

The Effect of Urban Trees on Energy Use of Residential Buildings: A Case Study from Gainesville, FL¹

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A city's trees reduce its energy use year-round. In warm months, trees shade buildings and provide evaporative cooling and in cold months, they block icy winter winds. Trees near a building tend to reduce air conditioning use in that building in the summer months. The same trees can either increase or decrease energy use in a building during the winter months depending where the trees are in relation to the building. Knowing the size of a given building and the sizes and positions of the trees near it will enable us to place an economic value on the trees based on how much they reduce or increase energy use in the building. The USDA Forest Service's Urban Forest Effects (UFORE) model (<https://www.nrs.fs.usda.gov/tools/ufore/> [20 October 2022]) was used to estimate urban tree heating and cooling effects on residential buildings in Gainesville, Florida. During 2006–2007, data were collected during a study of 93 one-tenth-acre, randomly located field plots. Estimates of tree effects on energy use are based on field measurements of the distance and direction of trees greater than 20 feet tall relative to space-conditioned residential buildings less than 2 stories high. Since trees have to be close to buildings to affect their energy use, only trees less than 50 feet from buildings meeting the criteria were measured (Escobedo and others 2010). The model also incorporated tree type (evergreen or deciduous) as well as building type and age, regional climate characteristics, and common carbon dioxide emissions from the generation of

electricity in the southeastern United States (McPherson and others 1999, Nowak and others 2006).

Based on a 2007 average retail price of electricity in Florida (EIA 2007), trees in Gainesville are estimated to provide about \$1.9 million in savings each year due to reduced air conditioning and heating use. However, trees also increase energy costs in winter by approximately \$367 thousand annually because their shade cools buildings and thus raises building heating costs. Table 1 provides a breakdown of the air conditioning and heating use and price savings provided by residential trees, as well as heat emissions costs residential trees incur.

Energy required to cool residences can be reduced by providing shade and wind control through urban trees. Trees clustered together near a building can create a microclimate cooling system via evapotranspiration (evaporation of water from plant surfaces and bodies of water). A tree can block solar radiation from the building. Similarly, a group of advantageously positioned trees can direct wind air flow either toward the house to help cool it down in warmer months or away from the house to diminish cooling effects during cooler months. A study in Auburn, Alabama, found that shade from a typical tree reduced electrical use by 4%, and a tree that provides dense shade reduced monthly electrical use by 9% (Pandit and Laband 2010).

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Depending on the time of year, the placement of trees around a building can influence the amount of shading and windbreak effects on buildings, thus affecting the energy required to maintain acceptable temperatures inside the building (McPherson and others 1999). Trees planted on the west side block the increase of solar heat in the afternoon during summer. Trees on the east and south sides of the house will block the solar heat in the summer, but unless they are deciduous these same trees will block solar heat from the structure and increase the need for heating in the winter (Pandit and Laband 2010). This is more common in northern, temperate climates. A good practice to follow is the rule of the right place for the right tree: plant deciduous trees, which lose their leaves in the fall, on the south and east sides of structures in order to let the sun's heat warm them in the wintertime.

We have seen how trees directly reduce (and sometimes increase) energy use in buildings; it follows that they also influence energy production in power plants used to heat and cool those buildings. By lowering (or increasing) energy production in power plants, trees can also lower (or increase) emissions of carbon dioxide (CO₂) and other green house gases emitted by power plants. When, as in Gainesville during the time of this study, there is a net offset of avoided emissions, the community saves money because of its trees (McPherson and others 1999). Using the average price of \$4 per ton of CO₂ emissions avoided (August 2008), we determined that the effect of trees on building energy use resulted in \$66,559 in benefits and \$38,241 in costs to Gainesville due to their effects on household cooling and heating, respectively: a benefit-cost ratio of 1.7 with regards to the offset in costs associated with energy production. Table 2 provides a breakdown of the energy savings and costs incurred by Gainesville's urban forests. It is important to consider that the price of carbon is variable due to markets, site-specific environmental policies, accounting requirements, and many other factors (<https://www.ecosystemmarketplace.com>).

Summary

It is important for homeowners to plant trees in the right places to maximize cooling benefits in the summer, while making sure not to increase heating costs in the winter. Take advantage of cooling winds by situating grouped plantings of shade trees far from the house (near the house, a mass of trees often creates a windbreak that will block cooling breezes). For year-round comfort, position deciduous trees on the south side of the house to afford more shade in summer and maximize surface area for solar heating in winter. Homeowners can find ways to exploit

the benefits of trees to maximize energy savings: when trees grow tall enough to provide effective shade, it may be possible to open a window at night and during the early part of the day instead of using the air conditioning. With good tree placement to maximize the sun, a homeowner may find the heating system unnecessary except during cold snaps and at night and on cloudy days. And of course, investing in energy-efficient buildings and heating-cooling units will help as well. With some knowledge and effort by citizens and planners, a well-kept urban forest can keep a town warm in winter and cool in summer and save money all year.

For more information about Gainesville's urban forest read the [Gainesville's Urban Forest series](#).

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Table 1. The benefits and costs based on energy use effects due to tree shading, windbreak, and climate effects near residential buildings in Gainesville, FL.

| | MWhs ¹ | Benefits* | Cost* |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|------------------|
| Heating avoided due to wind break | 2,072 | \$227,920 | |
| Heating avoided due to tree effects on surrounding climate | 573 | \$63,030 | |
| Air conditioning use avoided due to tree shading | 9,243 | \$1,016,730 | |
| Air conditioning use avoided due to tree effects on surrounding climate | 5,362 | \$589,820 | |
| Increased heating due to tree shading | 3,339 | | \$367,290 |
| Annual Sum of Benefits and Costs | | \$1,897,500 | \$367,290 |
| ¹ MWh = 1000 kWh, MWh = megawatt hour used for energy production and kWh = kilowatt hour used for residential and commercial units. *Assuming \$0.11 average price per kWh for Florida end-user (EIA 2007). | | | |

Table 2. Annual energy savings and costs due to tree location around residential buildings in Gainesville, FL.

| | Benefit or Cost | Ct/yr | CO ₂ t/yr | \$ CO ₂ savings/expenditures per year |
|----------------------------------------------------------|-----------------|-------|-------------------------|--------------------------------------------------------|
| Heating avoided due to windbreak | Benefit | 1725 | 6331 | 25,323 |
| Heating avoided due to local climate effects | Benefit | 469 | 1721 | 6,885 |
| Cooling avoided due to shading | Benefit | 1481 | 5435 | 21,741 |
| Cooling avoided due to climate effect | Benefit | 859 | 3153 | 12,610 |
| Heating emissions due to shading | Cost | 2605 | 9560 | 38,241 |
| From: ¹ Escobedo and others 2010. C = carbon. | | | | |