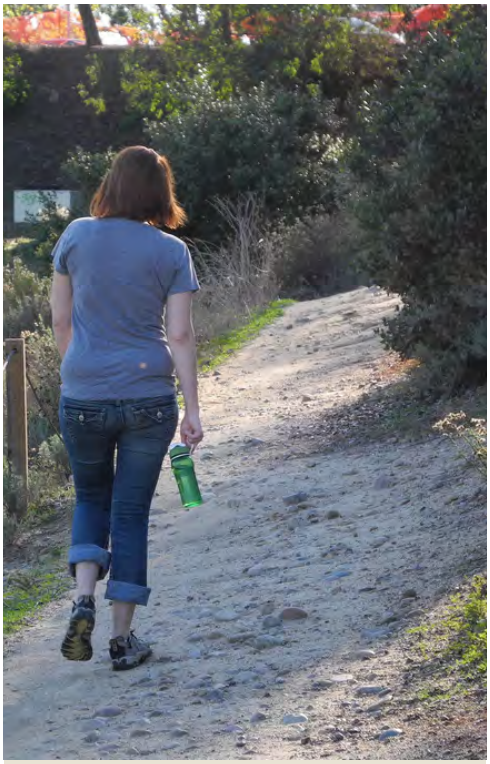
- Coordinating with urban farmers and regional San Diego County Farm Bureau; assessing alternate irrigation or protective recommendations.

**Drought has ripple effect on world food prices**

CNN - August 14, 2012

The Agriculture Department announced this season's first major crop yield forecasts, and they weren't pretty: a nationwide average of 123.4 bushels of corn per acre, the lowest level since 1995. Soybean yield is expected to be low too, though not as bad as corn. This will surely affect the price of food worldwide including here in United States. Get ready to cough up the cash.





## 5.3 NEXT STEPS

Table 5.1 provides a framework for the next steps that the City can undertake to develop a more robust adaptation plan. A general approach includes the following:

- Continue to collaborate with other government agencies, universities, non-governmental organizations and the private sector to gain access to the best available climate science, policy, and practices.
- Develop adaptation assessment guidelines to help identify risks and prioritize actions.
- Integrate climate projections into the Multi-jurisdictional Hazard Mitigation Plan and the City's Office of Homeland Security. This will ensure adequate planning and preparation for more frequent and intense extreme events, such as wildfires, heat waves and storms.
- Engage the public to stay informed of community issues, and to raise community awareness of the need for adaptation, and highlight actions individuals can take in their home and workplace.
- Understand the communication and risk disclosure requirements regarding impact vulnerability and land title for existing and prospective owners.
- Investigate the need for community-specific adaptation strategies in conjunction with community plan updates.
- Undertake climate change risk assessments and incorporate into the City risk profile.

Table 5.1 was developed as a summary that includes impacts, sensitivity, benefits and considerations for future research.

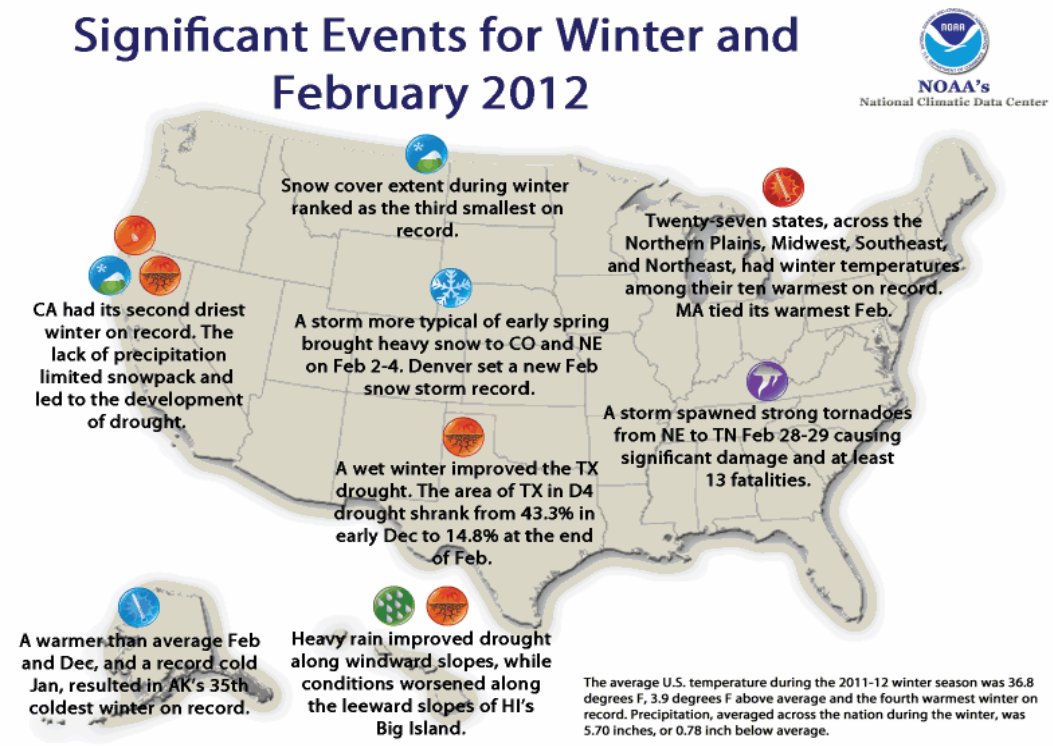



**Image Courtesy of: National Oceanic and Atmospheric Administration, State of the Climate, National Overview, February 2012 http://www.ncdc.noaa.gov/sotc/national/2012/2**

**Table 5.1 – Adaptation Strategies Table**

| Impact | Theme | Implication/Consequence | Sensitivity | Benefits | Current Policy / Program | Steps/Considerations | Stakeholders |
|---|---|---|---|---|---|---|---|
| All impacts | Municipal | Highlight climate change profile within government and combine with sustainability agenda and risk management | | Builds ongoing capacity for government to incorporate climate concerns into decisions ensuring vulnerability is not unduly increased | | Undertake climate change risk assessment and incorporate into City risk profile; review all processes and protocols to incorporate climate change considerations | City; residents; business and industry; insurer |
| All impacts | Municipal | Integrate climate projections into Multijurisdictional Hazard Assessments and City's Office of Homeland Security | | Ensures adequate planning in the case of more frequent wildfires, heatwaves, and extreme events | | Work with current communications channels | City; residents; business and industry; insurer |
| All impacts | Municipal | Raise awareness in community of need for adaptation and actions that can be undertaken at home and business to support City goals | | Ensures community understands reasoning behind other council decisions; builds action in the community | | Work with current communications channels to that climate change is smoothly integrated into City conversation in all areas | City; residents; business and industry; insurer |
| Increased temperature | Public Health | Increased temp and changes to rainfall may affect prevalence of vector borne disease (VBD) and health of waterways | Current prevalence of VBD and % of population vulnerable; existing health of water system; capacity for community to pay for additional treatment costs | Minimize VBD outbreaks and pressures to health services | | Review current alert systems with health services or CDC and revise to include potential changes due to climate change; work with health services to develop a communication campaign; engage environmental health workers to identify and monitor potential vector breeding sites | Vulnerable population groups; health service providers; City; CDC; environmental health managers; regional districts |
| Increased temperature | Public Health | Increased temp and changes to rainfall may affect prevalence of water borne disease (causing health risks and increased treatment costs and potential liability) | Current prevalence of water borne disease and ability to monitor and treat | Minimize water borne disease outbreaks, pressures to health services, and potential City liability for any health impacts | | Review current treatment and monitoring programs; assess impact of rising temperatures on water quality and potential impacts | Residents; health authorities; CDC; water authority; City; other water users |
| Increased temperature | Public Health | Increased risk of water and food borne disease at outdoor events esp. temporary food stalls | # of events and attendees | Minimize or eliminate health impacts due to food or water borne disease at outdoor events in increased temp conditions | | Review current food preparation and storage requirements for outdoor events and revise accordingly; include health issue advice in any relevant event permit applications to ensure awareness of issue; work with health providers to develop public awareness campaign | Event organizers; health services; City; event insurers; residents and event attendees and participants |
| Increased temperature | Natural Environment | Changing temps and rainfall patterns may have adverse impacts on biodiversity creating worsened and new pest and weed problems | Propensity for weeds and pests to be introduced to local habitat | Environmental benefits of managing weeds and invasive species reducing future costs to address habitat collapse | | Review existing weed and invasive management plans to address changing conditions and consider potential increased maintenance and resource requirements | Local residents; City; environmental authority; conservation agencies |

**Table 5.1 (cont.) – Adaptation Strategies Table**

| Impact | Theme | Implication/Consequence | Sensitivity | Benefits | Current Policy / Program | Steps/Considerations | Stakeholders |
|---|---|---|---|---|---|---|---|
| Drought | Water | Insufficient urban water supply | % of homes with raintanks installed; extent local industry reliance on urban water supply; community willingness and capacity to pay more for water; availability of alternative water sources; vulnerability of imported water sources | Identify non-critical water uses and reduce or eliminate; negotiate further shortage share agreements and determine residual shortfalls; minimize discretionary bathroom water use in residential and commercial; reduce ongoing water demand standard usage; maximize efficiency in new development; ensure more use means more revenue or demand control | GP: Water Management and Supply: Conservation D. Water Resources management (CE-D.1; CE-D.2; CE-D.4) | Take immediate steps to reduce reliance on imports; take immediate steps to reduce water needs for landscaping at municipal, industrial and residential level; price increases should consider social equity; public communications programs identifying district, sector and high users has potential to shift values and make price increases and water restrictions more acceptable | Local residents; hotels, gyms and other high using business and industry; water exporters |
| Drought | Natural Environment | Dead green spaces / loss of community use and pride / loss of tourism | Green space reliant on current rainfall or irrigation | Ensures green spaces remain useful and healthy; alleviates heat island effect; provides respite from heat and sun; contributes to local lifestyle and identity; minimizes water use for non-essential but important quality of life requirements | | Projections for 50% more drought years 2000-49; work within vegetation management and renewal or replacement cycles; assess temperature resilience as well as drought tolerance capacity of alternate species | Local residents and businesses; City; park keepers; water authority; tourism businesses |
| Drought | Land Use | Food systems altered due to global climate change and food scarcities | Agriculture reliant on current rainfall or irrigation | Allows community to develop more urban agriculture that is closer to the community centers | | Coordinate with urban farmers and regional Farm Bureau; assess alternate irrigation or protective recommendations | City; urban farmers and affiliated non-profit organizations |
| Drought | Natural Environment | Stressed trees dropping branches causing damage or injury (potential City liability) | Number of trees in city district | Dual benefit of ensuring healthy trees and minimizing or eliminating damage, injury or fatalities | | Stressed trees are more susceptible to strong winds and result in flying debris in storms; ensure a storm preparedness measure for hazard trees; incorporate monitoring into existing vegetation management program | Residents; City |
| Drought | Development | City approving new developments whose water requirements collectively outstrip available supply for existing population | Potential for new developments approved with significant water use profile | Not further challenging the water supply/demand balance for the City | | Review development application guidelines for impact on water supplies | Developers; residents; City; water authority |
| Drought | Infrastructure | Potential subsidence or erosion undermining road stability and safety | # roads with unsealed shoulders | Protects against erosion and subsequent road instability without increasing ambient heat | GP: A. General Urban Design (UD-A.1; UD-A.2; UD-A.3; UD-A.9; UD-A.10 | Align with maintenance schedules; address most vulnerable roads first; consider 50% increase in droughts expected which will reduce soil moisture content from 2000-2049; potential issue for all infrastructure foundations | Road users; road authority; City |

