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Section E

Energy and Climate Measures

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BAY AREA AIR QUALITY MANAGEMENT DISTRICT

939 Ellis Street
San Francisco, CA 94109
(415) 771.6000
www.baaqmd.gov

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ECM 1 - Energy Efficiency

Brief Summary:
This control measure consists of three components: 1) provide education and outreach to increase energy efficiency in residential and commercial buildings and industrial facilities, 2) provide technical assistance to local governments to adopt and enforce energy efficiency building codes, and 3) provide incentives for increasing energy efficiency at schools.

Purpose:
Decreasing the amount of energy consumed in the Bay Area through increased efficiency and conservation will reduce the amount of fossil fuels, such as natural gas, needed to produce the electricity that the region uses. This will, in turn, decrease the production of greenhouse gases and criteria pollutants emitted by combustion of fossil fuels.

Source Category Affected:
The emission source affected by this measure is primarily electricity production for commercial and residential buildings and industrial facilities.

Regulatory Context and Background:
The California Global Warming Solutions Act, or AB32, signed into law in 2006, requires the State of California to reduce greenhouse gas emissions to 1990 levels by 2020. In support of this goal, the California Air Resources Board "encourages local governments to adopt a reduction goal for municipal operations emissions and move toward establishing similar goals for community emissions that parallel the State in commitment to reduce greenhouse gas emissions by approximately 15 percent from current levels by 2020." According to the Air District's 2008 Source Inventory of Bay Area Greenhouse Gas Emissions, approximately fifty percent of the region's greenhouse gas emissions are produced through energy used in residential and commercial building, industrial facilities and electricity generation. The Bay Area cannot meet the challenge of AB32 without reducing energy use in buildings and industry.

Energy production at and for residential, commercial, industrial and other buildings is also a significant source of criteria pollutants such as NOx and PM. Improved energy efficiency can reduce these emissions from power plants, boilers, furnaces, etc.

PUC Strategic Plan: In September 2008, the California Public Utilities Commission (CPUC) adopted the state's first Long Term Energy Efficiency Strategic Plan, presenting an integrated framework of goals and strategies for saving energy from government, utilities and the private sector in the 2009 to 2020 period. Goals in the Strategic Plan include:

- All new residential construction in California will be zero net energy by 2020;
- All new commercial construction in California will be zero net energy by 2030;
- The Heating, Ventilation, and Air Conditioning (HVAC) industry will be reshaped to ensure optimal equipment performance; and
- All eligible low-income homes will be energy efficient by 2020.

Title 24: In California, energy efficiency requirements for new construction are addressed through Title 24 of the California Code of Regulations. Part 6 of Title 24, the California Energy Code, contains energy conservation standards applicable to all residential and non-residential buildings throughout California. In April of 2008, the California Energy Commission adopted new standards for Title 24, with the intent of decreasing energy use and greenhouse gas emissions throughout the state. The 2008 update is expected to achieve 13-15% energy savings in residential buildings and 8% savings in commercial buildings compared to the 2005 standards. The 2008 standards will take effect on January 1, 2010.

Progress in energy efficiency will be essential to achieve our greenhouse gas reductions goals. Comprehensive green building programs that include standards for energy efficiency and third party verification of building performance are critical to this objective. The most effective role for the District is to complement and build on the requirements embedded in the 2008 update of the Title 24 standards. One such gap is in the enforcement of Title 24. A study conducted by EDAW on behalf of the City of Seattle concludes that, as building codes and standards become more complex, there is a critical need for education and outreach to ensure that the codes are properly implemented and enforced.

In general, it is difficult for schools and school districts to access governmental funding resources to upgrade their facilities because, unlike city and county governments, schools and school districts have very little capital with which to leverage financing, and very limited resources to navigate the paperwork and research needed to develop effective proposals. The 2009 American Recovery and Renewal Act has provided funding and financing for building upgrades, however this funding is not available for schools to add solar power, as photovoltaic systems are not considered part of a school facility.

Implementation Actions:
This control measure consists of three components:

- Provide education and outreach, as resources permit, to increase energy efficiency in residential and commercial buildings and industrial facilities, including distributing information on state and local energy programs to permitted sources, and researching the newest methodologies and tools for quantifying GHG emissions from building energy use;
- Provide technical assistance to local governments to adopt and enforce energy efficiency building codes and green building ordinances, including distribution of model ordinances and collaboration with the California Energy Commission to convene building inspector trainings on new Title 24 regulations;
- Provide information and incentives, as resources permit, to increasing energy efficiency at schools, through the District's existing outreach and community grant programs.

Emission Reductions:
It is estimated that all actions in this control measure will result in a 1% reduction in electricity use in the Bay Area which draws from the results to date from local green building ordinances.

The Air District's *2008 Source Inventory of Greenhouse Gas Emissions* provides current levels of energy use and resulting CO2 emissions.

