URBAN HEAT ISLAND MITIGATION:
An innovative way to reduce air pollution and energy usage

Guidance and Resources for Valley Businesses, Local Government, and Residents

HEALTHY AIR LIVING™

March 17, 2011

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URBAN HEAT ISLAND MITIGATION

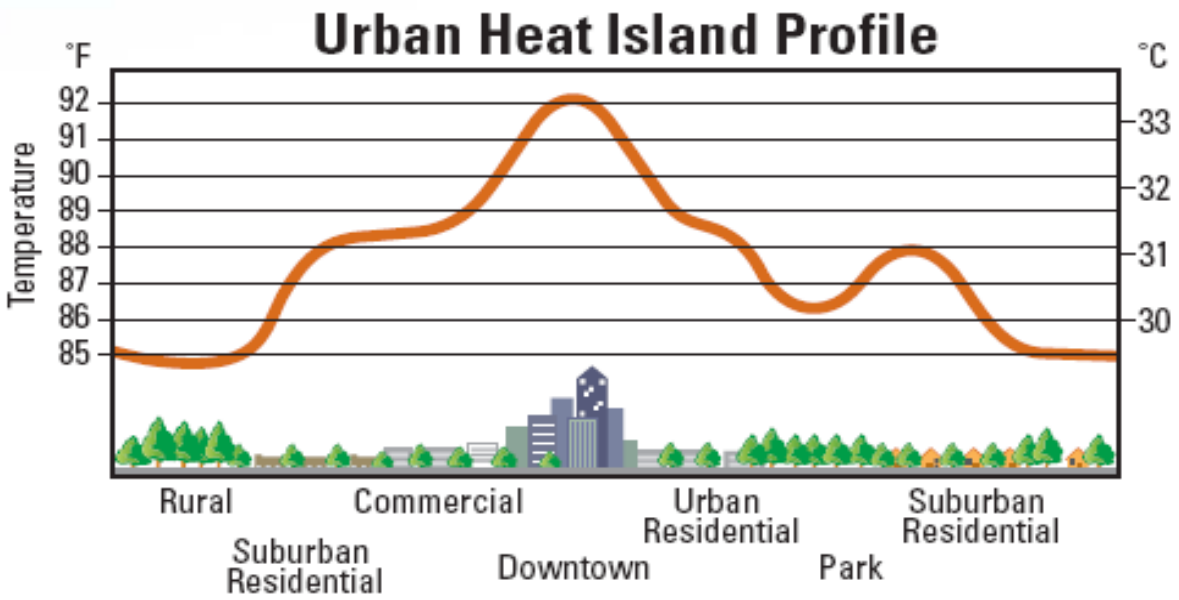
Valley residents, businesses, and municipalities can get involved in air quality improvements in a number of ways. By taking proactive steps to reduce urban heat islands, we can decrease ozone formation and reduce energy consumption. This document outlines simple, turn-key steps organizations can take to reduce urban heat island effects in the Valley. Furthermore, many of these options have additional benefits, saving money while contributing to improved public health.

Background

Despite major reductions in emissions that have significantly improved air quality, the San Joaquin Valley continues to face difficult challenges in meeting the federal ambient air quality standards. The District's Fast Track Action Plan, adopted to support the *2007 Ozone Plan,* identifies Heat Island Mitigation as a potential source of ozone emissions reductions to contribute to the Valley's progress toward health-based air quality standards. Higher temperatures attributed to the urban heat island effect increase the likelihood of NOx and VOCs forming smog, which has serious health consequences. Ozone can inflame the respiratory tract and increase the lungs' susceptibility to infections, allergens, and other air pollutants. Urban heat island mitigation is one way to help achieve more emissions reductions and improve air quality and public health.

What is an urban heat island?

Pavement, dark-colored roofs, and similar surfaces absorb more sunlight, trap heat, and increase local temperatures. Urban areas tend to have more roads, buildings, and parking lots and less green space. The high concentration of these heat-absorbing surfaces creates an isolated area where higher temperatures are more likely. Studies have documented that urban areas have air and surface temperatures that are, on average, 1.8 – 5.4°F higher than temperatures in surrounding rural areas, and there is potential for up to a 22°F difference in more extreme situations (EPA-RUHI, 2010).