**Table 5.1 (cont.) – Adaptation Strategies Table**

| Impact | Theme | Implication/Consequence | Sensitivity | Benefits | Current Policy / Program | Steps/Considerations | Stakeholders |
|---|---|---|---|---|---|---|---|
| Wildfire | Infrastructure | Damaged or destroyed public and private infrastructure and assets due to wildfire (resulting in financial impacts to residents and owners, pressures on welfare services, and temporary housing) | % infrastructure and assets at risk of wildfire (including City supporting services outside district area) | Reduced vulnerability to City infrastructure services to wildfire; reduced recovery times and detrimental impacts | | Collaborate with wildfire authorities and regional districts to identify key vulnerabilities to services and potential alternatives; review any changes to risk profile relevant to City insurers | Infrastructure owners and managers; City; regional districts; fire authority; alternate providers |
| Wildfire | Public Health | Potential injury or death due to wildfire, as well as air quality issues causing respiratory issues and health implications | Residents living in vulnerable areas; population vulnerable to respiratory issues | Reduced or avoided wildfire injuries and deaths; reduced respiratory illnesses and deaths; reduced pressure on health services to respond | | Collaborate with wildfire authorities, health services and regional districts to identify shared vulnerabilities and responses; review current air quality warning system and revise if necessary; develop school education program and protocols for wildfire affected air quality days | Residents; health providers; City; regional districts; fire authority |
| Wildfire | Public Health | Wildfires in water catchments causing water quality issues | Extent of water catchments (including for imports) vulnerable to wildfires | Reduced vulnerability to water supply and quality due to wildfire; alternative water sources; supply confidence | | Review vulnerability with water suppliers and authority; consider alternatives and negotiate agreements either as a city or region; consider specific water restrictions related to wildfire incidents | Residents; City; water authority and suppliers; fire authority; health authority |
| Sea Level Rise | Infrastructure | Flooding / inundation / beach loss of low-lying coastal residential areas | Residents and homes vulnerable to inundation; ability for homes to be protected; insurance coverage; capacity for residents to retreat | Aligned with California State Land Commissions recommendations; identifies vulnerable properties and works to ensure collaborative solutions and minimizes future liability; identifies range of potential response measures that together create a planned and progressive solution, minimizing social and economic damages | | California State Land Commissions' 'A Report on Sea Level Rise Preparedness' (2009) noting 'current statutory and case law governing coastal boundaries remains valid determining boundaries' of sovereign ownership of tidal waterways which 'continue to move with ever shifting lands and seas; including for accretion and erosion which is considered 'gradual and imperceptible'; consider potential impacts of engineered shoreline protection to contiguous coastal districts and any potential liability for negative impacts; potential for shocks to land values and subsequent legal challenges | Local residents, mortgage holders, insurers, City, CSLC, other coastal districts; emergency and recovery services; local businesses |
| Sea Level Rise | Infrastructure | Flooding / inundation / beach loss of low-lying coastal business and tourism areas causing damage and economic losses | Businesses, employment and local revenue generated by vulnerable properties; insurance coverage; capacity to recover from damages and closure | Maintain business confidence, services and employment in area; minimize damages and closures subsequent to floods; develop progressive shift strategy to alleviate future damage and uncoordinated alternative; ensures future community identity and appeal | | Determine which services are vital to sustain the community needs and vitality; level of local employment provided by vulnerable businesses; availability of alternative locations or capacity for retreat | Local residents, employees, business owners, property owners, City, CSLC, customers and suppliers, emergency and recovery services |
| Sea Level Rise | Natural Environment | Flooding / inundation of coastal estuaries and wetlands endangering local biodiversity | Ability for species to live in saline conditions; ability for species to retreat; resilience of vegetation buffers protecting the area | Identifies key issues and vulnerable species in the short, medium and long term; collaborates with other districts sharing resources and maximizing effective opportunities for species and habitat protection | | Remain sensitive to cooperative relationships between species and habitat by taking a systems approach in both vulnerability and protection assessments; establish principles with other relevant agencies and districts to guide solutions; ensure appreciation for ecosystem services in assessing vulnerability and values | City, other districts, local residents; tourism businesses based on healthy ecosystem; conservation and protection agencies |

**Table 5.1 (cont.) – Adaptation Strategies Table**

| Impact | Theme | Implication/Consequence | Sensitivity | Benefits | Current Policy / Program | Steps/Considerations | Stakeholders |
|---|---|---|---|---|---|---|---|
| Extreme Events | Energy | Power outage due to demand exceeding supply causing building evacuations; train stoppages and passenger strandings; loss of air con to community cool spaces (e.g. shopping centers and libraries) | Capacity of energy system vs. peak load in heatwave on weekday | Reduce cooling requirements and therefore energy consumption providing more capacity to cope with heatwave cooling demands; reduce GHG emissions | | Coordinate with commercial building managers and tenants (consider trials monitoring complaints to collect valid data); communicate importance to minimize energy during peak times; ensure building evacuation programs account for exposing people to extreme heat and potential transport delays | City, SDGE, commercial building managers; tenants/employees |
| Extreme Events | Public Health | Increased incidence of heat stress illness and death in outdoor urban areas exacerbated by lack of shade protection | Population in vulnerable groups unable to retreat to coolsafe areas during heatwaves and traversing unshaded streets or areas; response capacity of health system | More appealing outdoor areas in heat events; less heat stress illness and deaths; reduce heat island effect in urban districts; recued cooling requirements in surrounding buildings; rain protection also (depending on materials) | | Shade audit in conjunction with thermal imaging of city can also identify key areas for cool roofs, cool pavements and green space to develop an integrated heat protection program | Residents, City, street furniture and development companies; health providers |
| Extreme Events | Public Health | Increased incidence of heat stress illness and death at recreational, tourism and sporting events | Vulnerable population groups at outdoor events during heatwaves | Minimize heat stress illness and deaths at outdoor events | | Review existing heatwave response plans (if any) and adjust as necessary for more extreme and frequent events; consult with health and emergency services to ensure alignment; involve event sector to maximize compliance | Event organizers; health and emergency services; sporting groups; City; residents and event attendees and participants |
| Extreme Events | Public Health | Increased incidence of heat stress illness and deaths across community (including outdoor workers) | Population in vulnerable groups not able to retreat to coolsafe areas during heatwaves (elderly, ill or infirm, economically disadvantaged including homeless, outdoor workers, some cultural groups); capacity for health system to respond; % air conditioned or insulated housing; | Increased community awareness and resilience to heat stress illness and death for themselves and their neighbors or community; less stress on health services in heatwaves | | Work with aged care, children, social welfare services and health providers to create collaborative program that leverages their resources and communications programs; coordinate and promote coolsafe venues with proprietors and health services; review City OHS policy for outdoor workers and heat, prepare heatwave plan in collaboration with the region to ensure alignment; promote before summer to ensure community preparedness; require health services to record and report heat stress related death and illness to monitor impacts and results | Vulnerable population groups; health and social welfare service providers; City; coolsafe proprietors; regional districts |
| Extreme Events | Infrastructure | Flash flooding blocking access of residents, supplies, business distribution or emergency services resulting in adverse health outcomes | Roads with no or few alternative routes to or from health services | Ensure emergency services are aware of alternative routes and have opportunity to remove inundation risk in advance of extreme event and resulting crucial delay in health response | GP: Mobility C. Street and Freeway System (ME-C.2e; ME-C.4c) | Consider seasonal drainage issues such as fall leaves or post event litter; highlight routes to prevent road works or event closures that may limit access options. | Health service providers; emergency medical services; road authority; police; residents and businesses |
| Extreme Events | Infrastructure | Flash flooding due to surpassing drainage capacity causing extensive building and asset damage; potential injuries and fatalities | Amount of redundancy built into drainage systems to account for intense rainfall events | Reduce damage and injuries; less requirements on emergency services; better drainage capacity; maximize water capture for city use | | Review current flood preparedness programs; review current drainage capacity and constraints; promote flood preparedness measures in development approvals; assess stormwater harvesting potential using localized retention basins augmented by existing drainage network | Residents; building owners and tenants; insurers; City; water authority; emergency services |
| Extreme Events | Waste | Increased risk of pollution from open waste disposal site being inundated and dispersed | Extent of exposed waste disposal | Reduced waste and service costs, reduced pollution; increased resource recovery | | Review vulnerability of current waste collection system to intense rainfall events resulting in pollution dispersal; identify pollution channels and reduce to prohibit contamination; promote good waste practices with community | Residents; City; waste collection agency; environmental authority |
| Extreme Events | Water | Potential inundation of wastewater causing overflow resulting in adverse health or environmental issues | Wastewater systems vulnerability to flash flooding inundation | Reduced pollution of any wastewater overflows causing either health or environmental issues | | Identify wastewater systems in flash flood zones; consider potential to introduce stormwater harvesting system to alleviate flood occurrence or invest in protection measures (both may not be necessary but should be assessed) | Local residents; environmental authorities; health authorities; City; water users; water authority |

## 5.4 COST-BENEFIT ANALYSIS OF ADAPTATION

For many areas at risk, the potential loss from climate change can be reduced or eliminated by adaptation strategies. However, without adequate data, perceived threats from climate change may lead to implementation of strategies without understanding the short- and long-term impacts to the local economy. Reactive adaptation measures will in many cases be more costly than proactive, planned strategies. While the involvement of the private sector is essential, a disjointed approach to adaptation can lead to economic inefficiencies, or worse, limited or no protection for public resources such as water and open space.

As a result, it is necessary for public decision-makers to consider the possible risks and implementation costs from a holistic perspective, including the environmental and social impacts. While an adaptation strategy may provide beneficial economic impacts to a subset of the community, the costs may be unequally distributed, leading to hardship for economically disadvantaged populations.

The general framework illustrated below in Steps 1 through 3 provides a roadmap to assess the local risk from climate change and help identify a cost-effective set of adaptation strategies.

### Step 1. Estimate potential loss from a climate change event.

What is the value of what may be lost to vulnerable sectors by a climate change event? Put another way, what is the benefit of the vulnerable sector to the economy? The role of the economic analysis is to assess the economic impacts to assets. By first understanding the value, the potential losses to vulnerable market sectors from a climate change related event could be calculated. Assessment of vulnerable sectors should incorporate forecasted changes in the economy and regional demographics to account for the risk of climate change on a evolving economic and population base.

### Step 2. Calculate implementation costs of adaptation strategies.

Costs for adaptation strategies include the labor and resource costs necessary to implement a proposed strategy. From an economic perspective, the strategies can be divided into three general categories for cost assessment: 1) maintenance and operations; 2) capital investment including redevelopment; and 3) regulatory and climate change policy. Timing for implementation of specific adaptation strategies within these categories is an important cost consideration as well.

The probability is low that an entire sector would be eliminated. It is more likely that only a portion of the value will be affected, and over a limited period of time. Therefore, when estimating costs, loss of the entire sector is a baseline, with the understanding that the actual costs will depend on the frequency, magnitude, and overall vulnerability of the sector.

### Step 3. Perform cost-benefit analyses for proposed adaptation strategies.

The costs of adaptation and potential losses from future climate change are used in cost-benefit analyses to examine the impact of climate change. Through cost-benefit analysis, where the cost-benefit ratio is a measurement of the capital and operating expenditures against total

How much to adapt is an economic problem and requires decisions about allocating limited resources for climate adaptation strategies while also providing other necessary services. Decision-makers will ask: **What is the potential loss to local economies and communities from climate change?** What is the cost to implement adaptation strategies? Will the benefits outweigh the costs?

**Past 12 months warmest ever recorded in United States**

CNN - July 10, 2012

The mainland United States has experienced the warmest 12 months since record-keeping began in 1895, a top government science and weather agency announced Monday. As the Midwest, Southeast and Northeast cool a bit, the U.S. Southwest is practically boiling. The National Weather Service has issued excessive heat warnings for parts of Arizona and California through Wednesday, with temperatures forecast to peak Tuesday at 114 degrees in Las Vegas; 113 in Phoenix; 116 degrees in Yuma, Arizona; and 125 degrees in Death Valley, California.

economic benefit, decision-makers can compare, quantitatively, the financial impact of climate adaptation measures. Adaptation is not free, and it is not possible to hedge against all possible losses. To be cost-effective, adaptation strategies should:

### A. Identify cost savings through planned projects.

Proactive planning for climate adaptation is less expensive than reactive, emergency measures after a severe event.

### B. Prioritize hard, soft, and "no-regrets" adaptation strategies.

Adaptation strategies should be thought of as a suite of possibilities to be undertaken including hard, soft, and "no-regrets" options. Soft adaptation strategies including, but not limited to, land use planning, policy reform and greater access to information should be considered and combined with hard options (e.g., capital improvement). "No-regret" options are hard or soft adaptation strategies that have substantial co-benefits and therefore make sense regardless of whether or not climate change is occurring.

### C. Reduce risk exposure and mitigate residual losses with insurance.

Insurance reduces the exposure to climate change risk by covering the residual losses, and should be incorporated into the cost-benefit analyses of climate adaptation strategies. For further details, refer to Appendix V.

### Case Study #1:

Taken from: The Economic Costs of Sea-Level Rise to California Beach Communities, California Department of Boating and Waterways, San Francisco State University.

Table 5.2 shows the present value of year 2050 losses and costs associated with beach erosion for three different sea level rise scenarios at Torrey Pines State Beach. Also shown are the costs and requirements to adapt to and/or mitigate those effects by armoring the shoreline with seawalls or revetments and nourishing the beach with additional sand.

**Table 5.2 – Year 2050 Losses/Costs Associated with Beach Erosion (millions of 2010 dollars)**

| | 1.0 m Sea Level Rise 2050 | 1.4 m Sea Level Rise 2050 | 2.0 m Sea Level Rise 2050 |
|---|---|---|---|
| **Beach Erosion Impacts** | | | |
| Beach area eroded | 11.3 acres | 14.1 acres | 20.2 acres |
| Percent area eroded | 20.0% | 24.9% | 35.6% |
| Recreation and habitat value loss | $6.1 | $8.3 | $11.5 |
| Direct spending losses | $26.7 | $36.3 | $51.5 |
| Direct tax revenue losses | $1.0 | $1.4 | $1.9 |
| **Total Beach Erosion Losses** | **$33.8** | **$46.0** | **$64.9** |
| **Adaptation/Mitigation Measures** | | | |
| **Annual Beach Nourishment** | | | |
| Annual cubic meters of sand | 502,000 | 627,000 | 896,000 |
| Annual sand replenishment cost | $2.7 | $3.4 | $4.8 |
| **Coastal Armoring** | | | |
| Initial capital cost | $68.5 | $68.5 | $68.5 |
| Annual maintenance cost | $2.1 | $2.1 | $2.1 |
| **Total Adaptation/ Mitigation Costs** | **$73.3** | **$74.0** | **$75.4** |

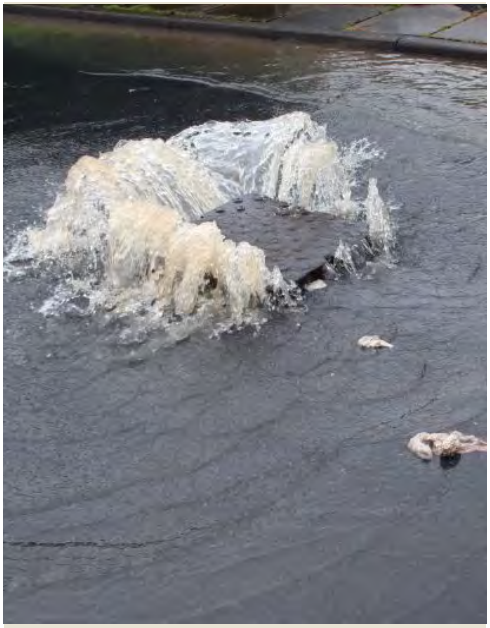
Sea level rise exacerbates flood damages by expanding the floodplain and increasing flood depth. Table 5.3 shows the potential monetary damages resulting from a 100-year flood as modeled under the same three sea level rise scenarios in year 2050.