ABAG projects an approximately 28% increase in Bay Area population from 2005 – 2035. From 2005 – 2020, this increase will be approximately 14%. Using the District's *Source Inventory,* the total electricity use is first expanded to incorporate this estimated growth, and then an estimated savings from the control measure implementation actions is applied. The *Source Inventory* uses 2007 data, so instead of applying the full 14% increase (representing an increase from 2005 – 2020), an adjusted increase of 12% has been applied.

After applying the increase due to population growth, a 1% decrease is calculated.

Emissions are in short tons/day (metric tons/day for CO_2):

Daily Energy Use	CO2	PM 10	PM 2.5	ROG	NOx	SO2	CO
149,474 MWh	43,099	28	28	4.2	46	40	57
2020 Projection*	48,270	32	32	4.7	52	44	64
1% Reduction	483	0.32	0.32	0.05	0.52	0.44	0.64

*12% increase over 2007 data

How Emissions Reductions Were Estimated:
Factors for greenhouse gas emissions from electricity use are based solely on the amount of energy used. Factors for criteria air pollutant emissions, on the other hand, are based not just on the amount of energy used, but also on the specific technology being utilized. Therefore, it is far more complicated to develop an emissions factor for criteria pollutants, and the numbers in the table above should be treated as general estimations and not specific projections.

Coefficients to translate electricity into CO2 emissions were taken from the California Climate Action Reserve General Reporting Protocol, version 3.1. Electricity coefficients for PM, ROG, NOx, SO2 and CO were derived by Air District staff based on regional averages of emissions factors from power plants in the region.

Exposure Reduction:
This measure could help to reduce exposure in impacted communities that are located near power plants, particularly "peaker plants", due to the reduction in electricity use.

Emission Reduction Trade-offs:
This control measure is designed purely to reduce energy consumption, so there would be no direct emission trade-offs. There might be indirect emissions associated with the production and delivery of some energy efficient technologies.

Cost:
Investing in energy efficiency is almost always cost-effective because there is a direct return on the investment in the form a reduction in energy expenditures. Numerous state- and utility-sponsored incentive programs exist which provide rebates or financing for purchasing and

installing energy efficient technologies. In addition, innovative financing strategies such as the Berkeley FIRST model, have emerged which negate the need for upfront capital investments on the part of building owners.

According to the CEC's Energy Consumption Data Management System, residential electricity use represents approximately 29% of all electricity use in the Bay Area. The table below outlines the net savings to building owners from investing in energy efficiency. The per household cost and savings numbers reflect averages between the cost estimates of new green building policies in San Francisco and Sonoma County, as reported to the CEC.

	Per Household	Total
Incremental annual cost*	$96	$27,945,600
Annual savings	$165	$48,031,500
Net Savings	$69	$20,085,900

*Total incremental cost of $1,929 amortized over 20 years

Co-Benefits:
Reducing the use of fossil fuels in grid-tied electricity production brings a number of co-benefits to a community, including:

- improved air quality near power plants (due to reduced production)
- Increased reliability of power supply and cost
- energy savings
- financial savings through reduced energy usage
- green job creation (local manufacturers/suppliers/contractors for installing technologies)

Monitoring Mechanisms:
The overall goal of the measure is to reduce fossil fuel use through the direct use of grid-tied electricity. Monitoring and evaluating progress will be measured by:

- Reduction in electricity use (information from PG&E)
- Number of businesses and residents reached, in site visits, meetings, through mailings and other methods of information distribution (tracked by District)
- Number of building inspectors and operators receiving enforcement training on Title 24 (reported to District by CEC)
- Number of permitted sources seeking technical assistance, funding or other assistance from state and federal agencies for energy efficiency as a result of District's information provision (will be tracked through a response survey included in the information packets)
- Reduction in electricity use from permitted sources (reported through permitting process)

Issues/Impediments:
It is not anticipated that there would be significant impediment due to the voluntary nature of this control measure.

Sources:
1) *"'Re-commissioning' Leans on Education",* A. Lee Chichester, NEMI Research Report

2) "Source Inventory of Greenhouse Gas Emissions" Bay Area Air Quality Management District, December 2008
3) *Seattle New Building Energy Efficiency Policy Analysis: Case Study California Title 24 Energy Code*; EDAW (11/2004); http://www.seattle.gov/environment/documents/GBTF_NewBldg_Title24_Case_Study.pdf
4) http://www.dsa.dgs.ca.gov/Code/title24.htm
5) http://www.seattle.gov/environment/documents/GBTF_NewBldg_Title24_Case_Study.pdf
6) http://ag.ca.gov/globalwarming/pdf/green_building.pdf
7) http://www.energystar.gov/index.cfm?c=heat_cool.pr_hvac
8) http://www.cpfund.ca/pdf/the-jobs-connection.pdf

ECM 2 - Renewable Energy

Brief Summary:
This control measure consists of two components: 1) promote incorporation of renewable energy sources into new developments and redevelopment projects, and 2) foster innovative renewable energy projects through provision of incentives. Note: In addition, as part of the Further Study Measure entitled "Enhancement to Energy Measures," the District will evaluate the cost-effectiveness of solar thermal technology for consideration as a potential solar hot water heating rule.