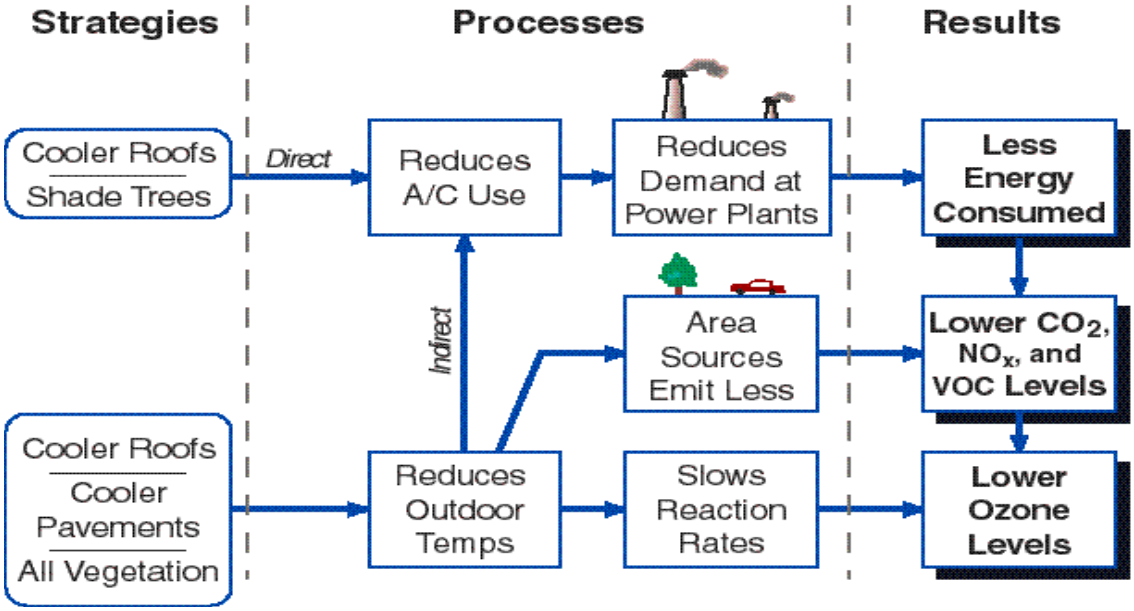


Source: US EPA Cooling Summer Temperatures: Strategies to Reduce Urban Heat Islands Brochure

How do urban heat islands affect air quality?
One way that higher temperatures in urban heat islands can affect air quality is by increasing ozone, commonly known as smog, formation rates. Ozone forms from chemical reactions of precursors such as volatile organic compounds (VOC) and oxides of nitrogen (NOx) in the presence of heat. In general, increased temperatures lead to increased ozone levels. The San Joaquin Valley, which records very high temperatures in the summer, also experiences high ozone levels in the summer. Reducing urban heat island effects can therefore contribute to decreased ozone levels.

Another way that higher temperatures in urban heat islands can affect air quality is by increasing energy consumption, which increases emissions of ozone precursors. On hot summer days, people use air conditioning units, fans, and evaporative coolers more, requiring more energy production. Power companies bring peaker unit generating stations online to meet spikes in electricity demand. These peaker units emit particulate matter (PM) and ozone precursors.

The Valley has historically experienced some of its highest ozone levels on hot summer days. Urban areas have also experienced some of the highest ozone levels due to the higher density of emissions sources, including mobile sources. The additional peaker unit emissions and the higher urban heat island temperatures exacerbate the Valley's existing ozone concerns.



Picture: Emissions Benefits of Heat Island Mitigation Measures
Source: Energy Savings Potentials and Air Quality Benefits of Urban Heat Island Mitigation by Hashem Akbari

Strategies for mitigating urban heat island impacts
This document highlights four main strategies for reducing urban heat island impacts:

- Trees and vegetation
- Cool Roofs
- Light Pavement
- Green Roofs

Each section of this document provides the costs, air pollution benefits, additional benefits, templates, and examples of each of these mitigation areas. At the end of the document, a model policy statement is presented for organizations who wish to take leadership roles. Also presented are a checklist of urban heat island mitigation measures and a resolution for HAL Business Partners.

Research shows that there are significant benefits from mitigating heat islands. For example, Lawrence Berkeley National Laboratory's (LBNL) *Heat Islands* project found that Sacramento buildings with cool roofs used up to 40% less energy for cooling than those with darker roofs (LBNL Heat Island Group, 2010). Research shows that trees can cool air temperature by approximately 3.6°F to 7.2°F more than neighborhoods with less tree coverage. Temperatures decrease by approximately 1.8°F per 10% canopy cover (Huang et al. 1987).

Studies have also shown that a combination of mitigation measures can be very effective. A recent UC Davis study projected that the city of Fresno, with a moderate implementation of urban heat island mitigation measures, would see a temperature decrease of approximately 1.3°F and a corresponding 8-hr ozone level decrease of 1.5 parts per billion (ppb) on hot summer days. With more extreme implementation of mitigation measures, the city of Fresno could achieve a temperature decrease of 4.5°F and a maximum corresponding decrease of 7 ppb in 1-hr ozone levels and 5.5 ppb in 8-hr ozone levels (Cook, Fang, Smith, Williams, 2010). These potential decreases could play an important role in helping the Valley achieve the federal 8-hour ozone standard of 84 ppb and the more stringent standards expected in future years.

Table 1: Cooling Potential and Costs from Mitigation Measures

Mitigation Measure	Cooling Potential	Cost	Additional Benefits
Vegetation	1 - 9°F	$15- $65 per tree each year	Aesthetics
Cool Roofs	0.6 - 1.4°F	0 - 7% higher than conventional roofing	Energy savings
Light Pavements	0.5 - 3°F	10 – 20% higher than conventional pavement	Water conservation
Green Roofs	0.2 - 3.5°F	88 – 93% higher than cool roofing	Roof endurance increased

* Please note that cooling benefits from combining heat island mitigation measures are not always additive.
** Information from table can be found in the EPA – Reducing Urban Heat Islands publication

How can you help?

As a Valley resident, business, or municipality, you can help improve the temperature and air quality in the San Joaquin Valley by adopting heat island mitigation practices. Planting more trees, installing light-colored roofs, installing a grass or gravel parking lot, or adopting a resolution committing to incorporating heat island measures into city plans and practices all contribute to lower Valley temperatures and decreased ozone formation.