**Table 5.3 – 100-Year Flood Damages (millions of 2010 dollars)**

| Scenario Year | Baseline 2000 | 1.0 m Sea Level Rise 2050 | 1.4 m Sea Level Rise 2050 | 2.0 m Sea Level Rise 2050 |
|---|---|---|---|---|
| Residential damage (structures & contents) | $1.4 | $1.7 | $1.7 | $1.9 |
| Commercial damage (structures & contents) | $1.6 | $1.7 | $1.7 | $1.8 |
| **Total flood damages** | **$3.0** | **$3.4** | **$3.4** | **$3.7** |
| **Sea Level Rise Impact** | | | | |
| Damages beyond baseline | -- | $0.4 | $0.4 | $0.7 |
| **% Increase from baseline** | **--** | **13%** | **13%** | **23%** |

### San Diego's Valuable Beaches

Beaches create value from opportunities for recreational use, including local and state tourism-related spending and tax revenue, and habitat benefits in the form of biodiversity, ecological services, and storm damage prevention. The year 2000 baseline value created by Torrey Pines State Beach (in 2010 dollars) has been calculated at $5.6 million in recreation and habitat value, $35.5 million in direct local and state spending, and $2.7 million in local and state revenue for a combined total of $43.8 million in economic benefits.



### Discount Rate

The choice of the discount rate for evaluating the net present value of these investments can be critical in determining whether or not to implement the associated mitigation efforts. By way of example, the Stern Review on the Economics of Climate Change utilizes a social discount rate of 1.4% for evaluating projects associated with climate change.

## Case Study #2:

Currently, the Mission Beach area requires flood mitigation an average of 12 times per year. During these events, City personnel are on site pumping away the floodwater from Mission Beach into the San Diego River. The costs in 2011, including damage claims, were $156,093. An increase in either the frequency or the intensity of storms would lead to increased costs of mitigation and damage claims. Figure 5.1 shows the increase in cost due to percentage increases in rainfall events. The amount of water lost is estimated as shown in Table 5.4, more than 40 million gallons.

**Figure 5.1 – Estimated Cost in Terms of Percent Rainfall Increase**

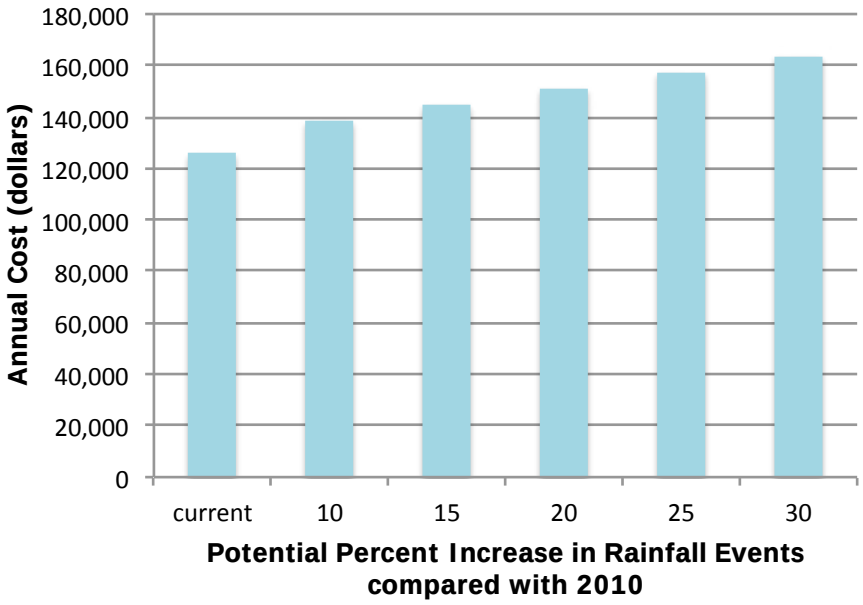



**Table 5.4 – Approximate Volume of Rainfall in Mission Beach**

| |
|---|
| Estimated volume of water during 1 inch rainfall event over 1 acre: 42,000 gallons |
| Mission Beach area: approximately 320 acres |
| Approximate number of events greater than 0.5 inches per year: 6 |
| Annual volume water falling during events: 46 million gallons |

There are no current adaptation plans for the potential climate change scenario of increased intensity of rainfall events in Mission Beach. However, as alternative adaptation strategies are developed, these strategies need to be evaluated using cost-benefit analysis. Investing in improved infrastructure to deal with more intense events requires significant capital investments up front in return for future benefits. The typical method for evaluating these projects employs net present value analysis. For example, should rainfall intensity increase by 100% by 2035 in Mission Beach, the cost in 2010 dollars of damage mitigation based on current known damage measures would be over $250,000.

# CHAPTER 6 - MONITORING AND IMPLEMENTATION

It is essential for the City to implement the GHG reduction measures and to monitor progress in order to meet the CMAP reduction targets. These steps will be taken to ensure accountability and action:

1. Designate Responsible Parties: The Environmental Services Department will designate staff to take the lead on the CMAP monitoring, and will coordinate with staff from other Departments and monitor citywide progress on the CMAP.

2. Create a master CMAP Monitoring Report: This will contain specific actions, proposed outcomes and a timeline with milestones for the most significant GHG reduction measures and adaptation proposals. City staff members will be assigned responsibility for tasks related to their respective department.

3. Update the citywide GHG inventory annually: The City will prepare an annual inventory of communitywide GHG emissions and compare those outcomes with the baseline inventory.

4. Prepare an Annual Report: The annual GHG inventory and the Monitoring Report are essential components of the Annual Report which will track and report on the City's progress toward meeting the goals of the CMAP.

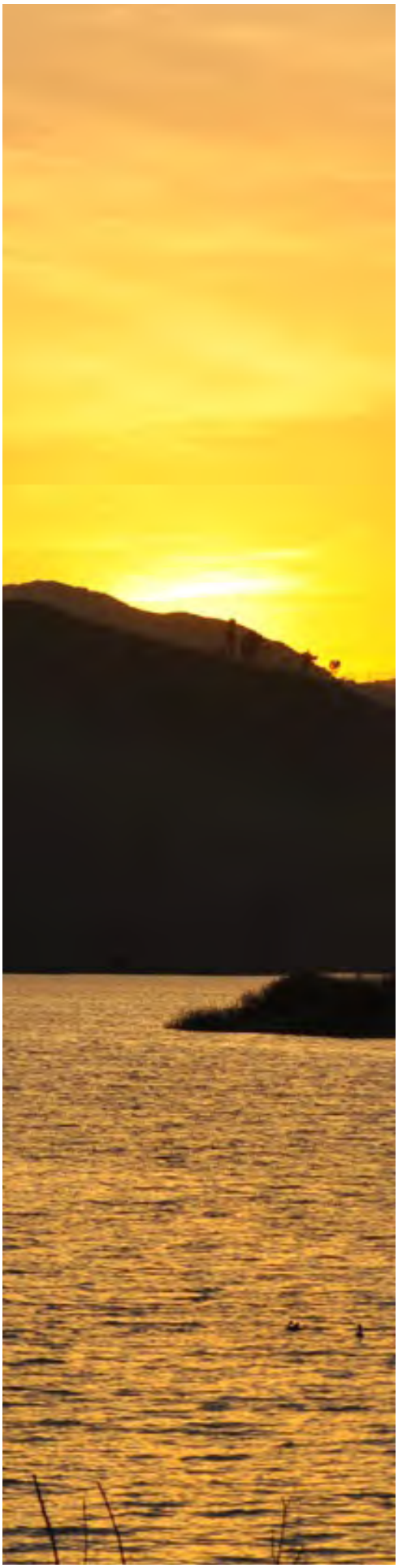
5. Citywide data collection and sharing: The City commits to sharing data with other government entities, academic institutions, military, corporate, and civic organizations.

6. Amend municipal codes: City policies, plans and codes will be evaluated and updated as needed to ensure the CMAP reduction targets are met.

7. To the extent possible, incorporate local climate-based research into future CMAP reports and actions:

    - Next-Generation Climate Models that examine the potential changes to the San Diego physical environment, and also the socioeconomic and political outcomes in different scenarios.
    - Ongoing and Long-term Observational Studies to help City staff better understand how different sections of the City respond to the changing climate.
    - Risk Assessment and Human Behavior Studies to help City staff better understand extreme weather events, rising seas, droughts, wildfires, hurricanes, fresh water shortages, and more. Understanding those negative effects and how to mitigate them will be of vital importance to the economic prosperity and environmental quality of the region.
    - Support legislation designed to reduce negative impacts of climate change. The City has an opportunity to take a leadership role in supporting State and Federal efforts to reduce carbon emissions.

8. Clarify the costs and benefits for adapting to a changing climate: Commission a study to help City officials and others involved with CMAP implementation bring the most important and viable solutions forward.

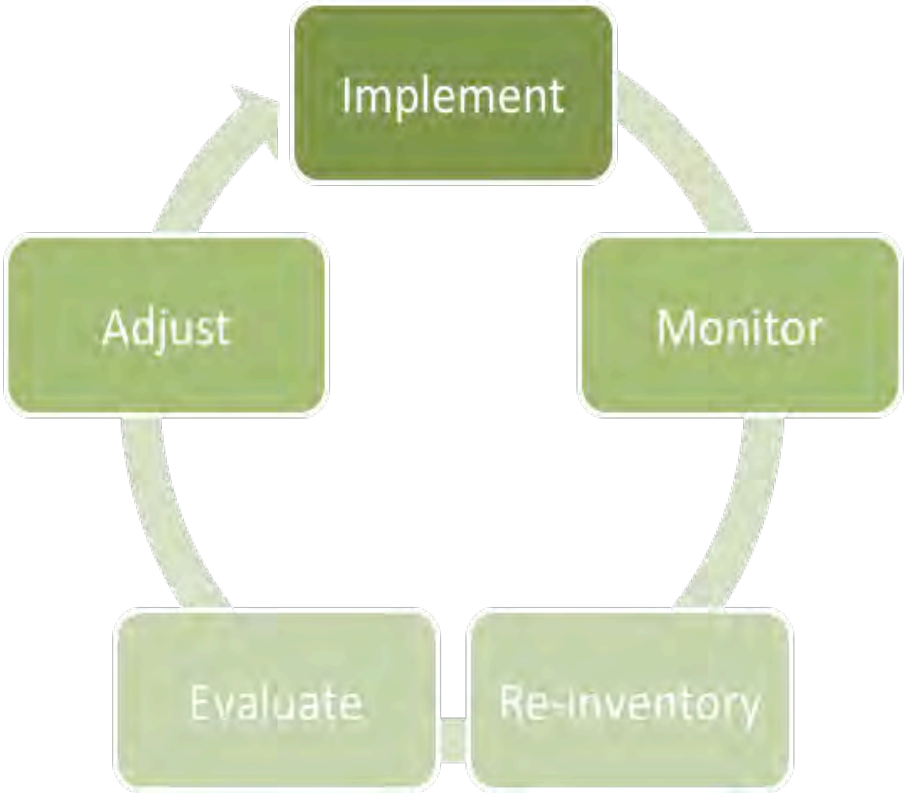


9. Educational outreach: Every person has an opportunity to be part of the solution. City leadership can help to shape and influence the actions taken today and institutionalize them for long-term success.

10. Follow the CMAP timeline: With highly visible deadlines, the public will know whether San Diego is progressing at an acceptable rate to meet the targets presented in the CMAP.

To maintain compliance with CEQA, the City will monitor the ongoing effectiveness of GHG reduction measures and adapt the CMAP to changing conditions. If the trend of annual GHG inventories indicates that the City is not moving toward meeting its GHG emissions reduction targets, then the City will adjust its GHG reduction measures accordingly. The City will periodically reevaluate the entire plan with respect to 2020 and 2035 targets and evaluate the individual strategies annually.

**Figure 6.1: Monitoring Flow Diagram**



# CHAPTER 7 – CONCLUSION

The Climate Mitigation and Adaptation Plan is a platform that holds the reduction targets and strategies to achieve the State of California mandates and guide the City of San Diego through 2035. There are next steps identified for each measure, which often include additional stakeholder participation to develop an action plan. The annual GHG inventory and Monitoring Report are essential components of the Annual Report. Ongoing measurement will allow for an unbiased review of the progress made toward meeting the targets.

The regional vulnerabilities to a changing climate have also been identified. For each of the topic areas, a number of recommendations are presented for further study. As previously stated, it is critical to understand the region's specific risks and to take timely action to alleviate the range of consequences. By so doing, San Diego can reduce vulnerability and exposure.

