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LIFE-CYCLE COSTING OF PLANT MATERIALS FOR RESIDENTIAL ENERGY CONSERVATION

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Abstract. **Engineering economic analyses for the life-cycle costing of plant materials for energy conservation are presented. Results are presented in the form of effective annual returns on investment. The analyses are performed on defined low energy and high energy residential landscapes. In all analyses, the purchase price, establishment costs and yearly maintenance expenses for pesticides, water and fertilizers are included.**

The analyses indicate effective annual returns on investment of 49.4% for plantings in a low energy landscape compared to a high energy landscape with no plants for an energy escalation rate of 20% over a 20 year life period. Other analyses indicate that an investment of $3,000 in a low energy landscape with native plantings yields a 20.6% return on investment for a 20% energy escalation rate over a 20 year life period.

Energy used in buildings for heating and cooling throughout the year accounts for a substantial portion of total energy consumed in the United States—a recent study reported that comfort conditioning of all buildings occupied by people requires 32% of energy consumed (11).

A qualitative discussion of the use of plants to reduce energy expenditures for comfort conditioning has been presented by many (1, 5, 10). Black (1) has discussed the use of different species of trees, vines and espaliered plants for protecting buildings from intense solar radiation. A quantitative economic approach on the value of various landscaping features has been presented by Buffington (3) for nine site-specific locations in Florida. His computer simulation results were summarized by evaluating the annual expenditures for cooling and heating a specified concrete block house with "low energy" and "high energy" landscaping designs. The "low energy" landscape consisted of heavy shade on light-colored walls and roof and an east-west orientation. The "high energy" landscape referred to a house with no shade on dark-colored walls and roof and a north-south orientation. The differences in present worths in Orlando of the "low energy" and "high energy" landscape for a 20 year life were $2,467, $5,624, and $14,820 for annual energy cost escalation rates of 10, 20 and 30% respectively, and for an assumed interest rate of 15%. For a 20% energy cost escalation rate, an interest rate of 15% and a 20 year life period, the present worths of the low energy versus high energy landscape designs varied from $3,939 in Tallahassee to $9,010 in Miami. Similar results were also presented for a wood frame house.

In evaluating the benefits of shading and other landscaping features for reducing energy expenditures for comfort conditioning residential buildings as discussed above, the costs associated with acquiring and maintaining the vegetation were not included.

The objective of this reported research was to determine the life-cycle costs of plant materials for energy conservation in Orlando, Florida. The costs of acquiring and maintaining the plant materials (pesticides, water, and fertilizer) were included in all life-cycle analyses.

Methodology

Computer simulations were used to perform detailed analyses of the thermal performance of concrete block and wood frame residential buildings as a function of 12 different combinations of landscaping features. The landscaping features considered were: 1. shading levels on walls and roof, 2. exterior colors of walls and roofs, and 3. building orientations.

The computer simulations were performed for Orlando, Florida with the Typical Meteorological Year (TMY) as developed by the National Oceanic and Atmospheric Administration used as the weather data set input (12). A description of both the concrete block and wood frame control houses and a discussion of the economic present worths of each landscaping feature for Orlando, Florida are presented by Buffington (4) in the previous manuscript in this Proceedings of Florida State Horticultural Society. Full details of the computer simulation analysis for evaluating the thermal performance of residential buildings are also presented by Buffington (2). Floor plan and side views of the control house used in this study are shown in Fig. 1.

The simulated yearly expenses for comfort conditioning the concrete block control house are presented in Table 1. The unit costs of the utilities used in the simulation analyses

