MEASURE 8.2.4 Plant trees and other foliage to provide shading.

RATINGS

New Facilities	Retrofit	O&M
B	C	

SUMMARY

Works well for shading low structures and the lower portions of tall structures. Improves appearance. You have to wait several years to get results. Requires surrounding land. Requires maintenance.

SELECTION SCORECARD

Savings Potential	$ $ $ $
Rate of Return, New Facilities	% %
Rate of Return, Retrofit	% %
Reliability	✓ ✓ ✓
Ease of Retrofit	☺ ☺ ☺

Tree shading is a technique as old as mankind, but it has not been used much in modern times to reduce mechanical cooling load. It deserves more attention for this purpose than it presently receives. Tree shading prevents direct entry of sunlight into the building through glazing, it reduces the surface temperature of the external opaque surfaces, and it lowers the temperature of the air surrounding the building. Figure 1 shows an application with a modern office building.

Trees may be the most economical and practical method of shading some buildings. Trees are inexpensive. They are fairly easy to plant. They do not have to be customized to the building. A special advantage is that they automatically adjust shading to the seasons. They may substantially improve the appearance of the property.

Tree shading has two major disadvantages. One is the long delay between the time the tree is planted and time it starts to produce savings. The other is a need for periodic maintenance.

Where to Consider Tree Shading

Consider tree shading for all types of buildings that receive a substantial amount of solar gain at an elevation below about 50 feet (15 meters). You can use trees to shade tall buildings, but they can shade only the lower portions of the buildings.

Trees also require soil, moisture, and sunlight conditions appropriate to the species planted. Trees can grow well even in areas that are heavily paved, provided that soil moisture is adequate.

Energy Saving Potential

Virtually no direct sunlight gets through the canopy of a healthy shade tree. A fully shaded surface has a solar gain of less than 20 BTU per hour per square foot. As a result, complete shading by trees eliminates over 90% of the solar energy falling on a surface. Shade trees are wide in relation to their height, so they continue to be effective when the sun is at low elevations.

Effect on Passive Heating

One of the major advantages of using deciduous trees for shading is that they do not seriously obstruct solar heat gain during cold weather. This makes tree shading compatible with passive solar heating.

Effect on Daylighting

Tree shading may help or hinder daylighting, depending on the geometry of the building and its glazing. Tree shading may enhance daylighting if it encourages occupants to open internal blinds to admit the pleasant sunlight of the shaded environment. On the other hand, tree shading is incompatible with daylighting techniques, such as “light shelves” (see Measure 8.3.2), which are intended to distribute the full intensity of sunlight.

Non-Energy Benefits

Tree shading has strong esthetic potential. If accomplished with a good sense of style, it can greatly enhance the appearance of a property.

Tree shading can also increase the usable area of space outside the building during warm weather for uses such as patio restaurants, cart vending, etc.

Tree shading has been promoted as a a means of purifying the atmosphere. This effect is minimal if trees are planted on a localized basis. Trees are more likely to succumb to air pollution than to correct it. Also, contrary to popular belief, trees do not reduce the amount of carbon dioxide in the atmosphere. Trees absorb a large amount of carbon dioxide as they grow, but they return carbon dioxide to the atmosphere as they decay.

Disadvantages

A serious disadvantage of tree shading is that it takes from three to eight years for trees to grow large enough to produce significant shading. This assumes that the trees are grown from small sizes. Trees that are purchased large enough to provide shading immediately are expensive. However, buying larger trees may be the most cost effective approach, especially if you need to shade large areas of glazing.

Trees require maintenance throughout their lives, although typically at long intervals. The life cycle cost of tree maintenance is not trivial, especially if you have to keep the trees manicured for decor.

How Tree Shading Works

Trees provide cooling in two principal ways:

- ***blocking solar radiation.*** Sunlight is either reflected from the tree, or it is absorbed by the foliage at a distance from the building. Heat absorbed by the tree is carried away by the surrounding air mass.
- ***evaporative cooling through transpiration.*** The surface of the foliage is cooled below ambient temperature by evaporation. Water drawn through the root system is evaporated from the leaves, cooling them. This process is called "transpiration." Its cooling effect does not appear to be well documented. Research by the Lawrence Berkeley Laboratory suggests that trees lower the air temperature by 3°F to 6°F (2°C to 4°C) in the vicinity. One could guess that the magnitude of the temperature drop is related to the evaporation rate (hence, to the species) and to the ambient wet-bulb temperature, as with any other form of evaporative cooling.

The beneficial effect of transpiration is limited if the climate is humid during warm weather.

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Fig. 1 Tree shading for an office building Above, two trees planted on the south side of this four-story building substantially reduce the cooling load through its large expanses of glass. Below, the trees shed their leaves in winter, allowing the building to benefit from passive solar heating. The trees form an effective visual divider between the office building and other buildings in this mixed-use neighborhood.

Evaporative cooling reduces sensible temperature by converting sensible heat in the air to latent heat, i.e., the heat in the air is used to evaporate water from the leaves. This increases humidity in the vicinity of the tree.

Some people have said that trees block "cooling breezes," reducing their overall cooling benefit. This is wrong. In warm weather, breezes do not cool, instead they warm. Furthermore, air motion has a cooling effect only on damp surfaces, notably human skin. This "wind chill" effect does not apply to the dry surface of a building.

How to Select Tree Species

A good way to start with selecting tree species is to observe which types of trees flourish in the vicinity. Take into account the soil type, the sun exposure, and the drainage at the planting site. Try to avoid trees that you cannot find growing in the area. No matter what the nursery says, foreign trees may grow more slowly than expected, or they may not survive at all. Even if a tree species is known to grow in a similar climate, it may not flourish locally because of conditions such as air pollution, soil acidity, etc.