How can the District help?
The District's ozone strategy is comprehensive and relies on all feasible precursor reductions. Because heat island mitigation is an important piece in the strategy, the District will:

- Provide a Policy Statement, the Recommended Objectives Checklist, and a Model Resolution to facilitate adoption and implementation of heat island mitigation programs and measures
- Actively seek out funding sources for opportunities to fund mitigation measures and innovative developments
- Support businesses, cities, and counties through the Small Business Assistance program available at (559) 230 - 5888
- Provide education opportunities through the Outreach and Communication program and the Healthy Air Living program (http://www.healthyairliving.com/)
- Be a constant resource for information about implementation of mitigation measures through staff assistance and information on the District website (http://www.valleyair.org/index.htm)

General Urban Heat Island Resources
EPA's Reducing Urban Heat Island Compendium of Strategies
http://www.epa.gov/heatisland/resources/pdf/BasicsCompendium.pdf

Lawrence-Berkeley Lab Heat Island Group
http://eetd.lbl.gov/HeatIsland/

EPA Science Corner – Heat Island Effect
http://www.epa.gov/heatisland/resources/reports.htm

EPA Heat Island Effect Resources
http://www.epa.gov/heatisland/resources/index.htm

Urban Heat Islands: Hotter Cities
www.actionbioscience.org/environment/voogt.html

TREES AND VEGETATION

Trees and vegetation help reduce the impacts of heat islands by increasing the amount of shade and cooling the air by evapotranspiration (McPherson, 1994). Careful placement and choice of vegetation will maximize its cooling benefits. Shade provided by trees and other vegetation prevents sunlight from reaching heat-absorbing surfaces such as sidewalks and parking lots, cooling the area by 1.0-9.0°F. Vines on or near building walls and ground cover and grass such as in a park or parking lot are other vegetation options that provide cooling benefits. Vegetation can also lower the cooling demand for a building by shading the walls from strong sunlight (EPA – RUHI, 2010).

Through the process of evapotranspiration, water stored in the leaves of plants and trees evaporates, dropping the temperature of the surrounding air (McPherson, 1994). Additional water is required for optimum cooling benefits from evapotranspiration, increasing maintenance costs and concerns of limited water resources. Because of the Valley's water limitations and other air quality concerns, new trees should be drought tolerant and low-VOC emitters. Low-VOC emitting trees ensure that an increase in vegetation does not increase ozone precursors here in the Valley.

Win-Win!

Trees and vegetation help to reduce pollution and…

- **Reduce energy costs**
- **Reduce greenhouse gases**
- **Increase property values**
- **Improve human health and comfort**

Where the measure has been put into practice

The City of Visalia requires trees along certain main roadways and medians. Implementation of the tree requirement increases the shade over the dark road pavements. The city also has tree planting requirement for streets that are part of new residential and commercial developments. For more information, visit: http://www.ci.visalia.ca.us/depts/parks_n_recreation/urban_forestry/street_tree_ordinance.asp

The City of Davis adopted standards in 2002 to protect certain tree species from removal, list approved tree species, and establish shade coverage for parking lots. Davis requires new and reconstructed parking lots to have 50% of the paved surface shaded after 15 years of growth. This is a good example of municipal initiative in helping minimize heat island impacts. For more information, visit: http://cityofdavis.org/cdd/pdfs/planning/forms/Parking_Lot_Shading_Guidelines.pdf

Air Pollution Benefits

Three strategically placed average shade trees can reduce annual energy use for cooling 10 to 50 percent and peak electrical use up to 23 percent (Simpson and McPherson, 1996). One study (Resenfeld et al., 1998) found that planting eleven million trees in the Los Angeles Basin would result in better and cooler weather, leading to $270 million in savings from energy and pollution decreases. Sacramento's Urban Forests for Clean Air analysis predicted that adding one million low-VOC trees to the region could reduce ozone formation by a total of

1.5 tons per day (tpd) and PM by 1 tpd. Greenhouse gas (GHG) reduction is another benefit, since one tree can reduce CO2 by 200 lbs annually through CO2 conversion to oxygen.

Air quality also benefits from a decrease in energy usage. The less energy used, the fewer peaker plants running and emitting ozone precursors. The total net savings when considering energy, ozone, and PM reduced from vegetation were valued at $210/tree EPA- RUHI, 2010)..

TREE PLANTING REMINDERS

For ultimate benefits, your tree should be a:

- ✓ **Low-pollen emitter**
- ✓ **Low- VOC emitter**
- ✓ **Drought tolerant**
- ✓ **Planted southwest of your home/building**
- ✓ **No more than 30-50 ft from your home/building**

Costs & Savings

Each tree's average cost is $15- $65 each year, including purchase, maintenance, and irrigation costs. The cost of a city or county tree planting program encompasses equipment costs, new tree, and maintenance such as pruning and watering.

Savings from trees and vegetation come from the decreased in energy used by businesses and individuals. In summertime, a building may see an energy savings of 7-47% because of tree shade. Because of energy and cooling savings for businesses and entire cities, tree programs have a cost benefit of $1.50 to $3.00 for every dollar invested. (EPA- RUHI, 2010).

Local Urban Forestry Programs

Tree Lodi http://www.treelodi.org/events.php

Tree Fresno http://www.treefresno.org/

Visalia Urban Tree Foundation and Tree Inventory
http://www.urbantree.org/treeinventory.asp
http://www.ci.visalia.ca.us/depts/parks_n_recreation/urban_forestry/default.asp

Tree Foundation of Kern http://www.urbanforest.org/

Master Gardeners of San Joaquin County
http://sjmastergardeners.ucdavis.edu/Tree_care_and_management/

Greater Modesto Tree Foundation http://www.treemodesto.org/

Tulare County CSET http://www.cset.org/services/communities/urban-forestry

Tree Selection and Low-VOC Options http://www.fs.fed.us/ccrc/topics/urban-forests/docs/Nowak_Trees%20for%20air%20quality.pdf page 4

