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Introduction

Jordan su ers from an ever-present lack of su cient energy resources. ere is an increasing concern about energy consumption and its impact on the national economy as well as the local environment. Getting bene t from trees-shade to reduce air cooling energy consume will help Jordan overcome these problems. Trees have a positive impact on human comfort, wind sheltering, evaporative cooling, air-pollution reduction and shading. Getting advantage of trees-shade will help reducing energy consumption in residential buildings during summer season. A further corporate bene t is the connection between trees, green areas and human behavior.

e primary goal of this study is how to use passive techniques to reduce cooling loads in residential buildings in Amman, to provide architects with information about the impact of tree-shade on energy saving in buildings. In order to achieve this goal, sub goals have been from tree shade in residential buildings, building construction and occupant behavior are two of many. While there are variables that influence shading potential and the quality and quantity of shading is determined by tree species, foliar condition, canopy volume, crown shape, foliation period, leaf area, and tree location and orientation with respect to a building. With the consideration of these variables, a tree can be planted strategically to maximize energy conservation [3].

Trees improve comfort conditions outdoors within the city by blocking hot and dust-laden winds. Trees can act like windbreaks that will lower the ambient wind speed; building physical characteristics will affect the building's cooling-energy use by lowering or raising it. Trees affect a building's energy balance as windbreaks in three ways [6]:

1. During summer, Lower wind speed on a building envelope slows the dissipation of heat from sunlit surfaces producing higher sunlit surface temperatures and more heat gain through the building envelope.

2. Lower wind speed results in lower air infiltration into buildings. This reduction has a major impact on reducing cooling-energy requirements for old houses.

3. Lower wind speed reduces the effectiveness of open windows during the summer, resulting in increased reliance on mechanical cooling.

Evaporative cooling: Evaporative cooling is sufficient in hot summer days, when trees act as natural "evaporative cooler" by using up to 100 Gallons of water a day resulting to lowering the ambient temperature. The absence of leaves on deciduous trees and the lower ambient temperature minimize the effect of evapotranspiration in winter. Oasis effect can be produced from the significant increase in urban trees that will maximize the evapotranspiration in this case the ambient temperatures are significantly lower and buildings will consume less cooling energy [6].

Shading: Solar radiation is the radiation from the sun, while terrestrial radiation is radiation emitted by objects on earth. Shade trees are very important in modifying both of them [7]. Tree's shade can reduce glare and block the diffused light from the sky and other surfaces this will affect the heat exchange from the building and its surrounding. Moreover, this will affect people's comfort. During the day, shade trees also indirectly reduce heat gain in buildings by altering terrestrial radiation and ultimately reducing ground surface temperatures [6-8].

In summer, trees block unwanted solar radiation entering the building and hence reduce the cooling load if placed properly around the building; while in winter, trees shades increase the heating loads. Applying deciduous trees is more appropriate, since they allow solar gains during winter, while minimizing it during summer. Trees shades reduce surface temperature, glare, and blocks the diffuse radiation reflected from the sky and the surrounding surfaces, thereby alerting the heat exchange between the buildings and its surroundings. Trees block the heat flow from the building to the cool sky and surroundings at night [6].

A study conducted by Heisler found that, on the south elevation a medium size deciduous tree can reduce irrandiance by 80% (with leaves on it) and 40% (if it was leafless). Trees by providing shade are an important factor in the radiative exchange process of ground and wall surfaces resulting in significant reductions of urban surface temperatures. Lack of shade in city environments, leads to higher surface and air temperatures. Therefore, shading by trees is of prime importance in reducing the ambient and surface temperatures of any artificial surface in urban built-up that will indirectly affect the building energy consumption [7].

The impact of tree location on energy reduction

Tree location is defined by tree-building distance and tree azimuth with respect to a building. Tree azimuth is the true compass bearing of a tree relative to a building. Changing tree location results in variation in the amount and timing of building shade [9].

The methodology to select the most suitable tree take into account; land regulations and ownership, planting space, aesthetic principles, social influences, and maintenance requirements, all contribute to achieving the highest chance of successful implementation [5,10-12].

Many researchers have investigated the impact of tree-building location on heating and cooling energy use [5,9,13-16] Akbari, Bretz, Hanford, Rosenfeld, Sailor, Taha, and Bos, simulated the impact of tree locations on heating and cooling energy use and found that savings can vary from 2% to over 7%. They also claimed that cooling energy savings were higher for trees facing west surfaces. Heisler [12], McPherson et al. [15] and Meerow and Black [13] found that the best two places to plant a tree around a building to reduce cooling costs is in front of west facing windows and walls and then comes in front of the east wall by providing shade for these facades in the morning and afternoon.

A study conducted by McPherson and Simpson [11] in California, USA studied the tree-building location and found that trees located within 12.2 m of east and west sides of buildings were in "positive sites" because trees provide benefits of shade. South trees located within 6.1 m from buildings were in "neutral sites" since benefits from limited summer shade are likely to be offset by undesirable winter shade. Trees located between 6.1 m and 12.2 m of the south side of buildings were in "negative sites" because most shade occurs during the heating season. Trees located to the north or greater than 12.2 m from buildings in other directions were in "neutral sites" because their shade would not fall on buildings [5].

Although trees have the potential to save energy, but if located to shade solar collectors and south-facing windows they can reduce collector efficiency and increase winter heating costs [5].

Akbari and McPherson et al. illustrated that in order to reduce energy use in winter, the most valuable way is considered to use trees as windbreakers to the north and northwest of a building to protect buildings from the cold north winter wind. Thus the savings in heating energy of urban areas could almost be doubled [6].