San Diego has demonstrated that it is resilient to economic challenges because of the commitment and expertise of its diverse population. If we demonstrate the same foresight, bringing to bear the expertise of our scientific community, businesses, health and human service providers, community advocates and public leaders, then we will certainly meet the new challenges that a changing climate requires.

Implementing the 2012 CMAP demonstrates to investors, businesses and residents that San Diego is acknowledging the impacts of a changing climate and is committed to keeping this in the forefront of decision-making. This can improve business development and retention, and the public will experience co-benefits such as better resource management and improved air quality. The CMAP will allow the City to contribute its fair share toward achieving the 2020 GHG reductions of 15% below the established baseline. Furthermore, the CMAP can enhance awareness in all sectors of the San Diego community about ways to participate in reducing GHG emissions and preparing for regional climate vulnerabilities.

**Union Pacific Railroad**

# APPENDICES

# APPENDICES

## TABLE OF CONTENTS


I. Glossary of Terms and Acronyms

II. Methodology for Estimating GHG Reductions

III. Cost Effectiveness of Methodology Documentation

IV. Participation Rates for CMAP Measures Chart

V. City of San Diego Adaptation Economic Analysis



2012 City of San Diego Climate Mitigation and Adaptation Plan

# Appendix 1 - Glossary of Terms and Acronyms

**Adaptation:** This is the response to the changes that are occurring because of the excessive human-induced GHGs that have been collecting in the atmosphere for the past 100 years. While mitigation strategies are similar for most areas of the United States, the way that a community chooses to adapt to a changing climate is very specific for each region.

**Baseline:** The baseline serves as a reference point to assess changes in greenhouse gas emission from year to year. According to the California Air Resources Board (CARB), in general, Baseline Actual Emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a two-year period which precedes the particular date and which is representative of normal source operation. For purposes of creating the baseline emissions, local governments estimate emissions from government operations and community-level.

**Business-As-Usual (BAU):** A scenario used for the projection of greenhouse gas emissions at a future date based on current technologies and regulatory requirements in absence of other reductions.

**Carbon Dioxide ($CO_2$):** This is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. It is naturally occurring and is also a primary by-product from combustion of fossil fuels and other industrial and agricultural processes.

**Carbon Dioxide Equivalent ($CO_2e$):** This is a common unit for normalizing greenhouse gases with different levels of heat trapping potential. For carbon dioxide itself, emissions in tons of $CO_2$ and tons of $CO_2e$ are the same, whereas for nitrous oxide and methane, stronger greenhouse gases, one ton of emissions is equal to 310 tons and 21 tons of $CO_2e$ respectively.

**Chlorofluorocarbons (CFCs):** A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy the ozone layer.

**The California Environmental Quality Act (CEQA):** This was a California statute passed in 1970, shortly after the United States federal government passed the National Environmental Policy Act (NEPA), to institute a statewide policy of environmental protection. CEQA does not directly regulate land uses, but instead requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects and adopt all feasible measures to mitigate those impacts.

**Climate:** This is typically defined as the "average weather," or more rigorously, as the statistical description in terms of the average and variability of weather over a period of time ranging from months to thousands of years. These variables are most often temperature, precipitation, and wind. Climate can also refer to the global climate system.

**Climate Action Plan:** A description of the measures and actions that an organization will take to reduce greenhouse gas emissions and achieve an emissions reduction target. Most plans include a description of existing and future year emissions; a reduction target; a set of

measures, including performance standards that will collectively achieve the target; and a mechanism to monitor the plan.

**Climate Change:** Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change results from: 1) natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; 2) natural processes within the climate system (e.g. changes in ocean circulation); and 3) human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.).

**Co-Benefit:** Multiple, ancillary benefits of a policy, program or intervention. Many climate change mitigation measures designed to reduce greenhouse gas emissions have other benefits such as energy and cost savings.

**Corporate Average Fuel Economy (CAFE):** The CAFE standards were originally established by Congress for new automobiles, and later for light trucks, in Title V of the Motor Vehicle Information and Cost Savings Act. Under CAFE, automobile manufacturers are required by law to produce vehicles with composite sales-weighted fuel efficiency, which cannot be lower than the CAFE standards in a given year. Standardized tests are used to rate the fuel economy of new vehicles.

**Discount Rate**: The choice of the discount rate for evaluating the net present value of these investments can be critical in determining whether or not to implement the associated mitigation efforts. By way of example, the Stern Review on the Economics of Climate Change utilizes a social discount rate of 1.4% for evaluating projects associated with climate change.

**Energy Efficiency:** This relates to a change in behavior in that the same function can be accomplished with less electricity. This usually requires newer equipment (such as televisions), different types of lighting (such as CFL bulbs) and other technology changes.

**Energy Conservation:** This is a typical practice using what you have more efficiently, such as shutting off the light or only using the dishwasher when it is full.

**Emissions:** The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere.

**Emissions Factor:** A set of coefficients used to convert data from electricity, natural gas, fuel and waste to calculate GHG emissions. These emission factors are the ratio of emissions of a particular pollutant (e.g., carbon dioxide) to the quantity of the fuel used (e.g., kilograms of coal). For example, when burned, 1 ton of coal = 2.071 tons of $CO_2$.

**Forecast Year:** Any future year in which predictions are made about emissions levels based on growth multipliers applied to the base year.

**Global Warming:** Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases.

**Global-warming Potential (GWP):** This is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval, commonly 20, 100 or 500 years. GWP is expressed as a factor of carbon dioxide (whose GWP is standardized to 1). For example, the 20 year GWP of methane is 72, which means that if the same mass of methane and carbon dioxide were introduced into the atmosphere, that methane will trap 72 times more heat than the carbon dioxide over the next 20 years.

**Greenhouse Effect:** The build-up of heat in the atmosphere (troposphere) near the Earth's surface due to infrared radiation from the sun being absorbed by water vapor, carbon dioxide, ozone, and several other gases. This heat is then re-radiated back toward the Earth's surface. As atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere gradually increases.

**Greenhouse Gas:** Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($NO_2$), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone ($O_3$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$).

**Heating, Ventilation, and Air Conditioning (HVAC):** These are mechanical systems that control the ambient environment (temperature, humidity, air flow and air filtering) of a building.

**Hydrofluorocarbons (HFCs):** Man-made compounds containing hydrogen, fluorine, and carbon that were developed as an alternative to ozone-depleting substances for industrial, commercial, and consumer products. HFCs do not have the potential to destroy stratospheric ozone, but they are still powerful greenhouse gases.

**Intergovernmental Panel on Climate Change (IPCC):** The IPCC was established jointly by the United Nations Environment Program and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

**Methane ($CH_4$):** A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 23 times that of carbon dioxide ($CO_2$). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills and sewage treatments, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.

**Measures:** Any action taken to reduce GHG emissions.

**Mitigation:** This is putting in place enforceable plans, policies, and programs to reduce GHG emissions now in order to slow the rate of increase in the atmosphere. Successful mitigation at local, national and international levels will reduce the impacts of a changing climate for future generations. This is the legacy we leave.

**Metric Ton (MT):** Common international measurement for the quantity of greenhouse gas emissions. A metric ton is equal to 2205 lbs. or 1.1 short tons.

**Mixed-Use:** In a land-use planning context, a project that has at least three of the following amenities within a ¼ mile radius: 1) residential development, 2) retail and/or commercial development, 3) park, and 4) open space. Mixed-use developments encourage walking and other non-auto modes of transport from residential to office/commercial locations. The project should minimize the need for external vehicle trips by including services and facilities for day care, banking/ATM, restaurants, vehicle refueling, and shopping.

**Natural Gas:** This is the typical fuel used in new power generating facilities in California. Underground deposits of gases consist of 50 to 90% methane and small amounts of heavier gaseous hydrocarbon compounds such as propane and butane.

**Perfluorocarbons (PFCs):** Potent greenhouse gases that accumulate in the atmosphere and remain there for thousands of years. Aluminum production and semiconductor manufacture are the largest known man-made sources of perfluorocarbons.

**Risk:** Denotes the result of the interaction of physically defined hazards with the properties of the exposed systems - i.e., their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences - i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability.

**Resiliency:** When referring to natural systems, the amount of change a system can undergo without changing state. When referring to human systems, the term "resiliency" can be considered as a synonym of adaptive capacity. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

**Sector:** A term used to describe emission inventory source categories for greenhouse gases based on broad economic sectors.

**Target Year:** The year by which the emissions reduction target should be achieved.

**Transit Oriented Development (TOD):** A moderate- to high-density development located within ¼ mile of a major transit stop, generally with a mix of residential, employment, and shopping opportunities. TOD encourages walking, bicycling, and transit use without excluding the automobile.

**Vehicles Miles Traveled (VMT):** This unit measures the aggregate mileage traveled by all vehicles in a specific location. VMT is a key measure of street and highway use. Reducing VMT is often a major objective in efforts to reduce vehicular congestion and achieve air quality goals. The transportation sector is the top GHG emitter in California, contributing roughly 40% of all California emissions. Poor fuel efficiency and high vehicle miles traveled (VMT) are primary contributors to transportation sector GHG emissions. Meeting California's GHG emissions reduction goals requires reductions in both per-mile emissions (often measured in as

a vehicle's miles per gallon performance) and vehicle miles traveled. Fuel efficiency has been addressed historically by the federal Corporate Average Fuel Economy (CAFE) standards, and California has passed its own legislation regulating GHG emissions from vehicles. The number of miles traveled has ramifications on insurance premiums, but there has not been and likely will not be any legislative action to curb VMT even though it is growing at a much faster rate than population or the economy.

**Vulnerability:** The degree to which systems affected by climate change are susceptible to and unable to cope with adverse impacts.

## Acronyms

AB - Assembly Bill

APCD – Air Pollution Control District (County of San Diego)

CACP - Clean Air and Climate Protection Software

CAP - Climate Action Plan

CAPPA - Climate and Air Pollution Planning Assistant

CARB - California Air Resources Board

CEC - California Energy Commission

CEQA - California Environmental Equality Act

$CH_4$ - Methane

$CO_2$ - Carbon dioxide

CMAP – Climate Mitigation and Adaptation Plan (City of San Diego)

$CO_2e$ - Carbon dioxide equivalent

EPA - U.S. Environmental Protection Agency

GHG - Greenhouse gas

HFC - Hydrofluorocarbons

HVAC - Heating, ventilating, and air conditioning

IPCC - Intergovernmental Panel on Climate Change

KWh - Kilowatt-hours

LCFS - Low Carbon Fuel Standard

MMT - Million metric tons

MW - Megawatt

$NO_2$ - Nitrous oxide

PPM - Parts per million

SANDAG – San Diego Association of Governments

SB - Senate Bill

TOD - Transit oriented development

USGBC - U.S. Green Building Council

VMT - Vehicle miles traveled

# Appendix II: Methodology for Estimating GHG Reductions

This document provides information about the data, methodologies, and sources used to estimate the greenhouse gas reductions associated with the measures included in the City of San Diego Climate Mitigation and Adaptation Plan (CMAP). Calculations were done for a series of city-based measures leading to GHG emissions reductions from electricity and natural gas, on-road transportation, land use and waste. Table 1 provides a summary of all the CMAP measures and their contribution to the overall reduction.

**Table 1. Summary Table of CMAP Mitigation Measures**

| | 2020 | | 2035 | |
|---|---|---|---|---|
| **LOCAL MEASURES** | **MT CO2e Reduction** | **% of total Reduction** | **MT CO2e Reduction** | **% of total Reduction** |
| **Energy** | | | | |
| Residential Efficiency Retrofits | 52,464 | 1% | 132,386 | 4% |
| Commercial Efficiency Retrofits | 20,646 | 1% | 196,118 | 4% |
| Commercial Retrocommissioning | 20,646 | 1% | 58,835 | 1% |
| New Construction Efficiency | 23,895 | 1% | - | 0% |
| Residential Solar Water Heaters | 9,596 | 0% | 26,652 | 1% |
| Comercial Solar Water Heating | 3,327 | 0% | 12,434 | 0% |
| Clean and Efficient Distributed Generation | 118,331 | 3% | 318,252 | 5% |
| Water Use Efficiency | 46,684 | 1% | 39,469 | 3% |
| City Facility Efficiency Retrofits | 13,222 | 0% | 18,634 | 0% |
| **Transportation** | | | | |
| Mass Transit | 105,613 | 3% | 119,649 | 3% |
| Bicycle Infrastructure | 17,194 | 0% | 38,522 | 1% |
| Parking - reduce spaces | 30,782 | 1% | 51,058 | 1% |
| Parking - preferred parking for Evs | 42,621 | 1% | 70,696 | 1% |
| Parking Increased fees | 110,474 | 3% | 130,158 | 2% |
| City Share of SB 375 Reductions (includes telecommute, carpool, vanpool, buspool, bottleneck relief, HOV/HOT lanes) | 192,663 | 5% | 710,413 | 6% |
| Signal timing and roundabouts | 3,571 | 0% | 4,761 | 0% |
| EV use | 228,321 | 6% | 631,799 | 5% |
| Convert municipal fleet to EV | 13,160 | 0% | 23,688 | 0% |
| **Land Use** | | | | |
| Smart growth - population density | 69,062 | 2% | 65,279 | 2% |
| **Waste** | | | | |
| Divert Trash and Capture Landfill and Waste | 523,090 | 13% | 656,668 | 13% |
| **Total Local Measures** | **1,645,362** | **41%** | **3,305,473** | **49%** |

| | 2020 | | 2035 | |
|---|---|---|---|---|
| **STATE/FEDERAL MEASURES** | **MT CO2e Reduction** | **% of total Reduction** | **MT CO2e Reduction** | **% of total Reduction** |
| **Energy** | | | | |
| Renewable Portfolio Standard | 593,765 | 15% | 722,734 | 11% |
| | | | | |
| **Transportation** | | | | |
| Pavley I | 1,190,930 | 30% | 2,146,749 | 21% |
| LCFS | 563,206 | 14% | 550,639 | 11% |
| CARB Tire Pressure Program | 30,670 | 1% | 26,201 | 0% |
| CARB HDV Aerodynamics | 9,970 | 0% | 11,083 | 0% |
| **Total State/Federal Measures** | **2,388,541** | **59%** | **3,457,406** | **51%** |
| | | | | |
| **TOTAL GHG REDUCTIONS** | **4,033,903** | **100%** | **6,762,879** | **100%** |

## COMMON ASSUMPTIONS AND SOURCES

A set of common assumptions and sources was used to calculate emissions reductions for the CMAP measures.