Picture: Shade Trees in Fresno
Source: http://www.fresnobee.com/2010/08/05/2031976/one-year-later-some-eaton-plaza.html

Additional benefits of vegetation:

- **Pollutant removal through dry deposition on leaves**
- **Carbon storage and sequestration**
- **Reduced pavement maintenance**
- **Enhanced quality of life**

Current Funding Opportunities

On behalf of California Fire, the Strategic Growth Council (SGC) announced the Urban and Community Forestry Grants for the 2010/2011 fiscal year. These grants fund activities that expand urban forests and improve urban forest management and knowledge. Leafing Out is a similar program designed for communities and organizations that have smaller urban forestry projects. For more information visit:
http://www.fire.ca.gov/resource_mgt/resource_mgt_urbanforestry.php
http://www.ufei.org/grantinfo.lasso

Turlock Irrigation District is currently funding tree planting at new residential construction sites. Builders can receive $20 toward the cost of each shade tree (3 max) planted near a new home. For more information, visit http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA127F&re=1&ee=1 .

Other Resources

EPA's Reducing Urban Heat Island Compendium of Strategies – Trees and Vegetation
http://www.epa.gov/heatisland/resources/pdf/TreesandVegCompendium.pdf

Great Valley Center's Urban Forestry Guidebook for the San Joaquin Valley
http://www.greatvalley.org/artman2/uploads/1/urbanforestryguide.pdf

National Tree Benefit Calculator
http://www.treebenefits.com/calculator/treeinfor.cfm?zip=93710&city=FRESNO&state=CA&climatezone=Inland%20Valleys

A Technical Guide to Urban and Community Forestry
http://www.na.fs.fed.us/spfo/pubs/uf/techguide/toc.htm

NC State – List of Drought Tolerant Trees
http://www.ces.ncsu.edu/depts/hort/consumer/quickref/trees/droughttolerant.html

Urban Forest Model
http://www.ufore.org/

USDA- Urban Forest Tools
http://nrs.fs.fed.us/units/urban/pubs/tools/

COOL ROOFS

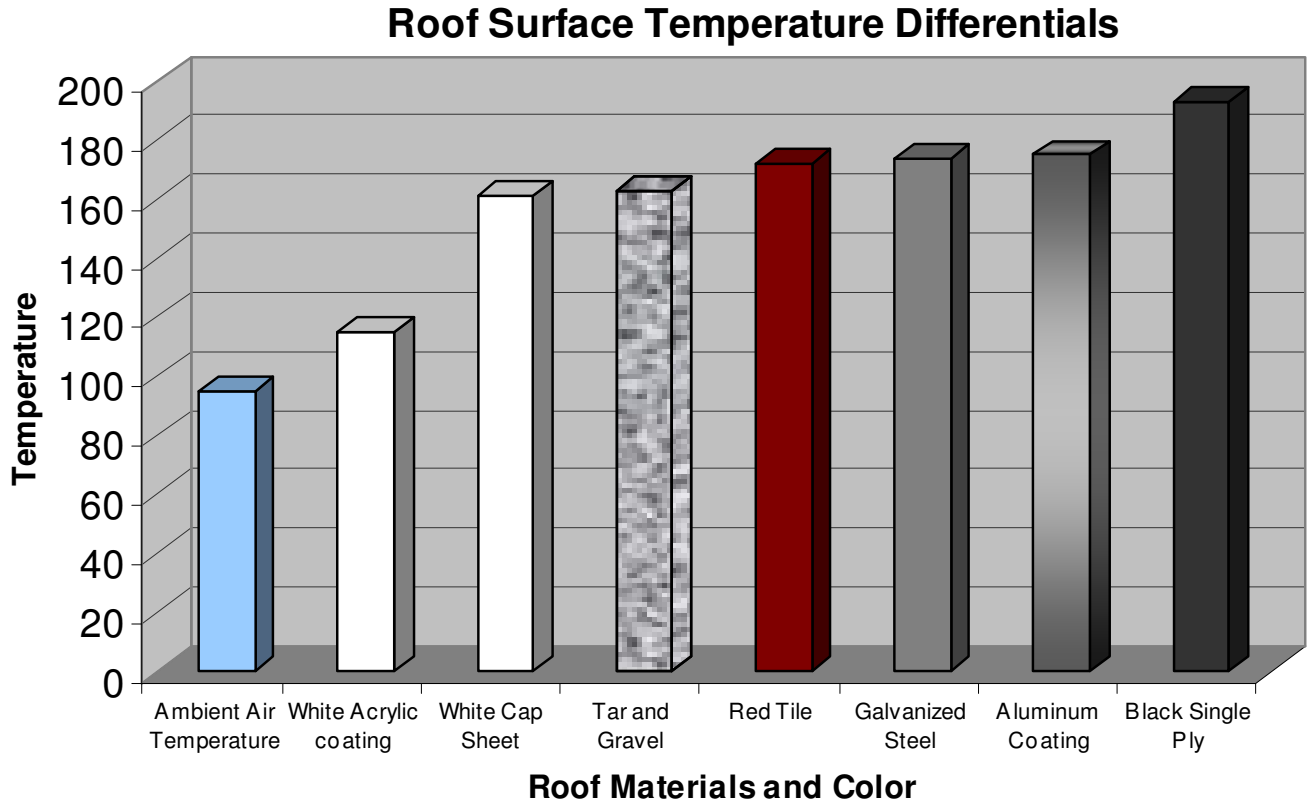
Cool roofs reflect sunlight instead of absorbing it into the roof material. In the summer, a typical roof reaches temperatures of 150 - 185°F. Light colored or highly-reflective shingles and roofing materials can stay within 10 - 20°F of the ambient temperature, instead of 55 - 85°F higher like most conventional roofs. These heat-deflecting roofing materials help cool the surrounding temperature and decrease the amount of energy used for cooling.