Select deciduous trees, rather than evergreens, except for sites that need cooling all year. Evergreen trees would substantially increase heating requirements in cold weather. Most evergreen trees have a less desirable shape for shading, and they cannot be pruned as well to create a desirable shape.

From the standpoint of shading, you want trees with these characteristics:

- ***rapid growth.*** A lot of cooling energy may be wasted during the 3 to 8 years that the tree grows to a useful height.
- ***adequate life.*** Tree life ranges from 30 years to 1,000 years. The more rapidly growing trees tend to have shorter lives, but the correlation varies. The tree should have a life span as long as the remaining life of the building.
- ***good shape,*** not only for shading, but also for view and for traffic under the canopy.
- ***proper timing of leaf growth and shedding.*** The tree should grow a well developed canopy by the beginning of the cooling season, if possible, and it should shed all its leaves by the beginning of the heating system. Not all deciduous trees shed well. For example, some species of oaks keep their dead leaves through the winter, and shed them only when new leaves push the dead ones loose in spring.

The fact that a particular tree can provide good shading does not alone make it desirable. Other important characteristics are:

- ***ability to flourish at the site*** without watering, fertilizing, or other frequent tending.
- ***absence of damage from root growth.*** Roots can damage adjacent foundations, lift sidewalks, and destroy pavement. Roots that grow on the surface can interfere with lawn mowing, and can make the space under the tree unusable.
- ***wind resistance.*** Some trees survive high winds by sacrificing branches, which is dangerous. Some trees topple in high winds. Resistance to toppling depends on soil conditions and local geology as well as the tree's root pattern.
- ***minimum shedding of annoying material,*** such as twigs and seed pods that clog gutters, resin spattering that sticks to automobile finishes, etc.
- ***compatibility with surrounding vegetation.*** All trees have some effect on surrounding shrubbery, decorative plantings, and grass. Select both the trees and the surrounding vegetation to be compatible with each other.

Where to Plant

Consider these factors when deciding where to plant the trees:

- ***the areas of greatest solar gain*** in the building. Give top priority to shading large windows that are exposed to direct sunlight. Then, shade smaller windows. Then, shade dark roofs and walls.
- ***how the sun moves*** with respect to the areas to be shaded. Plant the trees so that they provide shade for the largest fraction of time, during the cooling season.
- ***the tree's shape and dimensions*** during its useful life
- ***avoiding interferences,*** as with power and telephone wires. Utility companies perceive trees as a problem, and may cut them back drastically, without regard to the energy saving intentions of the building owner.
- ***appearance*** of the property, including arrangements with other plantings.

A common mistake is planting the tree too close to the building. The small sapling that you plant today will become a huge structure weighing many tons. Planting trees too close to the building, or too close to each other, may force them to be removed just as they become most effective for shading. Professional tree planters make this mistake as well as amateurs. If a tree is planted at a proper distance from the building, it will seem too far away from the building when it is still young.

Planting Foliage on Buildings

The concept of tree shading can be extended to the planting of shading foliage on the building itself. For example, a building with a large flat roof may have the roof covered with shading foliage.

Although this approach may have merit, it surrenders many of the advantages of planting trees in the ground. The building must be reinforced to support the weight of the foliage. Automatic watering systems are required. If the water is purchased, the annual cost is substantial, in contrast to trees planted in the ground, which find their own water. And, maintenance requirements are much greater.

Keep the Benefit Apparent

It is important to keep the building's owners and operators aware of the fact that the trees are intended to improve their summertime comfort and reduce cooling costs. This may be forgotten as the years pass, allowing some future decorator to remove the trees on a whim. As with other energy conservation measures, effective placards are a principal means of preserving the benefit. Install decorative, permanent (e.g., cast bronze, embossed stainless steel) plaques that describe the shading and comfort purposes of the trees, along with the usual botanical information. It is easy to get people interested in tree shading.

Possible Financial Assistance

Tree planting has become an ideological issue, which has prompted various levels of government to subsidize tree planting. Governments may provide funds directly or they may mandate subsidies by others, especially by utility companies. If you are going to plant only a few trees, government subsidies are probably not worth the paperwork. If you are going to plant many trees, cash in on any subsidies that are available.

For Additional Information ...

There does not appear to be much scientific research on tree shading to reduce cooling load. Research probably is less important than common sense, but it pays to begin by learning from the experience of others. For example, some electric utilities have tree shading programs.

Don't overlook the importance of checking local growth conditions, which you can learn from county agricultural agents and public arboretums. Take the advice of commercial landscape contractors with a grain of salt. They have a bias toward exotic and expensive species that require maintenance.

ECONOMICS

SAVINGS POTENTIAL: *70 to 90 percent of the cooling load of the shaded portions of the building, but only after the trees have grown sufficiently. The net saving is reduced by a small increase in heating load.*

COST: *$50 to $1,000 per tree, planted, depending mostly on the initial size of the tree.*

PAYBACK PERIOD: *Payback period does not apply to this Measure in the usual way, because there is a long delay before it starts to produce benefits. If you start the clock when the tree becomes large enough to provide substantial shading, the payback period would be one or two years.*

TRAPS & TRICKS

CHOICE OF METHOD: *If tree shading is a possibility, the big question is whether it makes sense to wait several years for results. Tree shading is especially attractive for existing facilities where other methods of reducing solar gain are not economical. Consider the other advantages and disadvantages of tree shading, which can be major issues.*

SELECTING THE TREES: *Have a strong bias in favor of trees that you observe to flourish in your locale. Find out all the bad habits of each species you are considering.*

LAYOUT: *Little trees become great big trees, which cannot be moved. Plant the trees in locations suitable for their final size. To get shading quickly without planting trees too close to the building, select species that have rapid vertical growth and that are tolerant of heavy pruning to limit their horizontal spread.*