Purpose:
Promoting the production and use of renewable energy in the Bay Area will reduce the portion of fossil fuel-based energy needed to produce the electricity that the region consumes. This will, in turn, decrease the greenhouse gases and criteria pollutants emitted by combustion of fossil fuels.

Source Category Affected:
The emission sources affected by this measure are primarily natural gas combustion associated with electricity production for commercial and residential buildings and industrial facilities.

Regulatory Context and Background:
The California Global Warming Solutions Act, or AB32, signed into law in 2006, requires the State of California to reduce greenhouse gas emissions to 1990 levels by 2020. In support of this goal, the California Air Resources Board "encourages local governments to adopt a reduction goal for municipal operations emissions and move toward establishing similar goals for community emissions that parallel the State in commitment to reduce greenhouse gas emissions by approximately 15 percent from current levels by 2020." According to the Air District's 2008 Source Inventory of Bay Area Greenhouse Gas Emissions, approximately fifty percent of the region's greenhouse gas emissions are produced through energy used in residential and commercial building, industrial facilities and electricity generation. The Bay Area can not meet the challenge of AB32 without reducing energy use and/or using renewable energy in buildings and industry.

There are two primary approaches to increasing renewable energy: change the fuel mix from which grid-tied electricity is produced; or replace grid-tied electricity with 100% renewable electricity produced through distributed generation such as solar panels, micro wind turbines, or onsite cogeneration.

Changes to the electricity fuel mix are most efficiently made upstream, at the utility level. The State of California has an aggressive "renewable portfolio standard" that requires publicly-held electric utilities to provide electricity that is produced from 20% renewable energy sources by 2010. The AB32 Scoping Plan adopted by the California Air Resources Board calls for this renewable energy target to increase to 33% by 2030.

A downstream approach to increasing the use of renewable energy is to promote non-fossil fuel-based energy technologies, such as solar thermal panels, solar photovoltaic (PV) panels, cogeneration systems that use waste heat or waste methane, micro-sized wind turbines, etc.

Implementation Actions:
Control measure consists of two components:

- Promote renewable energy sources in new developments and redevelopment projects as an emissions offset option included in both the District's new Indirect Source Review Rule, and as a mitigation measure within the CEQA process (promoted, in part, through the District's CEQA Guidelines)
- Foster innovative renewable energy projects and approaches through existing and new incentive programs (e.g. expand the Berkeley FIRST program, replicate Solar Sonoma County's streamlining of incentives policies)

Emission Reductions:
Currently, the Bay Area has 132 megawatts (MW) of installed solar power. The California Public Utilities Commission oversees the California Solar Initiative, which has a statewide program goal of installing 3,000 MW of new solar power by 2020. Current statewide capacity is 515 MW, reflecting a 482% increase over current capacity. Applying this increase to current Bay Area capacity would indicate that by 2020, installed capacity in the Bay Area would be in the neighborhood of 636 MW.

It is estimated that the implementation actions in this control measure would increase installed solar capacity in the Bay Area by approximately 1-5% above and beyond the goals set by the California Solar Initiative. This would result in additional installed capacity of 64 MW, which would offset grid-tied electricity.

Emission reductions are in short tons/day (metric tons/day for CO2)

Solar Capacity Increase	Annual MW	MT CO2	PM10	PM2.5	ROG	NOx	SO2	CO
10% by 2020	64	0.05	<.01	<.01	<.01	<.01	<.01	<.01

How Emission Reductions were Estimated:
Factors for greenhouse gas emissions from electricity use are based solely on the amount of electricity used. Factors for criteria air pollutant emissions, on the other hand, are based not just on the amount of energy used, but also on the specific technology being utilized at the power plant. Therefore, it is far more complicated to develop an emissions factor for criteria pollutants, and the numbers in the table above should be treated as general estimations and not specific projections.

Coefficients to translate electricity use into CO2 emissions were taken from the California Climate Action Reserve General Reporting Protocol, version 3.1. Electricity coefficients for PM, ROG, NOx, SO2 and CO were derived by Air District staff based on regional averages of emissions factors from power plants in the region.

The 10% estimate for increased solar capacity is a conservative estimate which draws from the results to date from local solar promotion programs.

Exposure Reduction:
This measure could help to reduce exposure in impacted communities that are located near power plants, particularly "peaker plants", due to the switch in electric load from grid-tied to distributed electricity generation.

Emission Reduction Trade-offs:
Emissions are created through the production and transport of renewable energy technologies (solar PV panels, etc.). Life-cycle criteria pollutant and other emissions, such as sulfur dioxide, nitrogen oxide and lead, associated with solar panels are due primarily to raw material extraction and energy consumption in the manufacturing process.

Cost:
The cost of renewable energy can vary widely, depending on available rebates, tax credits and other incentives, the energy needs of the building, and other factors. The payback period for solar PV systems is long (approximately 15-20 years), but may decrease if net metering laws change (see discussion on AB 560 below). In addition, innovative financing strategies such as the Berkeley FIRST model, have emerged which can reduce or negate the need for upfront capital investments on the part of building owners.