Win-Win!

Cool Roofs help to reduce pollution and…

- **Reduce energy costs**
- **Reduce greenhouse gases**
- **Increase property values**
- **Reduce peak-time energy usage**

A variety of cool roof options are available, depending on whether the roof is low-sloped or steep-sloped. Cool roof coatings, ideal for repair projects, are composed of cement particles or polymers and have an albedo of 0.65 or higher. Albedo is defined as the potential a surface has to reflect ultraviolet rays, instead of absorbing them and increasing the heat of the surface. Single-ply membranes, used for cool roof new construction or extensive repair projects, are sheets of synthetic rubber or plastic polymer that are glued and fastened to the roof surface.



Source: information from http://www.cooltexasbuildings.net/images/

Steep-sloped roofs use shingles, metal roofing, tiles and shakes, each having a high reflectivity option. Energy STAR roof materials have a 0.25 – 0.9 reflectivity, depending other whether the material base is asphalt, clay, or metal. Installation

of cool roofs on homes and businesses can help lower the urban heat island effect by reducing the amount of sunlight and heat absorbed.

Where the measure has been put into practice
Many cities throughout California have housing developments with Energy STAR roofing material. Through the 100 Cool Cities Global Initiative, some of the largest cities of the world, including Los Angeles, have developed customized implementation programs to cool their cities by installing cool roofing and pavement materials. For example, Chicago provides rebates of $0.50 to $0.80 per square foot for urban buildings that install environmentally friendly, reflective roofing materials.

Additional benefits of a cool roof include:

- **Reduced ambient and home temperature**
- **Reduced energy usage**
- **Improved human health and comfort**
- **Aesthetic value**

Air Pollution Benefits
Cool roofs decrease energy usage, lowering the peak energy demand by 12% - 46% (Akbari et al, 2001). Lower energy demands not only decrease ozone precursor emissions, but also reduce GHG emissions from a residence or building by 6%-7% (EPA –RUHI, 2010). The cool roof is less likely to warm the surrounding air and increase ozone formation rates.

Costs & Savings
The cost for cool roofing material varies from $0.75 to $3.00 per square foot, approximately $0.00 - $0.20 more per square foot than regular roofing materials. On a large home or business, the additional cost could be significant. However, when energy savings from lower A/C usage are considered, the net savings from a cool roof are $0.16 – $0.66 per square foot (EPA – RUHI, 2010). Installing cool roofs will provide energy savings while helping to improve local and Valley air quality.

Programs and Resources
The Energy STAR Program has a roofing materials component with specified reflectivity requirements. Energy STAR materials typically qualify as cool roof materials and will help reduce urban heat islands, while improving energy efficiency. Tables 2 and 3 include the program's albedo performance specifications for Energy STAR roofing materials.

Table 2 – Energy STAR Qualified Low-Slope Roofs

Characteristic	Albedo Performance Specification
Initial Solar Reflectance	Greater than or equal to 0.65.
Maintenance of Solar Reflectance	Greater than or equal to 0.50 three years after installation under normal conditions.

Source: http://downloads.energystar.gov/bi/qplist/roofs_prod_list.pdf

Table 3 – Energy STAR Qualified Steep-Slope Roofs	
Characteristic	**Albedo Performance Specification**
Initial Solar Reflectance	Greater than or equal to 0.25.
Maintenance of Solar Reflectance	Greater than or equal to 0.15 three years after installation under normal conditions.

Source: http://downloads.energystar.gov/bi/qplist/roofs_prod_list.pdf

California Title 24 requires commercial buildings to have roofs with an initial reflectivity of 0.75. White painted or white sealed roofs are typical for compliance with this requirement. The state of California does not yet have a corresponding requirement for residential roof reflectivity.

For more information about cool roofs and products, visit:
Cool Roof Requirements in Title 24
http://www.energy.ca.gov/title24/2005standards/archive/documents/measures/15/15_2002-03_COOL_ROOFS.PDF

List of Energy STAR roofing materials
http://downloads.energystar.gov/bi/qplist/roofs_prod_list.pdf

Current Funding Opportunities
PG&E's Cool Roof Program currently provides a rebate of $0.20 per square foot for installation of Energy STAR roofing material. PG&E's qualification requirements are summarized in Table 4.

Table 4 – PG&E Energy STAR Rebate Requirements

Type	Aged Solar Reflectance	Aged Thermal Emittance	Solar Reflectance Index (SRI)	Rebate Amount
Low Slope	≥ 0.55	≥ 0.75	≥ 64	$0.20/sq. ft.
Steep Slope -1	≥ 0.35	≥ 0.75	≥ 36	$0.20/sq. ft.
Steep Slope -2	≥ 0.25	≥ 0.75	≥ 23	$0.10/sq. ft.

For more information, visit: PG&E Cool Roof Rebate
http://www.pge.com/myhome/saveenergymoney/rebates/remodeling/coolroof/

Other utilities, such as Southern California Edison, have cool roof rebates or programs, but may not currently have funding available. The California Energy Commission is another potential source of funding for larger projects, depending on the availability of grants. California's Flex Your Power program has a webpage dedicated to information on Cool Roofs. It also contains information on

regional incentive programs, rebates, and grants for installation of a cool roof. This webpage is a great resource for local funding information within California. For more information, visit http://www.fypower.org/inst/tools/products_results.html?id=100123.