Materials and Methods

Study area

The study was conducted in the city of Amman, Jordan, latitudes 32° N. It consists of an arid plateau in the east, irrigated by oasis and seasonal water streams, with highland area in the west of arable land and Mediterranean evergreen forestry. The climate of Jordan is semi-dry in summer with average temperature in the mid 30°C (86°F) and relatively cold in winter averaging around 13°C (55°F).

The proposed model

In order to assess the impact of trees shade on summer time electricity use, this study assumed a hypothetical typical residential house that is located in Amman in a land that is categorized as Class (C) residential[1]. The house consists of two floors, six meters high. The house plan is 15*15 m^2

(GAM) regulation is; frontal setback 4(m), Side setback 3(m), Rear setback 4(m). ese setbacks and the Allowable built area are applied in our model. About the trees distributions; the northern façade has no trees because it receives almost no direct solar radiation. All trees are separated 2.5 m from the walls; three trees on each elevation. e distance between each tree and another is 4 m on east and west facades and 1.5 between trees located on south façade. We are getting

the center of the facade on the floor is the origin of the coordinate system, *x* represents the distance from the facade, *y* the offset of the point respect to the central orthogonal line to the facade, and z the height of the point from the floor. Figure 7 shows the angular coordinates of trees in relation to a central point on the building's façade while Figure 8 below illustrates the coordinates of trees around the building, related to central points of the facades (Figures 5 and 6).

Shade calculations

Having effective shading design contributes to reducing cooling loads in hot seasons in Amman. The energy consumption due to cooling loads will be reduced by the adoption of effective shading strategies. The simulation was conducted for the whole period of the hot season in Amman.

The simulation was conducted on; July 21st, and September 21st. These targeted days represent the hot season in Amman, Table 3 represent the temperatures in Amman city. The minimum mean temperature is high in the period between July 21st, and September 21st; and the Insolation is high too. The solar radiation was estimated as a percentage of the most available incident solar radiation on building facades (east, west, and south). In order to find these variables, we followed the process below:

The rectangle has been chosen as our geometric shape to calculate the tree shades. The dimensions of the basic shapes of the trees are shown in Table 2.

Geometric shape Rectangle Include the thick of foliage and sparse branches are left out of it (Tables 2 and 3).

From the table above we can figure out that the most heat gain is in July; since the high temperature values were during summer season.

To calculate the solar energy on building facades (east, west and south) we used the equations (3) and (4). We calculated the solar energy in both cases: the existence and the absence of trees, for the selected locations as shown in Figures 1,5 and 6.

I direct=1/3 * (Global irradiation) (3)

Energy on vertical surface=(direct solar radiation) (cos(φ)) (4)

Where (φ): is the angle between the solar rays and the vertical line (Figure 7).

The total incident solar energy on facades was simulated based on the calculated percentages of shaded area on building facades. The results showed the total incident solar energy on unobstructed facades, percentage of shaded area, actual incident solar power on facades, obstructed solar power on facades and the loss of solar energy attributed to the sun blockage by trees for July 21st as noted; in Table 4 for east facade, Table 5 for west facade, Table 6 for south façade.

For September 21st, the results show that there is significant shaded area of south building facades as noted. (Tables 4-7) (Figure 8).

To calculate the insolation efficiency on facades (east, west and south) in July 21st, we studied the insolation patterns drown for our model as shown in Figure 6 and by using equation (5). The results were presented in Table 8.

power on facades is reduced to be 54.30 KW, which means 5.5% lower. As noted in Table 8. Shade coverage reduces electricity consumption for cooling. However, not all shade is created equal; dense shade provides signi cantly more cooling in the summer than does moderate or light shade [13,14].

Our ndings showed the impact of tree shade on summer time energy use, increasing the overall amount of tree shade reduces energy used for cooling, late a ernoon shade, typically cast from trees on the west and south sides of a building in the summertime, reduces energy consumption more than morning or early a ernoon shade.

As results show, there is a signi cant reduction in summertime residential energy consumption, as compared to no shade. is nding has implications for the tree species that plant while realizing the energy savings in the future, such savings will be homeowners maximized by tree species with dense leaf canopies during the hot summer months, trees location (o set from the façade).

 e tree species in our study are Mimosa (*Albizia julibrissin*), Royal Poinciana (*Delonixregia*), and Common Fig (*Ficus*carica). All of these species lose their leaves during the winter months, thus homeowners enjoy the bene ts of reduced cooling costs due to relatively dense shade during the summer while there is no negative impact on heating costs due to winter.

Homeowners should be aware of relevant economic bene ts from tree shade; they have little direct incentive to plant trees and/or leave trees near their homes. Unless and until these directly-a ected parties can be 'shown the money' they will continue to make completely rational and predictable decisions that, for the most part, ignore the energy conservation bene ts from shade trees [10,11,15,16].

Conclusions

Our ndings added to the literature showed that there are potential energy savings using trees as external shading devices. A modeling method to assess the e ect of tree shade was developed. Simulations have helped to better understand the impact of tree shade on cooling energy consumption. For climates such as Amman, these bene ts area greatest when using deciduous trees which allow passive winter heating, exactly as suggested in our model.

Besides energy consumption reduction trees can improve air quality lowering ambient temperature and hence reducing the formation of urban smog.

Future studies are recommended to assess the major cost of tree planting programs. It is quite possible to design a low-cost tree-planting program.

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