The cost of including onsite renewable energy generation in buildings would be born by building and property owners. Potential long-term savings would accrue to property owners as well. In the example below outlining the cost and savings of a typical 2.5 kW PV system, the payback period is approximately 19 years.

Net cost of solar 2.5 kW PV system

	Costs/Credits	Balance	10% increase (25,600 systems)	Annual cost over 10 years
Up-front capital cost	$20,000	$20,000	$512,000,000	
State rebate	-$6,500	$13,500		
Federal tax credit	-$4,050	$9,450		
Final cost		$9,450	$241,920,000	$24,192,000

Savings

	2.5 kW system	10% increase (25,600 systems)
Annual electricity savings	4,000 kWh	102,400 MWh
Average cost per kW	12.5 cents	
Annual cost savings	$500	$12,800,000
Annual cost (over 10 years)	$945	$24,192,000
Annual net cost	$445	$11,392,000

Applying these cost and savings figures to the region-wide program outlined in this control measure would result in a total net cost of $11,392,000.

Co-benefits:
Replacing grid-tied electricity with renewable energy brings a number of co-benefits to a community, including:

- improved air quality near power plants (due to reduced production)
- Increased reliability of power supply and cost
- energy savings, including savings by reducing distribution losses between power plants and the end user
- financial savings through reduced energy usage
- green job creation (local manufacturers/suppliers/contractors for installing technologies – e.g., the world's largest solar cell manufacturer is in Palo Alto)

Monitoring Mechanisms:
The Air District will use existing staff resources to track the amount of solar PV and solar thermal capacity installed in the Bay Area by monitoring organizations which report on these statistics, such as the PUC and the California Solar Initiative.

Issues/Impediments:
It is not anticipated that there would be significant impediment to the voluntary approach described in component (1). Significant impediments to implementation of the incentive-based component to this control measure (2) are not anticipated, however, provision of financial incentives would be dependent upon the availability of adequate financial resources.

AB 560 and Net Metering: Under net-metering, the electric utility is required to "buy back" any electricity generated by a customer-owned generator as measured by an electric meter that can measure the flow of electricity in both directions. At the end of the year, the electric utility calculates the amount of electricity distributed to the grid by the customer and reduces the customer's annual bill by the amount of electricity generated by the customer. In California, utilities currently only have to offer net metering until the load served by net metering represents 2.5% of the utilities' total load. This limitation creates a general impediment to widespread installation of solar power by limiting its cost-effectiveness. Pending legislation in the State Assembly, AB 560, would increase the current cap on the amount of electricity that

can be generated under net metering from 2.5% to 10% of each utility's aggregate peak demand.

Sources:

1. "Source Inventory of Bay Area Greenhouse Gas Emissions", Bay Area Air Quality Management District, December 2008.
2. "Emissions from Photovoltaic Life Cycles", V.M. Fthenakis, H.C. Kim, and E.A. Alsema, *Environmental Science and Technology*, 2008.
3. AB560 Bill Analysis, California State Legislative Council
4. http://www.cpuc.ca.gov/PUC/energy/Renewables/
5. http://www.oregon.gov/ODOT/HWY/OIPP/docs/solar_panel_lifecycle.pdf
   http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_0551-0600/ab_560_cfa_20090508_122502_asm_floor.html

ECM 3 - Urban Heat Island Mitigation

Brief Summary:
The control measure includes regulatory and educational approaches to reduce the "urban heat island" (UHI) phenomenon by increasing the application of "cool roofing" and "cool paving" technologies.

Purpose:
The purpose of this control measure is to mitigate the urban heat island phenomenon. Reducing UHI effects can help to reduce ozone levels, as well as emissions of particulate matter (PM), air toxics and greenhouse gases related to energy consumption for air conditioning and cooling. In addition, it can help to offset temperature increases related to global warming.

Source Category Affected:
The sources of emissions affected by this control measure are primarily associated with electricity generation for buildings and evaporative emissions from automobiles.

Regulatory Context and Background:
As urban areas develop, natural, permeable surfaces and vegetation are replaced by impermeable structures and paved surfaces. This development transforms the area into a drier micro-environment, which absorbs, rather than reflects, the heat of the sun. Thus, urban heat islands are created, which can be up to 10^0 F hotter than natural background temperatures. Factors that contribute to UHI formation include the following:

- Many man-made surfaces are composed of dark materials that absorb and store the sun's heat.
- Buildings, industrial processes, motor vehicles and people produce anthropogenic heat.
- Loss of trees and vegetation due to urbanization causes a reduction in cooling from evapo-transpiration.
- Urban structures can form canyons that reduce ventilation and trap heat.

Elevated temperatures caused by UHIs can accelerate the formation of ground level ozone, or smog, and can contribute to adverse health impacts, such as respiratory and heat-related ailments. Higher temperatures can also result in increased electricity use to cool buildings. Mitigation methods include increasing the reflectivity of built surfaces, such as roads, parking lots and rooftops, increasing tree-cover and natural vegetation (for shading and the cooling effect of evapo-transpiration), and increasing ventilation.