Other Resources

EPA's Reducing Urban Heat Island Compendium of Strategies – Cool Roofs
http://www.epa.gov/heatisland/resources/pdf/CoolRoofsCompendium.pdf

City of Austin – Urban Heat Island
http://www.ci.austin.tx.us/urbanheatisland/

The Database of State Incentives for Renewables and Efficiency website (www.dsireusa.org)

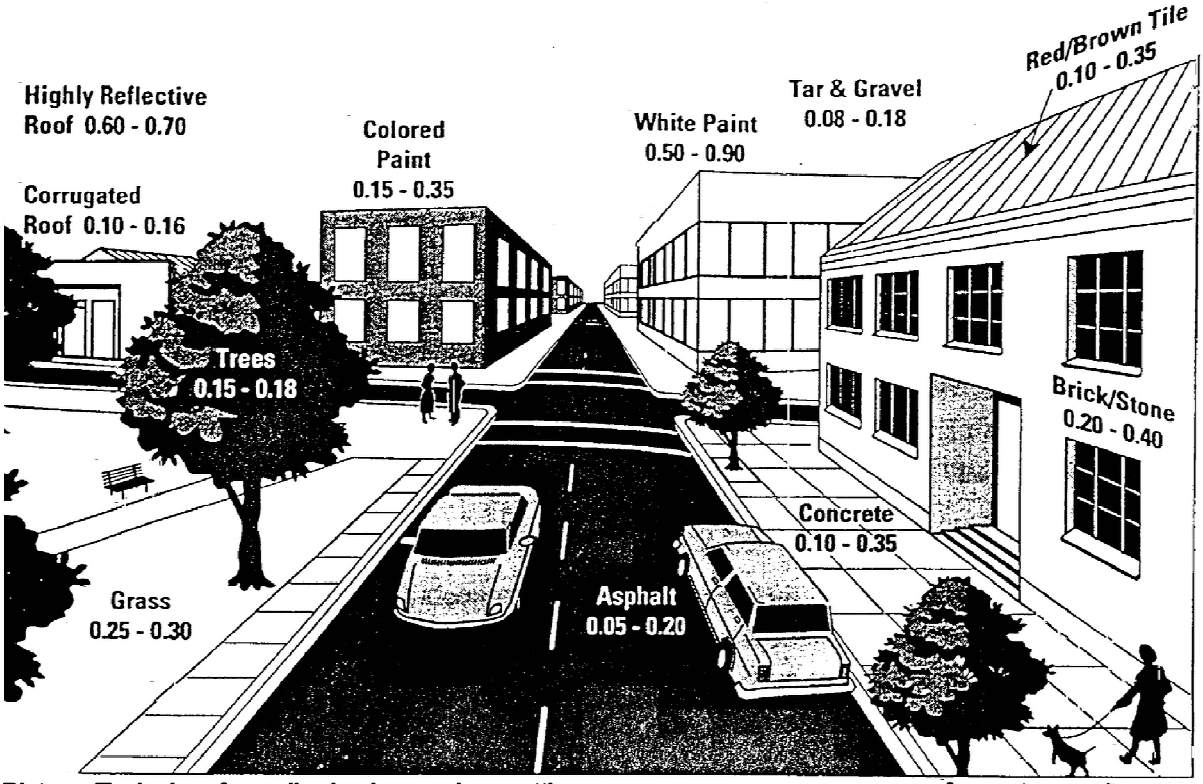
LIGHT PAVEMENT

Win-Win!
Light pavements help to reduce pollution and…
- **Reduce energy costs**
- **Increase water absorbency**
- **Can use recycled materials**

The high reflectivity of light pavements helps lower surface temperatures and reduce heat absorption. Light pavements include high albedo surfaces such as concrete instead of asphalt, and permeable pavements that allow air, water, and water vapor to be absorbed into the pavement to help keep it cool. For every 10% increase in solar reflectance, the surface temperature of pavement can decrease by 7°F (EPA –RUHI, 2010).

Pavements are used on highways, local streets, parking lots, sidewalks, and in many other applications. Different locations require different paving types to fit the appropriate use, weather conditions, and type of traffic. The main types of cool pavements include:

- Reflective pavements – used in low-traffic areas
  - Resin based pavements – clear tree resins to bind aggregate
  - Colored asphalt and concrete – pigments added to increase reflectance
- Permeable pavement – voids in surface to allow water to drain to sublayer or ground
  - Porous asphalt
  - Rubberized asphalt – shredded rubber imbedded into asphalt



Picture: Typical surface albedos in an urban setting Source: Huang and Taha, 1990

  - Pervious concrete

    - Brick or block pavers – clay or concrete with a variety of colors to increase reflectance; good for parking lots
- Vegetated permeable pavements – plastic, metal or concrete lattices that allow grass or vegetation to grow in the gaps
- Whitetopping and Ultra-thin whitetopping – using a layer of concrete with fibers on top of roads for the lighter pavement color
- Microsurfacing – thin light-colored sealing layer for road maintenance

City and County planning departments may want to consider incorporating of the more porous and lighter pavements mentioned above for parking lots that are considered low-use or overflow parking.

