Tomorrow's Energy Today for Cities and Counties: Cooling Our Cities[1]

U.S. Department of Energy[2]

Planting trees is an attractive strategy both for saving money through energy efficiency and for improving the quality of life in urban areas.

Urban summers are hot and getting hotter. Data collected over the last century clearly show an increase in inner cities' temperatures since buildings and pavement began replacing agricultural land near urban areas.

This trend may be costing your municipality money, because temperature increases in urban areas dramatically impact cooling costs. In cities with populations of more than 100,000, peak utility cooling demand increases 1.5% to 2% for every 0.6 degrees C (1 degree F) the temperature rises. Urban temperatures across the United States have risen an average of 1.1 degrees to 2.2 degrees C (2 degrees to 4 degrees F) in the last 40 years, which means your city is probably paying a premium to keep cool in the summer.

In Washington, D.C., for example, air conditioners typically run for about 1300 hours each year. This costs ratepayers about $40,000 for each hour of operation, or about $52 million a year!

Reducing city cooling loads can provide significant environmental and economic benefits for your community. Of the methods for reducing cooling loads, use of trees and "high-albedo surfaces" are often mentioned. High-albedo surfaces contain building materials that are more reflective of the sun's energy (usually light-colored surfaces) and can therefore greatly reduce a building's cooling load. This fact sheet focuses primarily on the use of trees as a method of cooling urban areas. For more information on high-albedo surfaces, refer to the first document cited under For More Information.
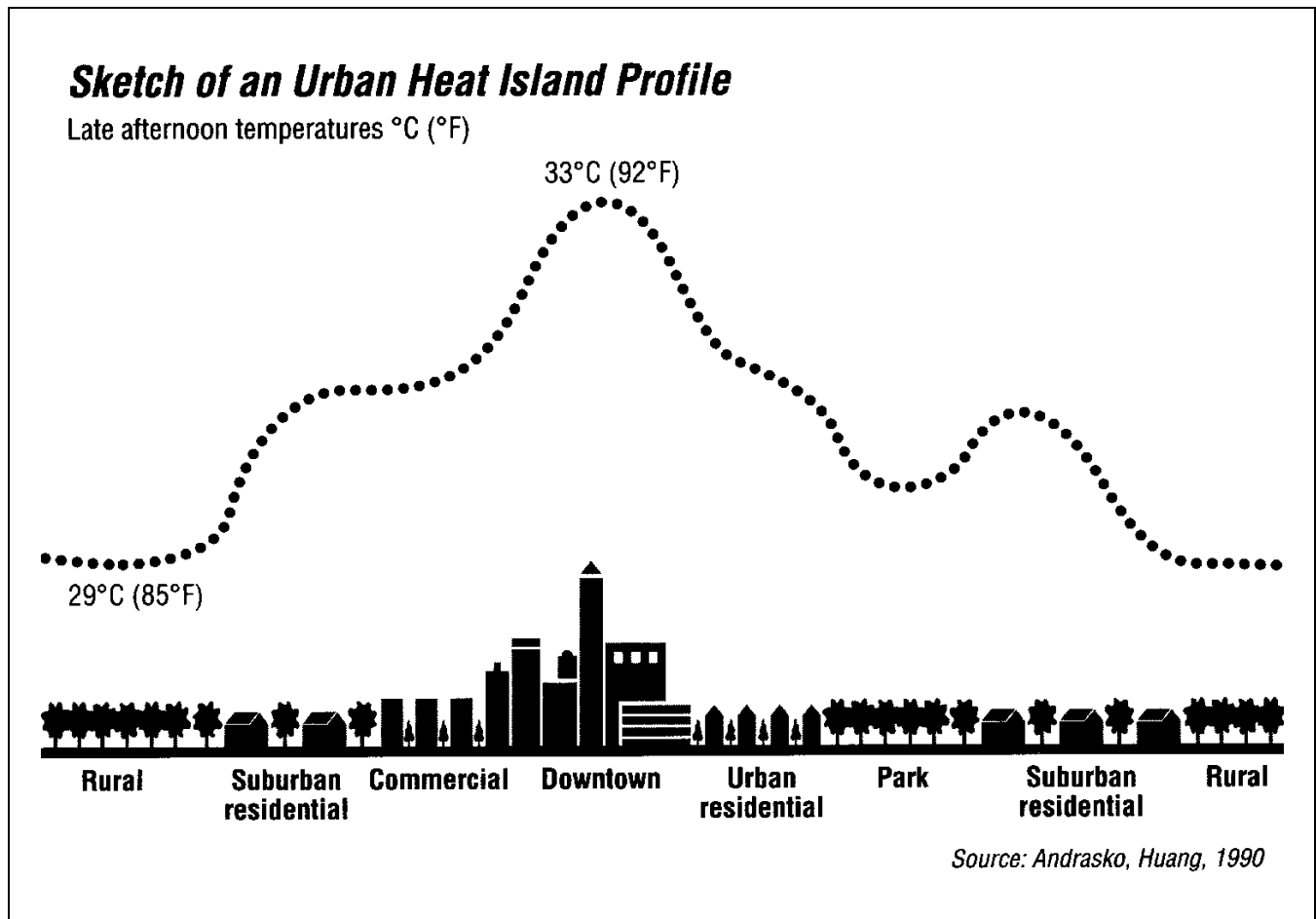
Tucson, Arizona, is one city using trees to take the heat off in the summer. "The Trees for Tucson/Global ReLeaf urban forestry program, which began in 1989, will eventually encourage the planting of 500,000 desert-adapted trees for Tucson," says Joan Lionetti, Executive Director of Tucson Clean and Beautiful, Inc. "That's one tree for each resident. We anticipate that the program will not only save money on cooling, but will also improve the quality of life in our community."