### Electric/Natural Gas Measures

The following assumptions were used in calculating greenhouse gas reductions for measures related to electric and natural gas.

#### Common Assumptions for Electric and Natural Gas Measures

- **Greenhouse Gas Intensity of Electricity** – The calculations include a dynamic greenhouse gas intensity of electricity in pounds per megawatt-hour (lbs/MWh). For example, as the percentage of electricity provided by renewable energy sources increases the greenhouse gas intensity of electricity falls. Consequently, each reduction in energy use yields a smaller greenhouse gas reduction. This calculation also includes the effects of increased electricity use for electric vehicles, which results in a reduction in emissions in the transportation sector and an increase in emissions in the electric sector.
- **Transmission Losses** – All electricity values include transmission losses of 7.5%.
- **Allocation of Energy Use in the Residential Sector** – The CMAP estimates assume that the total energy budget of the average residential unit is comprises 46% electricity use and 54% natural gas use.
- **Allocation of Energy Use in the Commercial Sector -** The CMAP estimates assume that the total energy budget of the average residential unit is comprises 70% electricity use and 30% natural gas use.

Common Sources for Electric and Natural Gas Measures

- Kavalec, Chris and Tom Gorin, 2009. California Energy Demand 2010-2020, Adopted Forecast. California Energy Commission. CEC-200-2009-012-CMF, available at http://www.energy.ca.gov/2009publications/CEC-200-2009-012/index.html.

## On-Road Transportation

Common Assumptions for Transportation Measures

- **Vehicle Miles Traveled** (VMT)– VMT data was provided by the City of San Diego for the years 1990, 2004, 2007, 2008 and 2009. VMT forecasts for 2010, 2020 and 2035 were made on the basis of the regional planning agency's (SANDAG) population growth forecast for the City.
- **EMFAC Model 2007** and **Pavley I and Low Carbon Fuel Standard Post Processor Version I**– EMFAC 2007 is an Emissions Factors model used California-wide by its regional transportation planning agencies to calculate air pollutants, including carbon emissions, from all on-road vehicles on all roads. EMFAC 2007 combines tested vehicle emission rate data with regional vehicle activity to provide greater accuracy for regional emissions. We used the EMFAC 2007 model to obtain the business as usual GHG emissions for the region using SANDAG's local input data files for 2020 and 2035. The output emissions data were fed into the California Air Resources Board (CARB) Post Processor to obtain CO2 reduction amounts in the region. The regional CO2 reductions from the Post Processor reflect changes expected from federal and state mandates in 2020 and 2035: the Pavley I standards (equivalent to mpg changes in CAFE), and the state Low Carbon Fuel Standard (LCFS).
- **Greenhouse Gas Intensity** – Dividing the regional CO2e by the regional system wide VMT provided the CO2e/VMT emissions factor, a greenhouse gas intensity factor, for the region, with and without the Pavley I and Low Carbon Fuel Standard reductions. This factor was further adjusted to account for miles driven by electric vehicles of 4% in 2020, and 11% EV in 2035. The effect of this (California Energy Commission) forecasted increased electric vehicles miles in 2020 and 2035 is to further reduce the carbon intensity of vehicle emissions but this is offset to some extent by an increase in the electricity sector emissions. It was assumed that the regional CO2e/VMT was representative of the City's CO2e/VMT. This CO2e/VMT was used for the calculation of the GHG reductions from those city measures that affect VMT. Because the carbon content of the fuel mix decreases with time, for example due to the state's Low Carbon Fuel Standard, the carbon intensity per mile also decreases. Consequently, with time, any future measure yields a proportionally

smaller greenhouse gas reduction. The CO2e/VMT factors used for the measures are provided in Table 2.

**Table 2 Greenhouse Gas Intensity of Vehicle Miles Traveled**

| Year | CO2e/VMT | Comment |
|---|---|---|
| 2010 | 5.04E-04 | Business-as-Usual Value |
| 2020 | 3.71E-04 | LCFS target met, Pavley I met, 4% EV miles. |
| 2035 | 3.08E-04 | LCFS target 2020 met, Pavley I met, 11% EV miles |

Measures that depend on reduction in fuel consumption were converted to CO2e reductions using an average factor of 0.01 metric tons per gallon.

- **Business-as-Usual (BAU) Projection** – The BAU CO2e projection for on-road transportation derives from the SANDAG EMFAC forecast of the VMT for the City and the BAU carbon intensity per VMT in the region in the target year 2020 or 2035.

Sources

- EMFAC 2007 is an EPA approved model used by California to assess effectiveness of its vehicular emissions, available at http://www.arb.ca.gov/msei/documentation.htm. EMFAC Series 12 input files were provided by SANDAG and used in CARB's Post Processor. The Post Processor is available at: http://www.arb.ca.gov/cc/sb375/tools/postprocessor.htm.
- Elasticity data for the calculation of VMT reductions from local measures and price effects were obtained from: Reid Erwing and Robert Cervero (2010): Travel and the Built Environment, Journal of the American Planning Association 76:3, 265-294; and, Victoria Transport Policy Institute, Transportation Elasticities, available at: http://www.vtpi.org/tdm/tdm11.htm
- Bicycle strategies elasticity data were obtained from: Technical Appendices, Moving Cooler, An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions, Cambridge Systematics, October 2009

# LOCAL MEASURES

## Electric/Natural Gas Measures Methodology

Electricity consumption accounts for about 25% of citywide greenhouse gas emissions, while natural gas accounts for about 17%. Because approximately 80% of electricity use and 90% of natural gas use is associated with buildings, many of the measures included in the City of San Diego CMAP target building energy use.

The City of San Diego CMAP includes 8 measures to reduce emissions from the electricity and natural gas categories. The following provides details about the data and methods used to calculate the energy and greenhouse gas emissions reductions.

## 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.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of existing single-family homes are retrofit to reduce energy use by 30% per unit and 15% of multifamily homes are retrofit to reduce energy use by 20% per unit by 2020. By 2035, the CMAP assumes that 25% of existing single-family homes are retrofit for an energy savings of 30% per unit and 30% of multifamily homes are retrofit for an energy savings of 20% per unit.
- **Pool of Homes for Retrofits** – It is assumed that all houses in San Diego County are eligible to be retrofit regardless of age. So, the target of reaching 10% means that 10% of all homes in the City of San Diego are retrofit.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average residential energy consumption. The average residential electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 40% electric and 60% natural gas.

Sources:

- California Public Utilities Commission Database for Energy Efficient Resources (DEER), available at http://www.energy.ca.gov/deer/.
- Berkeley Residential Energy Conservation Ordinance, available at http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=16030.
- Meeting AB 32 - Cost-Effective Green House Gas Reductions in the Residential Sector. CONSOL, August 2008, available at http://www.consol.ws/studies.php.
- Critical Cooling, SPUR, February 2009, available at http://www.spur.org/publications/library/report/critical_cooling)

## 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.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of commercial building space (square footage) is retrofit to reduce energy use by 15% per square foot by 2020, and 25% of existing square footage is retrofit for an energy savings of 15% per unit by 2035.
- **Percentage of Commercial Area that Can be Retrofit** – CMAP calculations assumes that all commercial area in San Diego County is eligible to be retrofit regardless of age. So, the target of reaching 10% means that 10% of all commercial square footage in the City of San Diego is retrofit.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 70% electric and 30% natural gas.

*Sources*

- SDG&E Standard Performance Contract program data for 2006 and 2007.
- California Public Utilities Commission Database for Energy Efficient Resources (DEER), available at http://www.energy.ca.gov/deer/.

## 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.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of all commercial building space (square footage) is retro-commissioned to reduce average energy use by 15% by 2020, and 25% of commercial space achieves a 15% reduction by 2035.
- **Percentage of Commercial Area that Can be Retro-commissioned** – The calculation assumes that all commercial building space in the City of San Diego is eligible to be retro-commissioned regardless of age.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to

million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 70% electric and 30% natural gas.

*Sources*

- The Cost-Effectiveness of Commercial Building Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, available at http://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.

## New Construction Efficiency (Residential and Commercial)

California has strong building energy standards, many local governments require or encourage new construction projects to exceed these standards. This measure estimates the incremental greenhouse gas reductions from exceeding statewide standards. For the residential sector, the total greenhouse gas reduction value includes both single family and multifamily dwellings. Note that this measure only estimates the incremental greenhouse gas reductions associated with requirements that are better than statewide building energy codes; energy reductions from statewide standards are described below in the Statewide Measures section.

- **Participation Rate –** CMAP calculations assume that 15% of residential and commercial projects participate through 2016 and then 100% of projects participate through 2020.
- **Average Energy Savings** – The CMAP assumes that all new residential and commercial construction reduces energy savings to a level that is equivalent to 15% better than Title 24 requirements.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average energy consumption per square foot for commercial and per unit for residential. The average electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two: 70% electric and 30% natural gas for commercial and 40% electric and 60% natural gas.
- **Energy Covered by Building Energy Standards** – Calculations assume that for commercial projects 60% of electricity and 70% of natural gas usage is subject to Title 24 requirements. For residential projects, it is assumed that 30% of electricity and 85% of natural gas is subject to Title 24 requirements.
- **Rate of New Construction** – For residential projects, it is assumed that single family homes are built at a rate of 1% of the total number of residential units in

2010, declining to 0.5% in 2020 and multifamily are built at a rate of 1% of total residential unit in 2010 and 2.2% in 2035.

- **Zero Energy Homes by 2020** – Calculations estimate emission reductions through 2020, assuming that by 2020 a zero energy home regulation will be in place and that there is not incremental emissions reduction from local policy.

*Sources:*

- California Energy Commission Residential Appliance Saturation Survey, available at http://www.energy.ca.gov/appliances/rass/
- California Energy Commission Commercial End Use Study California Energy Commission, available at http://www.energy.ca.gov/ceus/
- San Diego Association of Governments population and housing projections, SANDAG Data Warehouse, available at http://datawarehouse.sandag.org/

## Residential Solar Water Heating Retrofit

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.

- **Participation Rate** – The CMAP assumes that 5% of existing single-family homes install solar water heaters by 2020 and 15% by 2035.
- **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 study of CCSE Solar Water Heating Pilot Program, we assume that the 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.
- **Single Family Housing Only** – The estimates here only calculates the effect of solar water heaters on single-family homes.

*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.

## Commercial Solar Water Heating

On average, commercial customers use about 30% of their natural gas energy to heat water in the San Diego region. This measure estimates the impact of installing solar water heaters.

- **Natural Gas Only** – The CMAP estimates assume that in the commercial sector, solar water heaters will offset natural gas only.
- **Percentage of Total Water Heating Energy Covered** – The CMAP assumes that 5% of all the natural gas used to heat water in 2020 and 15% in 2035 is affected by solar water heating.
- **Energy Reduction** – A reduction of 50% of natural gas use for both 2020 and 2035 is assumed.

### *Sources*

- Commercial End Use Survey, California Energy Commission, 2006 (CEC-400-2006-005-1), available at http://www.energy.ca.gov/ceus/.
- 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.

## 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.

- **Total Installed Capacity** – The CMAP assumes that in 2020 there will be 50 MW of photovoltaic capacity on homes in the City of San Diego and 200 MW by 2035. For commercial buildings, the value is 150 MW in 2020 and 350 MW in 2035.
- **Capacity Factor** – Calculations assume a capacity factor of 20% to calculate the energy production of solar photovoltaics.
- **Useful Life** – We assume 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.

### *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, and Ryan Wiser, Tracking the Sun III: The installed cost of Photovoltaics in the US from 1998-2010, Lawrence Berkeley

Laboratory, December 2010, available at http://eetd.lbl.gov/ea/emp/reports/lbnl-4121e.pdf.

## Clean and Efficient Distributed Generation - Cogeneration

Cogeneration is typically more efficient than large centralized power plants because it uses waste heat for another useful purpose (e.g., heating or cooling water). Consequently, greenhouse gas emissions from cogeneration are lower per unit of energy than other types of generation using natural gas. Emissions reductions are calculated by multiplying the total amount of energy produced by cogeneration capacity by an emissions savings rate (lbs/MWh).