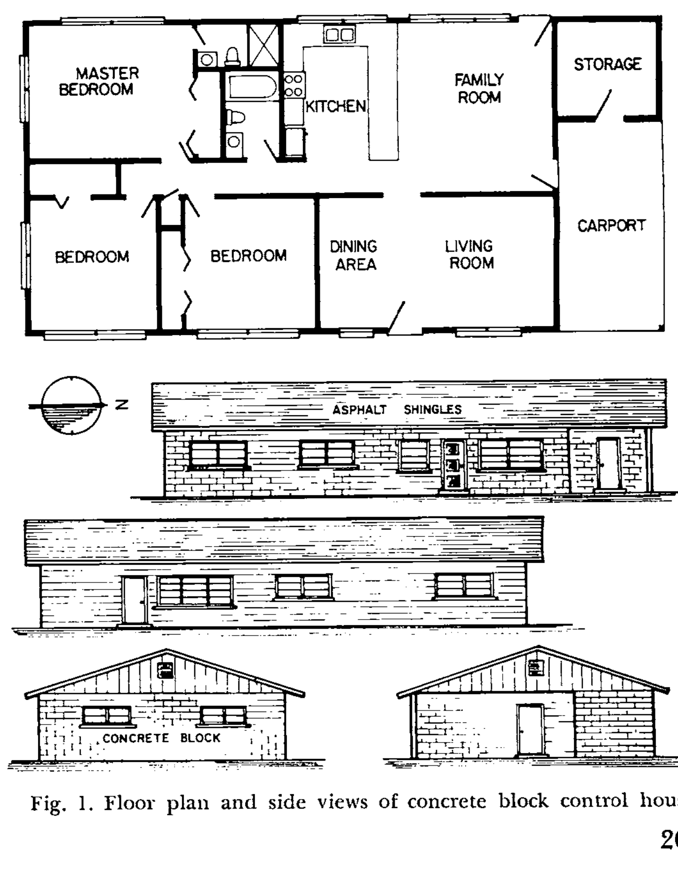

Fig. 1. Floor plan and side views of concrete block control house.

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Table 1. Simulated yearly expenses for comfort conditioning concrete block structure.

	Cooling	Heating	Total
	$	$	$
Control house	728	134	862
Modification			
Orientation			
East-West	680	140	821
Wall shading			
Light shading	684	137	821
Heavy shading	632	139	771
Roof shading			
Light shading	703	135	838
Heavy shading	681	132	813
Full shading	664	134	799
Wall and roof shading			
Light shading	665	138	803
Heavy shading	589	140	729
Exterior colors			
Dark-colored walls and roof	804	126	930
Light-colored walls and roof	683	139	822
Overall comparison			
High energy landscaping	804	126	930
Low energy landscaping	565	156	721

were $0.06 per Kw-hr of electricity and $1.35 per gallon of No. 2 residual fuel oil for Orlando in Autumn, 1981.

Estimated yearly expenses for maintaining a shrub in Orlando were:

$1.00 for pesticides
0.30 for water
0.05 for fertilizer

These estimated yearly maintenance costs per shrub were based on studies reported by Ingram and Black (7), Parker (9), and Case (6). The estimated purchase, establishment and maintenance costs for the first year were assumed to be $10.00 per shrub. The maintenance expenses associated with several shade trees in the landscape were estimated to be $100 every five years for pruning and trimming.

In the analyses involving the use of native plantings in the landscape, the first year expenses for purchase, establishment and maintenance remain at $10.00 per shrub; however, the yearly maintenance costs thereafter are only 35% of the maintenance costs for other shrubs. This reduced maintenance costs, as suggested by Ingram (8), is justifiable because the plantings are more suited to the natural Florida environment, especially if the native plants are situated in a micro-environment similar to their native habitat.

In all the life-cycle costing analyses, no charges were assessed for labor inputs or expenses associated with required equipment and tools.

The concrete block control house as shown in Fig. 1 is referred to as a high energy landscape. A low energy landscape for the house is shown in Fig. 2.

The high energy landscaping corresponded to the control house with north-south orientation, no shading on the walls or roof, and dark-colored exterior walls and roof. The low energy landscaping corresponded to the control house with east-west orientation, heavy shading on walls and roof, and light-colored exterior walls and roof.

Results and Discussion

The parameter used in all the engineering economic analyses of life-cycle costing of plant materials for energy conservation was the effective annual return on investment. Return on investment is a convenient parameter because one can compare the return rate earned through energy conservation to the interest rate he would have to pay to borrow money in order to invest in the energy conservation alternative. For the situation when a person has his own financial resources, then he is able to compare the return rate earned through energy conservation to the interest rate being earned from other investments.