URBAN HEAT ISLANDS

People have made urban landscapes significantly hotter than rural areas, a phenomenon known as an urban heat island (Figure 1). The difference in temperature from rural to urban areas ranges from as little as 1.1 degrees to 4.4 degrees C (2 degrees to 8 degrees F) in St. Louis, Missouri, to 5.6 degrees C (10 degrees F) in New York City, to as much as 10 degrees C (18 degrees F) in Mexico City.

The causes of urban heat islands are well understood, although more research is needed to quantify the effects. In a rural landscape, much of the solar energy that strikes vegetation is used by the plants for metabolic processes. A plant also uses moisture for controlling its own temperature and then releases the excess, thus cooling the surrounding air.

Sketch of an Urban Heat Island Profile

Late afternoon temperatures °C (°F)

33°C (92°F)

29°C (85°F)

Rural   Suburban   Commercial   Downtown   Urban   Park   Suburban   Rural
         residential   residential   residential

Source: Andrasko, Huang, 1990

Figure 1. Urban Heat Island Profile.

In a city, plants are replaced with surfaces such as asphalt, brick, and concrete. These surfaces have a low reflective capacity, so they absorb and store solar energy instead of reflecting it. The canyon-like structure of cities also reduces heat loss to the sky. The result is that well into summer nights, cities are much warmer than their less urban surroundings.

Summer's onset signals the beginning of an unfortunate cycle. The warming of our cities in the summer contributes to high pollution levels, and that pollution in turn contributes to the heat island effect. Higher temperatures speed the chemical reactions that lead to high ozone concentrations, and at night, the pollution lying over a city inhibits heat loss.

Another factor exacerbating the situation is that buildings and industrial development in urban areas continue to crowd out trees, and we are not replacing them as they die or are displaced. Typically, only one tree is planted for every four trees removed in American cities. New York City, for example, lost 20% of its urban forest (175,000 trees) in the last decade.

TREES AS A COOLING STRATEGY

One of the simplest and cheapest strategies for countering the urban heat island effect is to increase the number of trees and other plants. Vegetation cools directly by shading and indirectly through evapotranspiration, the process by which plants release water vapor.

The energy savings can be significant. In the United States, the annual effect of properly positioned trees is a savings averaging about 20% to 25% of residential energy costs, compared with the costs for the same house in an unsheltered area.