- **Total Installed Capacity** – The CMAP assumes that in 2020 there will be 150 MW of cogeneration capacity in the City of San Diego and 250 MW by 2035.
- **Capacity Factor** – CMAP estimates use an average capacity factor of 80% to calculate electricity production. This value represents the weighted average of capacity factors for the estimate additions by size (MW).
- **Emissions Savings Rate** – Calculations use an average emissions savings rate of 264 lbs/MWh, which is derived by taking an average emissions rate for combined cycle natural gas power plants and subtracting an average emissions rate for cogeneration.

*Sources:*

- E3 Modeling inputs for New CHP Built in 2008 and 2020, available at www.ethree.com/GHG/New%20CHP%20Data.032408.xls
- *Assessment of California CHP Market and Policy Options for Increased Penetration,* EPRI, Palo Alto, CA, California Energy Commission, Sacramento, CA: 2005, available at http://www.energy.ca.gov/2005publications/CEC-500-2005-173/CEC-500-2005-173.PDF
- Darrow, Ken, Bruce Hedman, Anne Hampson. 2009. *Combined Heat and Power Market Assessment.* California Energy Commission, PIER Program. CEC-500-2009-094-D, available at http://www.energy.ca.gov/2009publications/CEC-500-2009-094/CEC-500-2009-094-D.PDF
- SDG&E Cogeneration and Small Power Production Report, available at http://www2.sdge.com/srac/Jan_Jun_2011_Final.xls
- California Energy Commission Power Plant Database, available at http://energyalmanac.ca.gov/powerplants/POWER_PLANTS.XLS

## Water Use Efficiency

The water conservation goal for the City of San Diego according to SB 7X is to achieve a daily per capita of 142 gallons in 2020. The City target for 2035 is to achieve 30% per capita reduction from the average baseline in 1996-2005 of 116 gallons.

- **Energy Reduction** – The energy reduction from water use reduction is calculated on the basis of the most recent energy intensity data associated with the four of the five stages of water supply to the City (CEC 2006). These stages are: water supply and conveyance, water treatment, water distribution, end-use, and wastewater treatment. Water supply and conveyance is not included as the emissions from this are also not included in the City's inventory. End-use emissions are likewise not included because they are accounted for in the electricity and natural gas emissions. The remaining stages are assumed to be within the geographical jurisdiction of the region and representative of the stages that water supplied to the City must go through. Each stage uses a different intensity of energy (see below). The CMAP assumes that the City of San Diego achieves the energy reduction from these stages according to the water consumption goals set forth in SB 7X (142 gallons per capita per day) by 2020 and 30% below the average baseline 1996-2005 in 2035.
- **Water Consumption Levels** –The estimated 2008 per capita use in the City was 147 gallons. This includes residential, commercial, industrial, institutional and irrigational uses as well as system losses. The projected BAU level is 151 gallons in 2020 and 152 gallons in 2035.
- **Energy Intensity of Water** – The energy intensities for Southern California used were obtained from the latest (2006) CEC report on energy use in California. End-use was not included, as it is included in the electricity and natural gas sectors of the CMAP. Table 3 provides the energy intensity factors used to estimate water-related GHG reductions in the CMAP.

**Table 3 Energy Intensity of Water for City of San Diego**

| Category | Kilowatt-hours per/Acre-foot |
|---|---|
| Water Treatment | 9,727 |
| Wastewater Treatment | 1,272 |
| Water Distribution | 111 |

- **Greenhouse Gas Intensity of Electricity** – To estimate the greenhouse gas impacts of reducing water use, we assumed a greenhouse gas intensity of electricity of 600 lbs/MWh in 2020 and 500 lbs/MWh in 2035.

*Sources:*

- Urban Water Management Plan 2010: Table 3-10 on total water use and projections; Table 3-12 for Base Daily per Capita Water Use 10-15 Year Ranges; Table 7, end use breakdown of energy intensity of water uses. Available at: http://www.sdcwa.org/uwmp

- Ronnie Cohen, Barry Nelson, and Gary Wolff, Energy Down the Drain: The Hidden Costs of California's Water Supply. NRDC and The Pacific Institute, 2004. Available at http://www.nrdc.org/water/conservation/edrain/edrain.pdf
- California Energy Commission 2005. California's Water-Energy Relationship, California Energy Commission. CEC-700-2005-011-SF.
- Navigant Consulting, Inc. 2006. *Refining Estimates of Water-Related Energy Use in California.* California Energy Commission, PIER Industrial/Agricultural/Water End Use Energy Efficiency Program. CEC-500-2006-118.


City Facility Efficiency Retrofits

- **Energy Reduction** – The CMAP sets a target of retrofitting existing City facilities and infrastructure to achieve an overall energy savings of 20% by 2020 and 30% by 2035.
- **City Energy Data** – The City of San Diego provided electricity and natural gas consumption data for City operations.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to million British Thermal Units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 70% electric and 30% natural gas.

## TRANSPORTATION CATEGORY

On-road transportation accounts for 53% of all City GHG emissions. Eight (8) on-road transportation measures and one land use measures affecting transportation (community smart growth plans) were assessed for GHG reduction based on existing regulatory mandates. The greatest reductions arise from federal and state mandates for vehicle fuel economy, low carbon fuel and land-use changes.

### Measures Contained in SB 375

The City of San Diego will benefit from local measures that are part of the Sustainable Communities Strategy (SCS) adopted under the California Senate Bill 375. SB 375 requires that the region achieve a GHG reduction per capita from personal miles driven (passenger cars and light duty trucks) of 7% in 2020 and 13% in 2035 compared with the value in 2005. The measures that will be part of the SB 375 SCS Strategy have been described by SANDAG and include: voluntary measures based on incentives for telecommute, carpools, subsidies for vanpools, buspools, and safe routes to schools to encourage walking to school; bottleneck relief projects such as increase in miles of freeway lanes to reduce fuel inefficient congestion; increase in miles of high occupancy vehicle lanes and freeway tolls; increase in the price of parking; bicycle lane increases

and pedestrian zone improvements; smart growth and population density increases; and mass transit use increases. The most significant of these measures are described below.

However, the following measures are NOT included within the SB 375 emissions reduction amount and are provided separately below (Other Transportation Measures) in order to better differentiate measures over which the City has jurisdiction or better identify the effect of mass transit use within the City:

- Land use related to smart growth including population density within the City
- The portion of the regional parking pricing program over which the City has jurisdiction
- Bicycle infrastructure improvements within the City
- Mass transit increases within the City.

The per capita regional SB 375 GHG reduction amounts were scaled to the City level by population.

## Telecommute

This voluntary incentive based measure is included in the SB 375 reduction amount.

- **Percentage Jobs Eligible for Telecommute** - 33% of all jobs in the county
- **Percentage of Workers with Eligible Jobs that Choose to Telecommute** -- Not all eligible workers choose to telecommute. The current level is estimated as 10% of the eligible jobs in the county.
- **Number of Days Telecommuted** - A typical worker with a telecommutable job telecommutes twice per week. Several large software companies, such as IBM, have employees telecommuting on average 4 days per week, resulting in greatly reduced need for office space, thus costs

## Vanpools

GHG reductions due to vanpools are included in the SB 375 reductions. Vanpools are taxpayer (through SANDAG) subsidized dedicated vans operated by private entities and used for commuting from residential areas directly to the workplace and back. There are over 700 vanpools in operation in San Diego County, most covering large commute distances, such as from Temecula to San Diego city. Similar incentive programs are to be available to encourage carpools and buspools

- **Average one-way distance:** 56 miles.
- **Current average persons per vanpool**: 8.3
- **Monthly vanpool subsidy:** $400 to providers.
- **Monthly fee**: Vanpoolers pay up to $120 in fees.

## Bottleneck Relief Projects

Bottleneck relief projects include high occupancy vehicle toll lanes as well as other toll lanes, and freeway expansion for congestion relief. Both are measures included in the

SB 375 reductions to achieve GHG reductions from which the City of San Diego will benefit. GHG reductions from freeway expansion comes from short-term changes to the speed profile on freeways. The addition of freeway lanes in congested areas and peak hours allows traffic flow to harmonize, and speeds to change from very low (less than 15 mph) to more fuel-efficient levels between 40 and 65 mph.

- **Congestion relief**: freeway expansion on 132 miles of congested freeway by 2030.
- **High Occupancy Vehicle lanes and Toll (HOT) lanes** : 80 miles

*Source*

SANDAG Regional Transportation Plan 2050, Chapter 3, Sustainable Communities Strategy, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

SANDAG Board Meeting, July 9, 2010, Item 3, SB 375 Implementation, available at:
http://www.sandag.org/index.asp?committeeid=31&fuseaction=committees.detail -mSched

## Other Transportation Measures

The following measures are not included with the above SB 375 reductions: Mass Transit, Parking Fee Increases, Bicycle Lane increases, and Smart Growth/Population Density increases. Smart Growth/population Density Increase is described under "Land Use-Transportation". Other non-SB 375 measures described here are Preferred Parking for EVs, Reduction in Parking Spaces, Conversion of Municipal Fleet to EVs, and Increase in Electric Vehicle Miles Driven.

Mass Transit

- **Percentage commuters using mass transit** - Currently (2010) about 5.3% of commuters, SANDAG expects this value to increase to 7.8% in 2020 and 10.1% in 2035 by increasing the transit frequency, providing incentives, and adding some routes.

*Source*

SANDAG Regional Transportation Plan 2050, Chapter 3, Sustainable Communities Strategy, Final Environmental Impact Report, Appendix F-1, October 2011, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

Parking fee increases

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 GHG

reductions were based on research-based best estimates of the number of parking spaces in the City metropolitan area over which the City has jurisdiction.

- **Average daily parking rates**: increase from $20 per day in metropolitan area in 2008 to $24 in 2020 and $30 in 2035
- **Number of parking spaces under city jurisdiction**: 80,000 in both 2020 and 2035
- **Elasticity of parking pricing with VMT**: 0.1

*Source*

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

## Preferred Parking for EVs

By encouraging EV use, the average daily commute by conventional GHG -emitting vehicles would be avoided and replaced by zero emission vehicles.

- **Preferred Parking for EVs**: 10%, 20% of all metropolitan area parking spaces in 2020, 2035 respectively
- **Miles commute avoided by conventional vehicles per day**: 25

## Parking space reductions

Reducing parking spaces in metropolitan areas encourages alternative transportation, walking and biking, thus reducing VMTs.

- **Reduction in number of parking spaces***:* 10% less in 2020, 20% less in 2035
- **Number of spaces under City jurisdiction**: 80,000 in in 2020 and 2035
- **Miles commute avoided by conventional vehicles per day**: 25

## Convert Municipal Passenger Vehicle Fleet to EV

Converting the municipal passenger vehicle fleet gradually to EVs will reduce gasoline use, thus GHGs. The City of San Diego provided current use of gasoline consumption. It was assumed that there would be no changes in 2020 and 2035 to this gasoline demand.

- **Gasoline use**: 90% reduction in gasoline use 2020, 90% reduction in gasoline use in 2035, baseline year 2008

*Source*

City of San Diego for fleet gasoline consumption

## Bicycle Infrastructure

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. The City Bicycle Master Plan assumes a 279% increase in bicycle commuters by 2022. Based on bicycle commute elasticities (Moving Cooler 2009), this would require an estimated 4 miles/square miles then.

- **Miles of bicycle lanes**: Increase from 1.1 lane miles per square mile today in the City to 4 lane miles per square mile in 2020 and 8 lane miles per square mile in 2035.
- **Miles vehicle commute avoided**: 8 miles per day

*Source*

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

SANDAG Plan Report, City of San Diego Bicycle Master Plan, Alta Consulting, 2002.

Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions, Cambridge Systematics, July 2009.

## Percentage Electric Vehicles

Increasing the number of electric vehicles in the personal vehicle fleet helps to reduce emissions, particularly as renewable energy supplies a larger portion of electricity. The default percentage of miles driven by electric vehicles were calculated from a California Energy Commission projection of electricity use for electric vehicles in 2010, 2020 and 2035 in the SDG&E service territory. Electricity values were converted to miles using the following assumptions.

- **Electricity Equivalent of Gasoline** – CMAP estimated the percentage of miles that will be driven by electric vehicles using 33.7 kWh/gallon.
- **Miles per Gallon Equivalent** - Estimates assumed that electric vehicles would achieve 100-150 miles per gallon equivalent over the study period.
- **Percent driven by EV miles**: 4% of personal miles driven in 2020, 11% of personal miles driven in 2035. These are therefore the miles avoided by conventional fuel vehicles.

*Source*

- Kavalec, Chris and Tom Gorin, 2009. California Energy Demand 2010-2020, Adopted Forecast. California Energy Commission. CEC-200-2009-012-CMF, available at http://www.energy.ca.gov/2009publications/CEC-200-2009-012/index.html.
- US. Department of Energy, US Environmental Protection Agency, 2011. Fuel Economy Guide – Model Year 2011. DOE/EE-0333. http://www.fueleconomy.gov/feg/feg2011.pdf.

## LAND USE - TRANSPORTATION

### Smart Growth

Smart growth refers, among others, to land development that involves re-zoning land uses to enable more efficient urban mobility. It is assumed that all smart growth projects planned in the City's communities will be implemented by the target years. Smart growth projects reflect increases in mixed-use zones and population density increases, leading to reduced VMT.