Where the measure has been put into practice

University of California Merced's new parking lot has a light pavement lot in which cars park on gravel aggregate and the main driving section of the lot is asphalt. The gravel is more water permeable and a much lighter surface than asphalt, making it a cooler pavement. For more information and pictures, visit: http://jda-landplan.com/images/ParkingLot_UCMerced_1.jpg

Picture: UC Merced Parking Lot

Air Pollution Benefits

When pavement reflectivity is increased citywide by 10-35%, temperatures decrease 1°F (EPA –RUHI, 2010). The effectiveness of lighter pavements depends on the number of sunny hot days a region experiences. Since the Valley has many such days, cities could see significant temperature and energy efficiency benefits from light pavements. The resulting lower temperatures can reduce ozone formation. When temperatures are lowered 2 to 3°F, ozone levels tend to fall 7-10 ppb (Bowmen, 2000). Ozone reductions such as these would help the Valley reach healthier air quality levels.

Costs & Savings
The costs of lighter, more porous pavements are 10 – 20% higher than traditional pavements. The frequency of repaving, recoating, and replacing pavements to maintain the high albedo of a light-colored pavement may become a detriment for high-traffic areas. The light surfaces easily become dirty and worn down, increasing the cost to clean and refinish to maintain the light surface. Microsurfacing is a good short-term solution to the replacement of dark pavements. Resurfacing can occur during normal maintenance for the street or highway. Because most cities or counties schedule resurfacing every ten years, major streets could be light pavements in a relatively short period of time without much additional cost.

Savings from permeable pavements include a decreased need for grading, treatment ponds, or other drainage features for water infrastructure (EPA's RUHI, 2010). Also, the energy savings usually outweigh the increased costs of light pavements. Based on a Los Angeles city study, a cooler pavement would generate a stream of savings of $0.06/m^2 per year for the lifetime of the road—about 20 years (Resenfeld et al, 1998). Light pavements and microsurfacing will help decrease the heat islands effect and improve air quality.

Additional benefits of a light pavement include:

- **Increased pavement life and waste reductions**
- **Quality of life benefits**
- **Improved local temperature**

Current Funding Opportunities
The Database of State Incentives for Renewables and Efficiency website (www.dsireusa.org) is an important resource for information on state, local, utility and federal incentives to promote energy efficiency, including heat island reduction strategies, such as shading for buildings and light pavements.

Other Resources
Cool Paving Material Cost Information
http://www.cleanaircounts.org/resource%20package/a%20book/paving/other%20pavings/coolpave.htm

Lighter Pavement Durability
http://pavementinteractive.org/index.php?title=Cooler_Reflective_Pavements_Give_Benefits_Beyond_Energy_Savings:Durability_and_Illumination

EPA's Reducing Urban Heat Island Compendium of Strategies – Cool Pavements
http://www.epa.gov/heatisland/resources/pdf/CoolPavesCompendium.pdf

GREEN ROOFS

A green roof is flat or slightly-sloped with a water seal, soil, and live plants in place of traditional roofing material. The roofing surface incorporates the soil, water, and plants to maximize the cooling potential without the risk of water leaks. Soil and plants cool by blocking sunlight from reaching the underlying roof membrane. The shading reduces the heat transferred into the building or back into the atmosphere, cooling the surrounding temperature and improving the building's energy efficiency.

Win-Win!
Green Roofs help to reduce pollution and…

- Reduce energy costs
- Reduce greenhouse gases
- Increase property value
- Provide a community garden or park for apartments

There are two categories of green roofs: extensive and intensive. Extensive green roofs include succulent, hardy plants that need little maintenance or human intervention once planted. Plants suited for extreme climates are a good choice for extensive roofs as long as they are light-weight and drought tolerant. The extensive roofs are a more cost-effective retrofitting option for buildings because they require less structural support.

Intensive green roofs include a variety of plants from trees, shrubs, and ground cover plants, creating a garden environment. The intensive roofs require more soil, an irrigation system, and more structural support to accommodate the larger plants. Some intensive roofs are made into a park or community garden, providing a green space for building residents.

Where the measure has been put into practice
In Sacramento in the summer of 2008, construction was completed on the H. Allen Hight Learning Center, a learning center with an elementary school and a middle school as well as a green roof. The center is a model construction project showcasing environmentally sound practices and the potential for green roofs in California.


Picture: Residence in Carmel, CA

Air Pollution Benefits
Green roofs have a significant building cooling potential, which lowers energy usage. The lower energy demand reduces the need for additional energy production and lowers the amount of ozone precursors emitted in the Valley. Direct emissions reductions from green roofs include PM, ozone and GHG. These reductions are achieved through PM dry deposition on leaves, lower temperatures decreasing ozone formation, and

plants up-taking CO2 to decrease GHG. A thousand square foot green roof can remove 40 lbs of direct PM emissions in a year. The city of Washington D.C. determined that increasing the amount of green roofs in the city to 2 million square feet would remove 6 tons per year (tpy) of ozone and 6 tpy of PM (EPA's RUHI, 2010).

Additional benefits of green roofs include:

- Reduced ambient temperature
- Enhanced quality of life
- Noise reduction
- Aesthetic value
- Food production

Costs & Savings

A green roof can reduce a building's total energy usage by 10% (EPA-RUHI, 2010). The initial cost of an extensive green roof is approximately $10 per square foot, and for an intensive green roof, $25 per square foot. Though this is more expensive than conventional roofs, the green roofs can last longer than conventional roofs. With that in mind, the annualized costs for a conventional re-roofing would be $0.51 - $1.74 per square foot, whereas an extensive green roof would be $1.03 – $1.66 per square foot. (EPA – RUHI) Over its lifetime, a green roof offers a total savings of about $200,000, primarily from reduced energy usage.