In specific situations, the savings from shading can be impressive. In south Florida, researchers estimate that trees and shrubs next to a home can reduce summer air-conditioning costs by 40%. Very simple measures can save money. For example, directly shading that air conditioner is one of the most effective ways of reducing costs, because shading precools the air used by the air-conditioning unit, increasing its efficiency. Data from

central Pennsylvania indicate that shading can reduce the cost of cooling a small mobile home by up to 75%.

The effects of evapotranspiration are more difficult to quantify, but researchers using computer simulations estimate that planting a total of three trees per house on the south, east, and west sides would result in cooling energy reductions of 30% in Sacramento, California, 17% in Phoenix, Arizona, and 23% in Lake Charles, Louisiana. Shading accounts for about 10% to 35% of these savings, and the remainder results from lower temperatures caused by evapotranspiration.

Trees are a relatively inexpensive way to accomplish these energy savings. According to a study by researchers at Lawrence Berkeley Laboratory, it costs about $0.01 to reduce peak-load energy demand 1 kilowatt-hour (kWh) by planting trees. The cost of saving that same kWh by improving the efficiency of electrical appliances is about $0.025. One kWh generated by a new peaking power plant costs $0.10.

Interest in tree planting as a cooling measure is growing all over the country. American Forests began its Cool Communities program in January 1992 to collect information from different geographical areas on the costs and benefits of planting trees for cooling. Eight communities - Austin, Texas; Frederick, Maryland; Dade County, Florida; Atlanta, Georgia; Tulsa, Oklahoma; Springfield, Illinois; Davis-Monthan Air Force Base near Tucson, Arizona; and Tucson, Arizona - will plant trees and monitor the results.

TREES FOR TUCSON

The Trees for Tucson program in Tucson, Arizona, is an offshoot of Tucson Clean and Beautiful, Inc., a nonprofit organization funded by government and private grants and donations. The program is affiliated with the American Forests' Global ReLeaf program.

Trees for Tucson encourages tree planting and provides information to homeowners, neighborhood groups, and schools on low-water species appropriate to the local environment, and optimum placement of

trees for energy and water conservation. Individuals and groups can become involved in many ways: planting trees themselves; sponsoring a street tree planting through an organization; volunteering for or contributing to a school tree-planting program; or becoming a member of Trees for Tucson.

According to Joan Lionetti, Executive Director, Tucson Clean and Beautiful, Inc., "The Trees for Tucson program has been extremely successful in raising public consciousness of local environmental issues. This program touches every segment of the community, from elementary school kids to senior citizens, and gives them something they can do to help cool and beautify the city and improve the environment."

Trees for Tucson also encourages the community to take responsibility for its urban forest. "Participants in the program attend workshops held twice a year that teach the basics of pruning, planting, fertilization, and managing insects and disease," says Lionetti. "This ensures that the trees will be here for future generations to enjoy."

Other educational efforts include seminars for local landscaping and nursery professionals and an energy conservation training workshop for teachers that emphasizes information on using trees to reduce cooling costs. The local utility, Tucson Electric Power, is also participating by publishing an informational brochure encouraging customers to plant trees to conserve energy and supporting Trees for Tucson's educational effort.

Although hard data on energy conservation won't be available for several years, a U.S. Forest Service Study estimates net benefits of $236.5 million during the next 40 years. According to the city's calculations, each tree will save 227 kWh ($16.34) through cooling by evapotranspiration and 61 kWh ($4.39) through direct shading. Officials also estimate that planting 500,000 trees will save the city $600,000 in storm drainage management in 40 years.

A tree-planting program represents a rare opportunity to simultaneously benefit your city's citizens and the local environment while reducing cooling costs. Reliable information on tailoring a program to the needs of your locality is available from many sources. The three sources listed under For More Information will get you started.

ADDITIONAL BENEFITS OF TREES

Pollution Abatement

Trees help purify the air by reducing the energy used for cooling and thus the pollution caused by the generation of that energy. They also absorb carbon dioxide (the main "greenhouse effect" gas) and produce oxygen.