- **Population density increase**: 12% in 2020, 27% in 2035, compared with 2008
- **Elasticity of walking due to population density increase**: 0.07
- **Elasticity of transit use due to population density increase**: 0.07

*Source*

Demographics and Other Data, available at:
http://www.sandag.org/index.asp?classid=26&fuseaction=home.classhomePopulation

SANDAG, Regional Transportation Plan 2050, Chapter 3, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

More information about community smart growth plans are found at:
http://www.sandag.org/index.asp?projectid=296&fuseaction=projects.detail

## WASTE

### Divert Waste and Increase Capture Waste Gases

The IPCC Waste model was used by City staff to produce landfill methane and N20 emissions, which were converted to CO2e by multiplying by the GWPs. Waste disposed is forecast from 2011-2035 including diversion from 2022 as Miramar closes, and any additional waste is recycled, sent to Sycamore or diverted outside City of SD. Landfill gas capture data were provided by the City.

Wastewater emissions data and BAU calculations and results were provided by the City.

- **Landfill methane capture rate**: 80% capture of total estimated landfill gases in 2020 and 2035.
- **Wastewater treatment capture rate**: 98% capture of potential estimated wastewater treatment gases in 2020 and 2035.

## STATE AND FEDERAL MEASURES

### State Electric and Natural Gas Measures

Emissions reductions associated with the renewable portfolio standard is included the City of San Diego CMAP. As the percentage of renewable electricity delivered to residents and businesses increases, the greenhouse gas intensity of electricity decreases.

### California Renewable Portfolio Standard

Legislation signed into law in 2011 requires California's electric utilities to provide 33% of electricity supplies from renewable sources. This requirement is known as the Renewable Portfolio Standard (RPS). Increasing the level of renewable energy supply lowers the greenhouse gas intensity of electricity (lbs/MWh). The following assumptions are used to calculate the emissions reductions expected from the Renewable Portfolio Standard.

- **RPS Targets** – It is assumed that SDG&E will reach the 33% target by 2020 and maintains that level through 2035.
- **Electricity Sales as a Baseline for RPS Calculation** – Estimates use electricity sales as the baseline to calculate the emissions impact of renewable supply in the region. The level of sales is adjusted to account for energy efficiency measures included in the City of San Diego CMAP.
- **Renewable Energy has No Emissions** – For simplicity, calculations here assume that all renewable energy supply emits no greenhouse gases.

*Sources*

- Renewable Portfolio Standard Bill (SBX 1 2), available at http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.pdf.

## State and Federal Transportation Measures

Federal Corporate Fuel Economy Standards adopted by the federal government will improve the fuel efficiency of the fleet of cars and light-duty trucks in the City of San Diego. Furthermore, California has adopted a Low-carbon Fuel Standard that seeks to reduce the greenhouse gas intensity of transportation fuels. Both of these policies will reduce overall emissions in the City of San Diego.

### Pavley I and CAFÉ standards: Passenger Vehicle and Light Duty Truck Fuel Economy

The California AB 1493 (2002, Pavley I) required manufacturers to conform to stringent tailpipe emissions standards for greenhouse gases equivalent to achieving a significant increase in fuel efficiency of cars and light duty trucks. In May 2009, the federal Corporate Average Fuel Economy Standards were adjusted to conform to California's Pavley I equivalent. California then amended AB 1493 (Pavley I) to conform to the federal CAFE standard from 2012 to 2016, on condition that it receives a waiver to set

its own vehicle standards after 2016 and enforce its standards for model years 2009 to 2011. CAFE mandates the sales-weighted average fuel economy (in mpg) of the passenger cars and light-duty trucks for a manufacturer's fleet. New passenger vehicles must meet a sales weighted average of 39 mpg, light duty trucks a value of 30 mpg, resulting in an average 34.5 mpg for the fleet if it is met only by fuel economy improvements. This corresponds to a CO2e target of 250 grams/mile in 2016 from those vehicles.

- **Date Achieved** - The CMAP assumes that Pavley I or CAFE 2016 standards for new passenger vehicles are achieved in 2020
- **Improvements after 2020** – It is assumed that there will be no further fuel economy or tailpipe emission standards in 2035.

*Source:*

- Average Fuel Economy Standards, Passenger Cars and Light Trucks, MY 2011; Final Rule is available at http://www.nhtsa.gov/fuel-economy.

## Low Carbon Fuel Standard (LCFS)

The California LCFS (2010) requires that a regulated party reduce the carbon intensity per Mega Joule of its transportation fuel (gasoline and diesel) by 10% in 2020. A regulated party is any supplier of transportation fuel, including importers. Electricity suppliers are considered regulated parties only if they elect to provide credit to fuel distributors. At this time, there are no monitoring reports of the status of use of electricity credits for the LCFS to indicate the magnitude of carbon intensity reduction that electric vehicles will play in 2020. Therefore, for CMAP purposes, miles driven by electric vehicles are not considered a part of this standard. CMAP also assumes no new low carbon fuel mandates in 2035. It is possible that the interaction of this standard with electric vehicles will have to be re-visited in the future.

*Source:*

Information about the LCFS program is available at:
http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

# BUSINESS-AS-USUAL PROJECTION METHODOLOGY

A business-as-usual projection was calculated to estimate the level of emissions in 2020 and 2035 if no action were taken. This estimate assumes that no new policies are adopted and that there is no further activity on existing policies. This estimate becomes the baseline from which emissions from all measures is subtracted to determine if CMAP targets are reached. There are a number of assumptions that are used to estimate future projections. The following sections provide information on the methodology used to project emissions and the assumptions included in those calculates.

## On Road Transportation

The City of San Diego provided vehicle miles traveled (VMT) data for the years 1990, 2004, 2007, 2008 and 2009. Forecasts for VMT for 2010, 2020 and 2035 were made based on San Diego Association of Government (SANDAG) population growth rates for the City.

EMFAC 2007 Series 12 input files for the region were provided by SANDAG for the years 2010, 2020 and 2035. EMFAC 2007 was run in burden mode to provide CO2e for the region for the years 2020 and 2035. This was converted to a CO2e/VMT for the region, which was assumed to represent the CO2e/VMT for the City. City emissions projections were calculated with this CO2e/VMT factor and the City's forecasted VMT.

The BAU projections for on-road transportation do not include emissions reductions due to the Pavely I/CAFÉ fuel economy standards or the Low Carbon Fuel Standard, or the miles driven by electric vehicles.

## Electricity

The City of San Diego provided historical electricity consumption values for 1990, 2004, and 2007-2009. To project City of San Diego values, we used California Energy Commission (CEC) forecasts for the San Diego Gas and Electric (SDG&E) service territory through 2020 (linear projections to 2035) to develop an average ratio between City of San Diego total consumption and SDG&E consumption for years 2007-2009.

This ratio value was multiplied by the CEC forecast through 2035 to get an estimate of the City of SD consumption levels. The ratio value used (42%) is roughly equivalent to the ratio of franchise fee revenue from the City of San Diego to the overall SDG&E territory for years 2006 and 2007.

To estimate emissions from electricity, projected consumption levels were multiplied by the greenhouse intensity value for electricity (lbs/MWh) used by the City of San Diego to calculate electric emissions in 2009. The value used was 720 lbs/MWh.

### Forecast Assumptions

The following provides a list of programs and policies that are included in the electricity forecast.

- Renewable Portfolio Standard – 11.9% of retail electricity sales in 2010
    - GHG Intensity of electricity 722 lbs/MWh
    - Assumes direct access providers have the same GHG intensity
- New Residential Building Standards – 2005 Title 24 (effective 10-1-05)

- New Commercial Buildings Standards – 2008 Title 24 (effective 1-1-10)
- Appliance Standards – those in effect in 2010
- AB 1109 Lighting Standards – electric savings through 2020
- Utility Energy Efficiency Programs – electric savings from 2010-2012 program cycle

## Natural Gas

The City of San Diego provided historical natural gas consumption values for 1990, 2004, and 2007-2009. To project City of San Diego values, we used California Energy Commission (CEC) forecasts for the San Diego Gas and Electric (SDG&E) service territory through 2020 (linear projections to 2035) to develop an average ratio between City of San Diego total consumption and SDG&E consumption for years 2007-2009.

This ratio value was multiplied by the CEC forecast through 2035 to get an estimate of the City of SD consumption levels. Note that the gas data used by the City of San Diego to calculate their inventory includes gas used for electric generation using cogeneration, therefore the ratio of City-provided consumption levels is higher than the ratio (about 75%) without natural gas for cogeneration (about 45%).

To estimate emissions from electricity projected consumption levels were multiplied by a conversion factor of 0.0053052 MMT CO2e/million therms. This is equivalent to 5.31 metric tons of CO2E per therm.

### Forecast Assumptions

The following provides a list of programs and policies that are included in the natural gas forecast.

- New Residential Building Standards – 2005 Title 24 (effective 10-1-05)
- New Commercial Buildings Standards – 2008 Title 24 (effective 1-1-10)
- Appliance Standards – those in effect in 2010
- Utility Energy Efficiency Programs – therms savings from 2009-2012 program cycle

## Waste

The City of San Diego provided both landfill and wastewater treatment emissions for 1990, 2004, 2007, and 2007-2009, and forecasts for 2020 and 2035. For landfill emissions, the City of San Diego used the IPCC Waste Model to calculate landfill methane and N20 emissions, which were converted to CO2e by multiplying by their global warming potentials. Changes to waste disposal inputs as well as closure of the Miramar landfill from 2022 were taken into account for forecasts for 2035. The business as usual projection for 2020 and 2035 includes the current approximately 70% of the total potential landfill gas emissions captured today.

Wastewater emissions were calculated by the City based on EPIC's 2008 GHG Inventory methodology. This used a methane or nitrous oxide emissions factor per person developed by the California Air Resources Board for the region. The emissions factor for methane was 9,855 grams per capita, for nitrous oxide 95 grams per capita. The BAU for 2020 and 2035 includes the approximately 71% of wastewater treatment emissions captured today.

6-6-12

*Sources*:

IPCC Waste Model, available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

EPIC Greenhouse Gas Inventory, Waste, available at: http://www.sandiego.edu/epic/ghginventory/

## Water

The BAU projections for the City's water use are available in the County Water Authority's Urban Water Management Plan (UWMP, 2010). The 2008 per capita value of 147 gallons was interpolated between the 2005 and 2010 actual water use data in the UWMP 2010. The BAU per capita daily value 2020 is 151 gallons. The 2035 BAU per capita daily value is 152 gallons.

*Sources*:

Table 3-10, Urban Water Management Plan 2010 available at: http://www.sdcwa.org/uwmp

# Appendix III: 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)**

**Cost Effectiveness of CMAP Measures ($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 | $100 |
| Residential Photovoltaics | $175 |
| Commercial Photovoltaics | $327 |
| Residential Efficiency Retrofit - SF | $596 |

| Transportation Measures | 2020 |
|---|---|
| Mass Transit with health benefits | ($3,373) |
| Traffic light retiming with health benefits | ($457) |
| Traffic light retiming | ($341) |
| Roundabouts | ($340) |
| Parking Fee Strategy | $9 |
| Prefered Parking for Evs | $15 |
| Mass Transit | $1,809 |
| Bicycle Strategy | $40,864 |

Note: Because of the difference in methodology, no 2010 values are available for transportation measures.

# 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 15 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 $0.01/kWh for operations and maintenance 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.

| CMAP Measures | Inputs | | Basis for Participation Rates |
|---|---|---|---|
| **Local Measures - Electric/Natural Gas** | **2020** | **2035** | |
| **Commercial Retro-Commissioning** | | | |
| Average Energy Reduction (%) | 15% | 15% | Based on (1) The Cost-Effectiveness of Commercial Building Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, available at http://eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf,and (2) CEC Options for Energy Efficiency in Existing Buildings - http://www.energy.ca.gov/2005publications/CEC-400-2005-039/CEC-400-2005-039-CMF.PDF. |
| % Commercial SF | 10% | 25% | Based on California Long-Term Energy Efficiency Strategic Plan. |
| **Commercial Efficiency Retrofits** | | | |
| Energy Reduction (%/unit) | 15% | 15% | Based on energy reduction levels from SDG&E Standard Performance Contract Program. |
| Area Retrofit (% of SF) | 10% | 25% | Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan. |
| **Residential Efficiency Retrofit - Single Family (SF)** | | | |
| Energy Reduction (%/unit) | 30% | 30% | Based on Energy Upgrade California program participation. |
| Number of Units Retrofit (% total units) | 10% | 25% | Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan. |
| **Residential Efficiency Retrofit - Multi Family** | | | |
| Energy Reduction (%/unit) | 20% | 20% | Based on City of San Diego multi-family efficiency program participation. |
| Number of Units Retrofit (% total units) | 15% | 30% | Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan |
| **Residential Solar Water Heating Retrofit - SF** | | | |
| Number of Units (% total units) | 5% | 15% | Based on incentives available through the California Solar Initiative (CSI). Energy savings based on CSI evaluations. |
| **Commercial Solar Water Heating Retrofit** | | | |
| Reduction in water heating energy | 50% | 50% | Based on average energy reduction due to solar water heating. |
| % commercial water heating energy affected | 5% | 15% | Based on incentives available through the California Solar Initiative. |
| **Residential PV** | | | |
| Total Capacity (MW) | 50 | 200 | Based on current trends and availability of incentives through 2016. |
| **Commercial PV** | | | |
| Total Capacity (MW) | 150 | 350 | Based on current trends and availability of incentives through 2016. |
| **Cogeneration (MW)** | | | |
| Total Capacity (MW) | 150 | 250 | Based on a prorated share of technical potential for the SDG&E territory. |