Cool Paving: On average, about 12% of an urban city's land area is devoted to parking lots. This number can be even higher in suburban communities.

Many parking lots are resurfaced every 5-10 years. The amount of parking lot construction and re-surfacing that occurs in the Bay Area provides a significant opportunity to substantially

increase albedo (reflectivity) while providing ancillary benefits such as an extended life of the paved surface and storm water benefits associated with use of porous paving.

The hottest pavements tend to be impermeable and dark in color, with solar reflectance values (albedo) under 25%. These pavements can heat to 150^{o}F or more on hot days. Utilizing cool paving techniques can reduce this temperature by 30^{o}F or more. There are two ways to make pavements cooler: 1) by increasing albedo, and 2) by increasing their ability to store and evaporate water.

Cool Roofs: Most existing flat roofs have an albedo (reflectivity) of only 10 to 20 percent of sunlight. These roofs absorb much of the remaining solar radiation and heat up the buildings they cover. Cool roofing technologies, such as lighter or more reflective paint, coatings, membranes, shingles or tiles, can increase a roof's albedo, on average, to about 50-60%. A 2000 study by Lawrence Berkeley National Laboratory revealed a 13-18% reduction in air conditioning-related electricity use in residential and commercial buildings in San Jose due to the application of cool roof strategies.

While cool roofing reduces the need for air conditioning during periods of heat, it can have an opposite impact during periods of cold by reflecting solar radiation away from the buildings, requiring an increase in heating during winter months. In most locations, the balance of these two effects results in a net reduction in energy use. However, in some locations, there may not be an energy reduction benefit from the application of cool roof technologies. Air District staff will continue to follow research efforts in this area.

Implementation Actions:
Control measure consists of the following components:

- Promote building code requirements for new construction or re-roofing/roofing upgrading for commercial and residential multi-family housing to meet specific "cool roof" standards.
- Include minimum "cool roof" standards for new commercial and residential multi-family housing construction and re-roofing or roofing upgrades in specified areas as mitigation measures under the District's CEQA Guidelines and ISR rule.
- Develop and promote adoption of a model zoning ordinance for "cool paving" standards to be met when existing parking lots undergo re-surfacing.
- Provide training for public works staff and private construction/paving companies on benefits of and how to meet new cool paving standards.
- Encourage construction of new and re-surfacing of existing parking lots and other paved surfaces to meet minimum reflective and permeable surface standards by including this as a mitigation measure under the District's CEQA Guidelines and ISR rule.
- Perform outreach to cities and counties to make them aware of the benefits of cool roofing and cool paving, and of new tools available.
- Provide training for building inspectors on benefits of and how to meet new cool roofing standards.

Emission Reductions:
Lawrence Berkeley National Laboratory's (LBNL) Heat Island Group conducted a study of the impacts that surface lightening of rooftops and pavement, combined with tree shading, might have on the Los Angeles air basin. The study found that the widespread application of these combined activities could achieve a decrease in ambient air temperature of 3°C (5.4°F). Half of this temperature reduction is due to albedo (roofs and pavement) and half to trees.

While no similar study has been conducted for the Bay Area, the results can be applied to similar temperature zones, such as San Jose and the Diablo Valley. This reduction in ambient air temperature would result in a reduction in electricity use to cool buildings. While no empirical studies have been conducted for the Bay Area, studies of individual buildings by LBNL, the Florida Solar Energy Center, and others have shown that energy savings on the order of 20% to 30% are commonly achieved with a cool roof surface.

Contra Costa County, Napa County, Santa Clara County and approximately half of Solano County are expected to be the most appropriate locations for applications of cool roofs in the Bay Area Air Quality Management District's jurisdiction due to their warmer temperatures and higher use of air conditioning. It is assumed that cool roofs in these counties would reduce air conditioning-related electricity use by 20%.

Emission reductions are in short tons/day (metric tons/day for CO2)

Source Category	MWh	CO2 (MT)	PM10	PM2.5	ROG	Nox	SO2	CO
Electricity	80	23	0.015	0.15	<0.01	0.03	0.02	0.03

Emission Reduction Methodology:
Factors for greenhouse gas emissions from electricity use are based solely on the amount of electricity used. Factors for criteria air pollutant emissions, on the other hand, are based not just on the amount of energy used, but also on the specific technology being utilized at the power plant. Therefore, it is far more complicated to develop an emissions factor for criteria pollutants, and the numbers in the table above should be treated as general estimations and not specific projections.

Coefficients to translate electricity use into CO2 emissions were taken from the California Climate Action Reserve General Reporting Protocol, version 3.1, using the most recently CCAR-approved coefficient for PG&E (for year 2007). Electricity coefficients for PM, ROG, NOx, SO2 and CO were derived by Air District staff based on regional averages of emissions factors from power plants in the region.