Noise Reduction

Some researchers estimate that belts of trees 31-meters (100-feet) wide and 14-meters (45-feet) high can reduce high-way noise by almost 50%. Evidence also suggests that people find noise less annoying when the source is obscured by vegetation.

Water Management

Trees can reduce the cost of managing storm runoff. For example, the canopy of the urban forest in Salt Lake City, Utah, reduces surface runoff by about 42.8 million liters (11.3 million gallons), or 17%. Other cities experience similar reductions, depending on the size of their forest canopy.

Public Relations Benefits

a healthy urban forest enhances citizens' and visitors' experiences of your city's environment. Like the trees, tree planting programs have benefits that go far beyond their initial purpose. For instance, New York City's Tree Consortium program encourages volunteerism and provides educational programs and publications. Similarly, the Twin Cities Tree Trust program in Minneapolis/St. Paul, Minnesota, employs disadvantaged youths and adults to plant trees.

FOR MORE INFORMATION

Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing, United States Environmental Protection Agency, January 1992.

Available from:
Superintendent of Documents
P.O. Box 371954
Pittsburgh, PA 15220-7954
Attn: New Orders
Reference GPO Document #055-000-00371-8, $13.00

Shading Our Cities: A Resource Guide for Urban and Community Forests, Edited by Gary Moll and Sara Ebenreck, American Forests, 1989

Available from:
Island Press, Suite 300
1718 Connecticut Avenue, NW
Washington, DC 20009
(800) 828-1302
Cloth $34.95, paper $19.95

American Forests
P.O. Box 2000
Washington, DC 20013-2000
(202) 667-3300

This organization is an excellent information resource for local governments. Its Cool Communities program is designed to foster partnerships between interested communities and other government agencies with the purpose of mobilizing resources.

Urban Consortium Energy Task Force
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004
(202) 626-2400

EREC
P.O. Box 3048
Merrifield, VA 22116
(800) 523-2929

The Energy Efficiency and Renewable Energy Clearinghouse (EREC) is a service funded by the U.S. Department of Energy to provide general information on renewable energy and energy efficiency.

DOE REGIONAL SUPPORT OFFICES

The DOE Office of Energy Efficiency and Renewable Energy reaches out to the states and private industry through a network of regional support offices. Contact your DOE regional support office for information on energy efficiency and renewable energy technologies.

Atlanta DOE Support Office
730 Peachtree Street NE, Suite 876
Atlanta, GA 30308
(404) 347-2837
(AL, FL, GA, KY, MS, NC, PR, SC, TN; Territory: VI)

Boston DOE Support Office

One Congress Street, 11th Floor
Boston, MA 02114
(617) 565-9700
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Chicago DOE Support Office
9800 South Cass Avenue
Argonne, IL 60439
(708) 252-2000
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Dallas DOE Support Office
1420 West Mockingbird Lane, Suite 400
Dallas, TX 75247
(214) 767-7245
(AR, LA, NM, OK, TX)

Denver DOE Support Office
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Golden, CO 80401
(303) 231-5750
(CO, MT, ND, SD, UT, WY)

Kansas City DOE Support Office
911 Walnut Street, 14th Floor
Kansas City, MO 64106
(816) 426-4784
(IA, KS, MO, NE)

New York DOE Support Office
26 Federal Plaza, Room 3437
New York, NY 10278
(212) 264-1021
(NJ, NY)

Philadelphia DOE Support Office
1880 JFK Boulevard, Suite 501
Philadelphia, PA 19103
(215) 656-6950
(DC, DE, MD, PA, VA, WV)

San Francisco DOE Support Office
1301 Clay Street, Room 1060 North
Oakland, CA 94612
(510) 637-1960
(AZ, CA, HI, NV; Territories: AS, CM, GU, RP)

Seattle DOE Support Office
800 Fifth Avenue, Suite 3950
Seattle, WA 98104
(206) 553-1004
(AK, ID, OR, WA)