Current Funding Opportunities

The "Saving by Design" program, sponsored by several large California utilities, provides "design assistance to commercial, industrial, agricultural building owners to promote energy efficient design and construction practices." They help tailor new construction or remodeling projects to fit individual business needs and to be as energy efficient as economically feasible. Many of the energy efficiency measures, such as cool or green roofs, will help minimize heat island affects. For more information on the details of this program, visit http://www.savingsbydesign.com/aboutus.htm.

Other Resources

Green Roofs for Healthy Cities
http://www.greenroofs.org/

Living Roofs, Inc.
http://www.livingroofsinc.com/about_us/?x=1

Green Roof Energy Calculator
http://www.greenbuilding.pdx.edu/test.php#retain

EPA's Reducing Urban Heat Island Compendium of Strategies – Green Roofs
http://www.epa.gov/heatisland/resources/pdf/GreenRoofsCompendium.pdf

The Healthy Air Living Partners program is an initiative to encourage Valley businesses, government agencies, and organizations to voluntarily commit to actions to reduce the Valley's air pollution problem. The HAL Partners program provides guidance and turn-key resources to help participants implement less-polluting alternatives at their own facilities, many of which will also save money and improve productivity, employee satisfaction, and visibility in the community. It should be noted that the Heat Island Mitigation strategy below is only one component of the comprehensive HAL Partners program, and that participation in HAL Partners - and any portion thereof - is voluntary.

*The **Policy Statement** below is intended for businesses, government, and organizations who desire to commit to a heat island mitigation strategy in their longer-term vision. The **Recommended Objectives Checklist** includes measurable performance standards to guide upcoming projects and planning processes.*

*The **Model Resolution** is a voluntary method for municipalities, institutions (e.g., school districts, churches), and private businesses to declare their commitment to air quality and heat island mitigation. The resolution is a commitment to consider implementing heat island mitigation measures wherever possible in facilities planning.*

HEAT ISLAND MITIGATION
POLICY STATEMENT

(name of organization) is committed to lead the community in air quality improvements by reducing the causes of urban heat islands. We commit to implement a Heat Island Mitigation strategy which includes:

- Increasing the amount of trees and vegetation around buildings, walkways, parking lots, and streets.
- Installing cool roof materials and green roofs (if feasible), when new roofs are needed.
- Using light colored and permeable pavement for new parking lots, and refinishing parking lots with light-colored coatings when pavement maintenance is required.

HEAT ISLAND MITIGATION
RECOMMENDED OBJECTIVES CHECKLIST

1. Landscaping: Plant trees and vegetation in key locations to provide shading for buildings and pavements

    a. Parking Lot Canopy – One tree for every six parking spaces or shading for 50% of the parking lot area by 15 years after installation

    b. Road Tree Canopy – Provide 40% shade coverage after 15 years of growth for local roads and sidewalks

    c. Residential Tree Canopy – Shade 40% of each house after 15 years of growth in new housing developments

2. Parking Lot, Sidewalk, and Low-Traffic Road Pavements: Employ light-colored, more porous paving materials or coatings

    a. Employ light-colored paving materials or coatings (albedo of at least 0.2) and permeable materials for at least 30% of the paved area in each parking lot

    b. Install a high-reflective paving material or coating for 60% of the new surface

3. Residential and Commercial Roofs: Install cool roofing with a 0.85 albedo or higher on 50-70% of the roof area for new and retrofitted roofs, or a vegetative “Green Roof”

BEFORE THE _____BOARD OF THE
_____
_____

IN THE MATTER OF: ADOPTING THE PROPOSED COMMITMENT TO INTEGRATING HEAT ISLAND MITIGATION INTO THE FACILITY PLANNING PROCESS	**)**	**RESOLUTION NO._____**

WHEREAS, a growing body of scientific evidence exists to document increased temperatures in urban areas compared to the surrounding countryside, caused by decrease vegetation and increased impervious cover; and

WHEREAS, this phenomenon, called the urban heat island effect, can raise the average temperature of urban areas by 1-9 degrees Fahrenheit; and

WHEREAS, decreasing urban temperatures can lower air pollution, both by decreasing the need for fossil-fueled power plants, and by lowering the regions overall temperature, in turn reducing the creation of harmful ozone and fine particulate matter; and

WHEREAS, the _____'s utility can inexpensively save large amounts of energy and reduce summer peak demand by reducing the heat absorbed by buildings through heat island mitigation techniques such as light-colored roofs and streets, green roofs, and increased tree shade; and

WHEREAS, studies have estimated that lowering energy consumption and air pollution can save millions of dollars; and

WHEREAS, the increased comfort and beauty of a heat island mitigation plan will better the region's quality of life;

WHEREAS, _____ has an opportunity to serve as a community model for environmental leadership by incorporating heat island mitigation measures;

NOW, THEREFORE, be it resolved that the _____ adopts the following heat island mitigation policies:

_____ hereby agrees to institute local efforts to **increase the number of low-VOC emitting trees** in locations with a high amount of exposed pavement.

_____ hereby agrees to institute efforts to **increase the number of light colored roofs and green roofs** in the community

_____ hereby agrees to institute efforts to **increase the use of lighter colored pavements** on roads, parking lots, and other paved areas.

Nothing contained in this policy shall be construed as requiring _____ to procure products or services that do not perform adequately for their intended use or are not available at a reasonable price.

THE FOREGOING was passed and adopted by the following vote of the _____ Board of the _____ this ___th day of _____ 20___, to wit:

AYES:

NOES:

ABSENT:

(Organization Name)

By _____

(Chair)

ATTEST:

Clerk to the Board

By_____

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