| CMAP Measures | Inputs | | Basis for Participation Rates |
|---|---|---|---|
| **Residential New Construction** | | | |
| % better than T24 | 15% | | Based on California Green Building Code and California Long-Term Energy Efficiency Strategic Plan to achieve net zero energy homes by 2020. |
| Participation Rate after 2015 | 100% | | Assumes that this level is required. |
| **Commercial New Construction** | | | |
| % better than T24 | 15% | | Based on California Green Building Code and California Long-Term Energy Efficiency Strategic Plan to achieve net zero energy homes by 2030. |
| Participation Rate after 2015 | 100% | | Assumes that this level is required. |
| **Water Use Efficiency** | | | |
| Gal/person/day | 142 | 116 | 2020 values based on 2010 Urban Water Management Plan, goal adopted for the City of San Diego under SB 7X. 2035 value Represents a 30% per capita reduction from average baseline 1996-2005 from UWMP, viewed as an acceptable goal by stakeholders |
| **City Building Efficiency** | | | |
| % reduction in total energy consumption | 20% | 30% | Based on historic energy reductions in City of San Diego operations |
| | | | |
| **Local Measures - Transportation** | **2020** | **2035** | |
| **Mass Transit** | | | |
| % mode share | 8% | 10% | SANDAG RTP 2050 forecast for the region applied to the City |
| **Bicycle Infrastructure** | | | |
| Bicycle lanes per square mile | 4 | 8 | City of San Diego Bicycle Master Plan 2002 assumes a 270% increase in bicycle commuters within 20 years.<br>To achieve this would require nearly tripling the bicycle lane miles per square mile in 2020 from current (2010) estimated 1.4 lanes/square mile. 4 miles in 2020 is then a reasonable expectation. |
| **Parking - reduce spaces** | | | |
| % of total reduced Metro area | 10% | 20% | As advised by City of San Diego |
| **Parking - preferred parking for EVs** | | | |
| % reserved for electric vehicles | 10% | 20% | As advised by City of San Diego |
| **Parking - Increased fees** | | | |
| $ per day | 24 | 30 | 2020 value from SANDAG RTP 2050 SCS Scenario measure for Metro region. 2035 value extrapolated from SANDAG RTP 2050 SCS Scenario measure for Metro region |

| CMAP Measures | Inputs | | Basis for Participation Rates |
|---|---|---|---|
| **City of San Diego Share of SB 375 Reductions** (Includes telecommute, carpool, vanpool, bus pool, bottleneck relief, HOV/HOT lanes, safe routes to school) | | | Based on and extrapolated from SANDAG's Sustainable Communities Strategy. |
| % of target achieved | 100% | 100% | Based on SANDAG's estimates for SB 375 emission reduction targets scaled to City |
| **Signal timing and roundabouts** | | | |
| Number of signals and roundabouts, each | 15 | 20 | Based on discussion with City traffic management as feasible |
| **Electric Vehicles** | | | |
| % miles driven of cars and light duty truck miles (private vehicle miles) | 4% | 11% | Based on CEC projection of electricity use for electric vehicles in 2020. 2035 value is linear extrapolation from 2022 value. |
| Convert municipal fleet to EV | | | |
| % reduction gasoline fuel | 90% | 90% | As advised by City of San Diego |
| **Local Measures - Land Use** | **2020** | **2035** | |
| **Smart Growth** | | | |
| % increase in population density from 2010 | 12% | 27% | SANDAG RTP 2050 Growth Forecast |
| **Local Measures – Waste** | **2020** | **2035** | |
| **Divert Trash and Capture Landfill Gas** | | | |
| % landfill gas capture | 80% | 80% | As advised by City of San Diego and state mandate |
| % wastewater gas capture | 98% | 98% | As advised by City of San Diego as planned and feasible |
| **State/Federal Measures** | **2020** | **2035** | |
| **Renewable Portfolio Standard** | | | |
| % of sales that is renewable | 33% | 33% | Statutory requirement. See CA Public Utilities Code § 399.11 et seq. and CA Public Resources Code § 25740 et seq., as adopted in SBx1-2 on 4-12-11. |
| **Pavley I (approximately equivalent to CAFÉ standards in mpg)** | | | |
| MPG for New Passenger Vehicles | 34.5 | 34.5 | Based on federal CAFÉ standards |
| **Low-Carbon Fuel Standard** | | | |
| % reduction in carbon intensity | 10% | 10% | Low-Carbon Fuel Standard requirements as adopted by the California Air Resources Board applied to the fuel consumption of the City of San Diego. |
| **CARB Tire Pressure Program** | | | |
| % CARB goal achieved | 100% | 100% | Tire Pressure Program requirements as adopted by the California Air Resources Board applied to the City of San Diego |
| **CARB Heavy Duty Vehicle Regulation** | | | |
| % CARB goal achieved | 100% | 100% | Heavy Duty Vehicle Regulation requirements as adopted by the California Air Resources Board |

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# Appendix V – City of San Diego Adaptation Economic Analysis

**Krout & Associates**

The Costs Come Before the Benefit

How much to adapt is an economic problem—how to allocate limited resources for climate adaptation strategies while also providing other necessary services. Decision-makers ask: What is the potential loss to local economies and communities from climate change? What is the cost to implement adaptation strategies? Will the benefits outweigh the costs?

For many areas at risk, the potential loss from climate change can be reduced or eliminated by adaptation strategies. However, without adequate data, perceived threats from climate change may lead to implementation of strategies without understanding of the short- and long-term impacts to the local economy. Reactive adaptation strategies implemented by the public agencies, private businesses, and residents may protect individual assets (i.e. homes and businesses), but may not address the local economy's cumulative needs. Reactive adaptation measures will in many cases be more costly than proactive, planned strategies. A homeowner or business may take their own actions to adapt, without public interventions, but under the guidance existing public policy. These spontaneous and autonomous actions are vital to the overall effort to adapt to a changing climate; however, the private sector is primarily market driven, and as a result, will act in there own best interest. A disjointed approach to adaptation can lead to economic inefficiencies, or worse, limited or no protection for public resources such as water and open space.

As a result, it is necessary for the public decision-makers to consider the possible risks and implementation costs from a holistic perspective. Consideration should be given not only to the economic implications of adaptation strategies, but also the environmental and the social impacts. Ecosystems already suffer environmental degradation and climate change will pose an additional stresses. Climate adaptation strategies should consider the value (benefit) of amenities and resources from an economic and social-value perspective. Additionally, exposure to climate change poses different risks to different groups of people. In general, temperature increases have a larger detrimental effect on older individual and the physically ill as compared to the general population. Low-income households are more likely to live in floodplains and susceptible to flood. While an adaptation strategy may provide beneficial economic impacts to a subset of the community, the costs may be unequally distributed leading to hardship for economically disadvantaged populations.

There are numerous methods and models available to perform an economic analysis of climate adaptation strategies. The intent is not to define a detailed model, nor to evaluate a specific adaptation strategy, but rather to illustrate the general framework of analysis. The framework describes the general steps to perform the analysis. The general framework should provide a

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roadmap to assess the local risk from climate change and help identify a cost-effective set of adaptation strategies.

Economic Framework for Assessment

The economic framework illustrates a multi-step process for quantitatively evaluating a set of climate adaptation strategies. The first step is to estimate the potential loss from climate change to vulnerable sectors. The second step is to determine the cost to protect and preserve those vulnerable sectors. The final step is to develop detailed cost-benefit assessments of climate adaptation strategies.

1. Estimate potential losses
2. Calculate implementation cost of adaptation strategies
3. Perform cost-benefit analyses for proposed adaptation strategies

With limited resources, it is not always feasible to implement every climate adaptation strategy. A quantitative evaluation of the strategies should be considered the baseline for discussion. The section concludes with a discussion of the economic implications that should be considered when evaluating adaptation strategies. In combination, the understanding of quantitative and qualitative data can provide clarity for decision-makers considering climate adaptation strategies.

Step 1. Estimate potential loss from a climate change event

What is the value of what may be lost to vulnerable sectors by a climate change event? Put another way, what is the benefit of the vulnerable sector to the economy? The evaluation of the potential loss depends upon calculations of climate change risk and the asset value within the market sectors vulnerable to climate change. This risk is defined as the likelihood of an event occurring and the magnitude of consequences should that event occur (NPCC). Forecasts of the frequency, magnitude, and sector vulnerability are traditionally forecast with the use of specialized climate change probability models. The potential loss is calculated as a function of the severity and frequency of the climate hazard, the value of assets exposed to the hazard, and the vulnerability of those assets to the hazard.

The role of the economic analysis is to assess the economic impacts to assets. Local businesses; cultural and recreational centers; and the underlying physical infrastructure (including water and transportation networks) provide tangible and intangible value or benefits (economically, environmentally, and socially) to a community. By first understanding the value, the potential losses from a climate-change related event (by not implementing adaptation strategies), can be calculated. Assessment of vulnerable sectors should incorporate forecasted changes in the economy and regional demographics to account for the risk of climate change on a evolving economic and population base.

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An estimation of infrastructure and other tangible resource values can be calculated using the replacement cost and adjusting for inflation (all else held equal). The cost of replacing intangible resources is more difficult. Environmental quality and social cohesion are complex resources to apply a monetary value, yet methods do exist to provide estimation[1]. By measuring the overall value or benefit, decision-makers can understand the total economic, environmental and/or social loss to the local community if a significant climatic event occurred.

Step 2. Calculate implementation costs of adaptation strategies

Cost for adaptation strategies include the labor and resource costs necessary to implement a proposed strategy. From an economic perspective, the strategies can be divided into three general categories for cost assessment: Maintenance and operations, capital investment including redevelopment, and regulatory and climate change policy. Timing for implementation of specific adaptation strategies within these categories is an important cost consideration as well. Maintenance and operations costs will occur in the short and long-term; however, capital improvements may decrease maintenance costs over the long-term if implemented in the short-term.

The asset valuation is highly dependent on the associated risk in terms of understanding the possible level of frequency and magnitude. When estimating the economic value of an asset, we assume the entire benefit may be lost from a climate change event. The probability is low that an entire sector would be eliminated. It is more likely that only a proportion of the value will affected and over a limited period of time. Therefore, when estimating costs, loss of the entire sector is a baseline, with the understanding that the actual costs will depend on the frequency, magnitude, and overall vulnerability of the sector.

Step 3. Perform cost-benefit analyses for proposed adaptation strategies

The costs of adaptation and potential losses from future climate change are used in cost-benefit analyses to examine the impact of climate change. Through cost-benefit analysis, where the cost-benefit ratio is a measurement of the capital and operating expenditures against total economic benefit, decision-makers can compare, quantitatively, the financial impact of climate adaptation measures. A simple terms, the most cost-effective adaptation strategy is one where:

Adaptation Costs < Potential Losses from Climate Change (without Adaptation)

Take for example a local park that would be hypothetically inundated by water from increased rainfall and flooding. Assume in this example that the cost to replace the park facilities is $200,

[1] A series of methods exist for benefit estimation including the travel-cost method, hedonic pricing, and contingent valuation.

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the monetary value, of the park[2]. Assume that decision-makers can select from one of two strategies: Upgrade of existing storm drains or development of new bio-swales to divert water. Assume implementation of the first adaptation strategy costs $150 (up-front) to prevent or reduce damages from climate change events by $200. Now assume the second adaptation strategy, bio-swales, costs $100 (up-front) to prevent or reduce damages by $200. In this simplified example, the second scenario has a greater benefit-to-cost ratio, and therefore could be the recommended strategy.

Cost-benefit approaches are typically more complex than the example above. The models traditionally attempt to normalize costs and benefits over time. Future expected costs and benefits are converted into a "net present value" amount using a selected discount rate. The discount rate used for climate change adaptation strategies is highly subjective. Risk associated with possible losses from climate change events can be calculated via probability models and incorporated into the discount rate.

Economic Assessment Considerations

Adaptation is not free. On the other end, the investment potential is unlimited to hedge against all possible losses. To be cost-effective, adaptation strategies should:

Identify cost savings through planned projects

"Planning for climate change today is less expensive than rebuilding an entire network after a catastrophe." – Plan NYC

Proactive planning for climate adaptation is less expensive the reactive, emergency measures after a severe climate action event. Through planning, decision-makers can determine the overall feasibility and applicability of the most cost-effective adaptation strategies.

Prioritize hard and soft adaptation strategies

Adaption strategies can be categorized in to "hard" and "soft". Hard adaptation strategies usually imply the use of specific technologies and actions involving capital goods, such as dikes, seawalls and reinforced buildings, whereas "soft" adaptation strategies focus on information, capacity building, policy and strategy development, and institutional arrangements (World Bank).

Hard adaptation strategies (e.g., capital improvement) is often more expensive than soft adaptation strategies. At the same time, they may also be less flexible in the long term if forecasting of future climate impacts is over- or under-estimated. Soft adaptation strategies (e.g., policy reform) are often less costly in monetary terms, more flexible and tend to focus on

[2] This analysis ignores the underlying opportunity cost of the land. The assumption is the land use would remain constant.

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the affected people rather than the affected land, should be considered and combined with hard options.

III. Reduce risk exposure and mitigate residual losses with insurance

The total cost of climate change is the sum of the cost of adaptation, mitigation, and any residual potential losses not averted by the mitigation or adaptation strategies. It is not normally cost-effective to implement adaptation or mitigation strategies that completely reduce the potential losses from a climate change event. Insurance reduces the exposure to climate change risk, by covering the residual losses, and should be incorporated into the cost-benefit analyses of climate adaptation strategies.

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