Estimations for electricity used for air conditioning in the selected counties was taken from the Energy Information Administration's (EIA) 2001 Residential Buildings Energy Consumption Survey and the California Energy Commission's (CEC) 2006 California Commercial End-Use Survey. Data on energy consumption by county and by sector from the CEC's Energy

Consumption Data Management System was used to estimate the amount of electricity used for air conditioning that occurred in these counties.

Exposure Reduction:
This measure would help reduce smog formation by reducing the ambient air temperature, particularly in areas that experience excessive heat. It would be especially effective in reducing population exposure in those areas of the Bay Area that experience higher daily ambient temperatures, like San Jose, Concord, and San Leandro/East Oakland.

Emission Reduction Trade-offs:
It is unlikely that this measure would increase any emissions appreciably. However, caution would have to be taken in compiling the technology specifications to ensure that products that could produce toxic emissions during their use are not recommended.

Cost:
Cool roofs deflect some desired heat gain during the winter. In general, though, cool roofs result in net energy savings, especially in areas where electricity prices are high.

Although costs will vary greatly depending on location and local circumstances, the cost premium for cool roofs versus conventional roofing materials ranges from zero to 5 or 10 cents per square foot for most products, or from 10–20 cents for a built-up roof with a cool coating used in place of smooth asphalt or aluminum coating.

A California study found that cool roofs provide an average yearly net savings of almost 50 cents per square foot. This number includes the price premium for cool roofing products and increased heating costs in the winter as well as summertime energy savings, savings from downsizing cooling equipment, and reduced labor and material costs over time due to the longer life of cool roofs compared with conventional roofs.

A 2007 study titled "California Rooftop Photovoltaic (PV) Resource Assessment and Growth Potential by County," conducted by Navigant Consulting for the CEC's PIER program provided estimated roof space for the residential and commercial sectors within the selected counties. An estimated cost of 10 cents per square foot was used to calculate the cost of applying cool roof technologies to this potential roof space. Assuming a cool roof penetration program rate of 10%, we estimated upfront capital cost of $7,600,637 for the residential sector and $2,311,504 for the commercial sector.

	Residential	Commercial	Total
Upfront Capital Costs	$7,600,637	$2,311,504	$9,912141
Annual Savings	$38,003,185	$11,557,521	$49,560,706
Net Annual Savings	$30,402,548	$9,246,017	$39,648,565

To estimate the electricity cost savings that would be achieved in the residential sector, we again reference the California Energy Commission's Energy Consumption Data Management

System for the amount of expenditures in California for electric Air Conditioning in 2007. This was then scaled down based on the share of statewide electricity used by the selected counties, and reduced by 80% to arrive at the amount of electricity use that would be avoided by cool roofs. We largely used the same methodology for the commercial sector, except that we did not have actual expenditure data. Instead, we consulted the Energy Information Administration's Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State report to find the average retail price of electricity. This was then applied to the scaled down air-conditioning electricity consumption data.

Co-Benefits:
Heat island mitigation measures bring a number of co-benefits to a community, including:
- improved air quality
- improved public health (lower risk of respiratory and heat-related ailments)
- energy savings
- financial savings through reduced energy usage
- green job creation (local suppliers/contractors for installing technologies)

Monitoring Mechanisms:
Monitoring and evaluating progress could include:
- Tracking how many cool roof building codes are adopted
- Measuring increases in square footage of cool roofs, both in new construction and existing buildings
- Measuring increases in square footage of cool parking lots

Issues / Impediments:
Advocating for building code requirements that include "cool roof" standards for re-roofing/roofing upgrades may raise concerns about a potential increase in up-front costs among some stakeholders, such as the construction and development industries or local governments. Similar requirements for "cool paving" may also raise concerns due to a lack of information on the availability and sourcing of these technologies and products. By promoting and encouraging adoption of these types of policies, the Air District will facilitate demonstration of the actual cost benefits of such policies and work toward overcoming these barriers.

Sources:
1) Cool Houston: A Plan for Cooling the Region (2004)
2) Heat Islands: Understanding and Mitigating Heat in Urban Areas; Gartland (2008)
3) California Energy Commission, http://www.energy.ca.gov/title24/coolroofs/
4) http://www.energy.ca.gov/title24/coolroofs/documents/QUESTIONS-ANSWERS_BUILDING-OWNERS.PDF
5) USEPA, http://www.epa.gov/heatisland/
6) Consumer Energy Center, http://www.consumerenergycenter.org/coolroof/faq.html#faqs-04

7) Cool Roof Rating Counsel, http://www.coolroofs.org/coolroofing.html; http://www.autolife.umd.umich.edu/Environment/E_Casestudy/E_casestudy2.htm; http://www.concretenetwork.com/pervious/environ_benefits.html
8) California Energy Commission. Energy Consumption Data Management System. Available online: http://ecdms.energy.ca.gov/elecbycounty.aspx
9) Energy Information Administration, 2001. Residential Buildings Energy Consumption Survey (RECS), Consumption and Expenditure Data Tables. Available online: http://www.eia.doe.gov/emeu/recs/recs2001_ce/2001tblce.html
10) California Energy Commission, March 2006. California Commercial End-Use Survey. Publication # CEC-400-2006-005, Table 8-2, p.153. Available online: http://www.energy.ca.gov/ceus/
11) Navigant Consulting, Inc. 2007. California Rooftop Photovoltaic (PV) Resource Assessment and Growth Potential by County, California Energy Commission, PIER Program. CEC-500-2007-048. Available online: https://norman.baaqmd.gov/exchweb/bin/redir.asp?URL=http://www.energy.ca.gov/2007publications/CEC-500-2007-048/CEC-500-2007-048.PDF
12) Energy Information Administration, November 2009. Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, Available online: http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html

ECM 4 - Shade Tree Planting

Brief Summary:
The control measure includes voluntary approaches to reduce the "urban heat island" phenomenon by increasing shading in urban and suburban communities through planting of (low VOC-emitting) trees and preservation of natural vegetation and ground cover.

Purpose:
The purpose of this control measure is to reduce ozone precursors, criteria pollutants (ozone, NO_2, PM10, SO_2) and greenhouse gases by mitigating the urban heat island phenomenon.

Source Category Affected:
The sources affected by this control measure include electricity generation as well as evaporative emissions from mobile sources.

Regulatory Context and Background:
As discussed in the Urban Heat Island control measure, due to their impermeable structures and paved surfaces, as well as a lack of vegetation, urban areas tend to absorb, rather than reflect, the sun's heat. These urban heat islands can be up to 10^0 F hotter than natural background temperatures. These elevated temperatures can accelerate the formation of ground level ozone, or smog. They can also result in increased electricity use to cool buildings. In addition, parked cars can release emissions from the vehicle's carburetor or fuel system. These "evaporative emissions" increase as ambient temperatures rise.

Planting trees through a comprehensive urban forestry program that includes goal-setting and ongoing management of the urban tree canopy can mitigate the urban heat island phenomenon and conserve energy use in three principal ways:

- Shading reduces the amount of the sun's energy absorbed and stored by built surfaces
- Transpiration converts moisture to water vapor and thus cools by using solar energy that would otherwise result in heating of the air
- Wind-speed reduction reduces the movement of outside air into interior spaces and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows)

In addition, urban trees provide the following air quality and climate protection benefits:

- Absorbing gaseous pollutants (ozone, nitrogen oxides) through leaf surfaces
- Absorbing CO2 (carbon sequestration)
- Intercepting particulate matter (e.g., dust, ash, dirt, pollen, smoke)
- Reducing emissions (GHGs and criteria pollutants) from power generation by reducing energy consumption

- Releasing oxygen through photosynthesis
- Reduce evaporative emissions in parking lots
- Street trees also enhance conditions for pedestrians and cyclists, thus supporting alternatives to the automobile.

The Sacramento Municipal Utility District (SMUD) shade tree program has a goal to plant 500,000 trees in Sacramento. The tree planting program was found to produce net benefits from air conditioning savings. Three scenarios were assumed (base, highest, and lowest benefits) based on the SMUD program and a Best Available Control Technology cost analysis was performed to determine if shade trees planted in residential yards can be a cost effective means to improve air quality. Annual planting and maintenance costs, pollutant deposition, and biogenic hydrocarbon emissions were estimated over a 30-year period with existing models.

Some tree species emit volatile organic compounds, or VOCs, which contribute to the formation of ground level ozone, particularly in hot weather. It is important for tree planting programs to carefully select the species to be planted, opting for low VOC-emitting species.

Implementation Actions:
Control measure consists of the following components:

- Include tree planting standards for new developments in specified areas as mitigation measures under the District's CEQA Guidelines and ISR rule
- Promote adoption of a model municipal tree planting ordinance, including tree planting in parking lots
- Provide information via outreach materials, presentations and workshops to local government planning and public works department staff on how to maximize air quality, GHG and public health benefits of municipal tree planting programs, including promoting the Bay-Friendly Landscape Guidelines
- Provide information on and encourage the use of low VOC-emitting tree species for new planting and, as appropriate, replanting
- Monitor the outcomes and findings of current tree planting programs, such as the Air District Climate Protection Grant to Urban ReLeaf for tree planting and air quality monitoring in West Oakland.

Emission Reductions:
Implementation actions #1 (include as mitigation options under CEQA and ISR) and #2 (promote municipal tree planting ordinances) are estimated to increase the Bay Area's tree canopy by 1% over the next 10 years, from the current 29% of land cover to 30%.

Increase in Canopy cover (%)	Canopy cover (%)	# of Trees	Increase in # of Trees
Baseline = 0	29	41,172,735	0
Ten year goal = 1	30	42,593,715	1,420,980

The table below illustrates the annual energy savings and emission reduction benefits of planting an average medium sized deciduous tree, in this case a Cherry Plum tree, in a residential neighborhood. Benefits are given for 1,420,980 ten year old trees (representing a 1% increase in existing tree canopy).

Emission reductions are in short tons/day (metric tons/day for CO2)

	MWh	CO2 (MT)	PM10	PM2.5	ROG	NOx	SO2	CO	BVOCs
Benefits for 1,420,980 trees	85,259	67.56	0.04	0.04	<0.01	0.07	0.062	0.09	-0.002

Emission Reduction Methodology:
Even low-voc trees will result in some release of biogenic VOC. This has been factored into the emission reduction estimates, and these emissions are listed as BVOCs in the table above.

The 1% target for increasing tree canopy is a more conservative, reduced target taken from the report, *"State of the Urban Forest: San Francisco Bay Area Progress Report"*, published by the Center for Urban Forest Research in 2007. This report examines a 3% increase in tree cover. Estimated energy savings were also taken from this report. In quantifying the emission reductions from this measure, coefficients to translate electricity into CO2 emissions were taken from the California Climate Action Reserve General Reporting Protocol, version 3.1. Electricity coefficients for PM, ROG, NOx, SO2 and CO were derived by Air District staff based on regional averages of emissions factors from power plants in the region.

Exposure Reduction:
This measure would reduce smog formation by reducing the ambient air temperature, particularly in areas that experience excessive heat. The measure would also reduce local air pollution by decreasing the accumulation of ozone precursors and PM due to the absorptive ability of trees.

Emission Reduction Trade-offs:
Caution must be taken in compiling the list of recommended species for planting to ensure that only low-VOC emitting trees are recommended. Planting deciduous trees ensures that there is no cooling dis-benefit in cooler months.

Cost:
According to the report, "*City of Berkeley, California Municipal Tree Resource Analysis"*, prepared by the Center for Urban Forest Research in 2005, the energy reduction benefits of the City of Berkeley's tree planting program are approximately $15 per tree. Applying these benefits and costs to the Bay Area as a whole (and planting a total of 1,420,980 trees) creates the following results:

	Per Tree	Total(1)
Total benefits	$15	$21,314,700
Total costs	$65	$92,363,700
Net cost	$50	$71,049,000
Cost-benefit ratio	4.3	

1. This table represents the benefits and costs of planting 1,420,980 trees in the Bay Area.

In this analysis, benefits come from reduced net energy use due to shading.

Co-Benefits:
Tree planting brings a number of co-benefits to a community and the region.

Regional benefits:
- reduced urban heat island effect
- improved air quality
- improved public health (lower risk of respiratory and heat-related ailments)
- green job creation (tree planting and maintenance)

Local benefits:
- reduced energy use in buildings
- financial savings through reduced energy usage
- reduced storm water run-off
- increased community livability/quality of life
- enhanced bike and pedestrian environments
- increased property values

In the *"State of the Urban Forest: San Francisco Bay Area Progress Report"*, the Center for Urban Forest Research estimates that approximately 90% of the monetary benefits achieved by urban tree planting programs are due to increased property values.

Monitoring Mechanisms:
Monitoring and evaluating progress will be done by:
- Tracking local tree planting ordinances and tree planting programs

Issues/Impediments:
Due to the voluntary nature of this measure, significant impediments to implementation are not anticipated.

Sources:
1) *Cool Houston: A Plan for Cooling the Region* (2004)
2) *Heat Islands: Understanding and Mitigating Heat in Urban Areas*; Gartland (2008)

3) "Estimating Cost Effectiveness of Residential Yard Trees for Improving Air Quality in Sacramento, California, Using Existing Models," E. Gregory McPherson, Klaus I. Scott, James R. Simpson, USDA Forest Service, Pacific Southwest Research Station, Davis, CA, October 1997.
4) "City of Berkeley, California, Municipal Tree Resource Analysis," Scott E. Maco, E. Gregory McPherson, James R. Simpson, Paula J. Peper, Qingfu Xiao, USDA Forest Service, Pacific Southwest Research Station, Davis, CA, March 2005.
5) *"State of the Urban Forest: San Francisco Bay Area Progress Report,"* Jim Simpson, Greg McPherson, Chad Delany, Center for Urban Forest Research, USDA Forest Service, PSW Research Station, Davis, CA; June 20, 2005.
6) *"Actualizing microclimate and air quality benefits with parking lot tree shade ordinances,"* McPherson, E.G., J.R. Simpson and K.I. Scott. 2001.
7) *Parking Lot Shading Guidelines*, City of Davis Municipal Code, Section 40.25.100,
8) California Energy Commission, http://www.energy.ca.gov/title24/coolroofs/; http://www.energy.ca.gov/title24/coolroofs/documents/QUESTIONS-ANSWERS_BUILDING-OWNERS.PDF
9) USEPA, http://www.epa.gov/heatisland/
10) Consumer Energy Center, http://www.consumerenergycenter.org/coolroof/faq.html#faqs-04
11) Cool Roof Rating Counsel, http://www.coolroofs.org/coolroofing.html
12) http://www.autolife.umd.umich.edu/Environment/E_Casestudy/E_casestudy2.htm
13) http://www.concretenetwork.com/pervious/environ_benefits.html