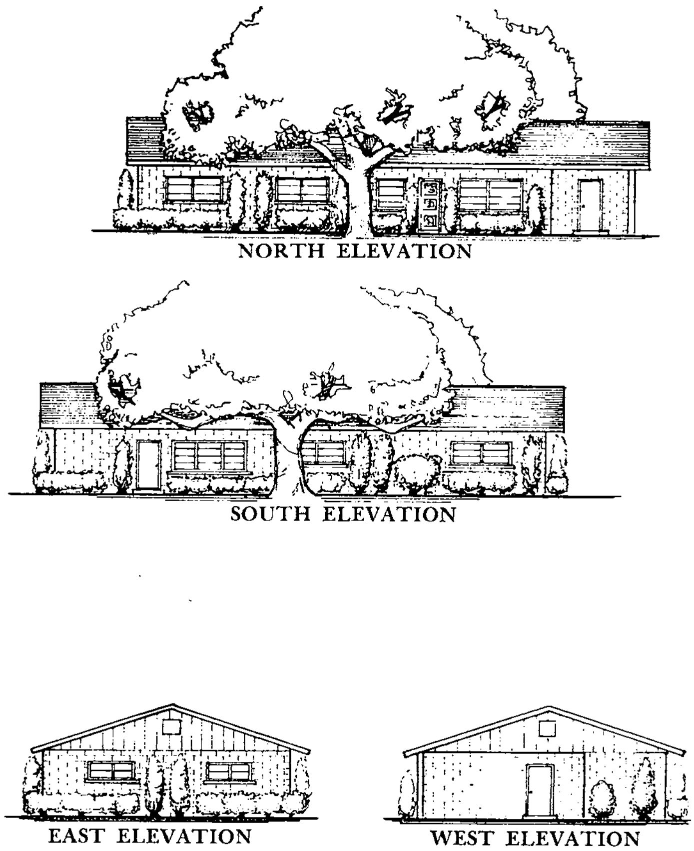

Fig. 2. Elevation views of concrete block house with low energy landscaping design.

The simulated yearly savings of the low energy versus high energy landscape for the control house in Orlando is $209. This figure is obtained from Table 1 by subtracting the simulated yearly expenses for comfort conditioning the high energy landscape ($930) and the low energy landscape ($721).

The control house with the low energy landscape requires about 38 shrubs and two large shade trees as shown in Fig. 2. Using the assumed values of $10.00 per shrub for the first year and $1.35 per year thereafter, a cash flow diagram over a 20 year period was developed as shown in Fig. 3 for the case of a 10% annual increase in both energy costs and maintenance costs. For this particular case the annual return on investment in the shrubs and their maintenance is 51.5%. Results of the engineering *economic* analyses for escalation rates ranging from 0 to 30% and for 10 and 20 year life periods are presented in Table 2.

For the case of incorporating the once every five years cost of $100 for pruning and trimming the two shade trees, the cash flow diagram over the 20 year period for 10% cost escalations is shown in Fig. 4. The annual return on investment in shrubs and maintenance for shrubs and trees is 40.0%, as presented along with additional results in Table 3.

The tangible advantage of incorporating native shrubs into a landscape is the reduction in maintenance expenses for the plants. For the case of using native shrubs for all

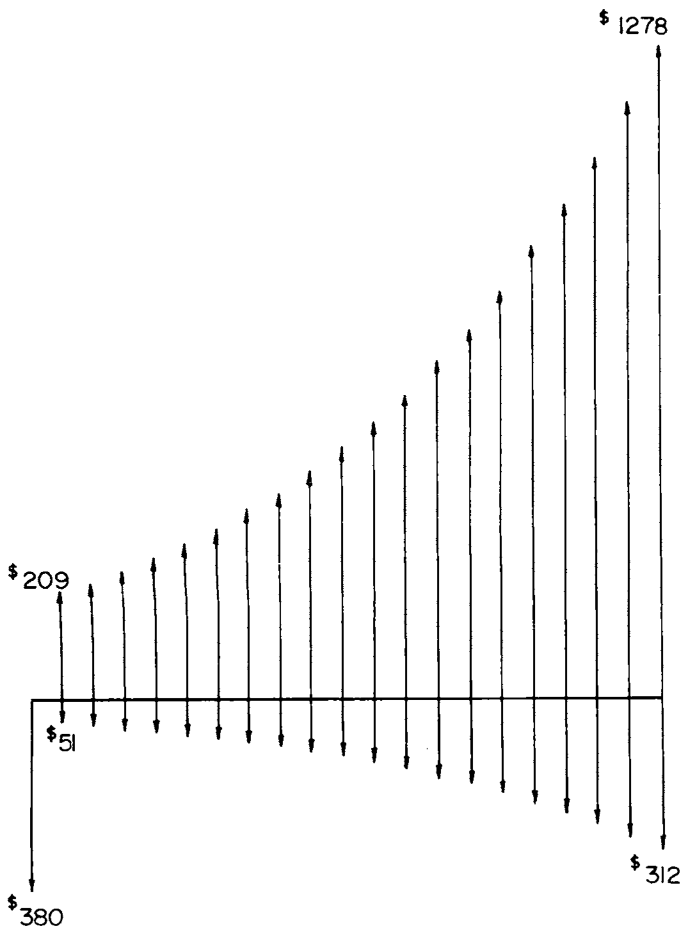

Fig. 3. Cash flow diagram for benefits of low energy landscaping with establishment and maintenance expenses of shrubs for a 10% annual energy cost escalation rate and inflation rate.

Table 2. Engineering economic analyses of the low energy landscape with first year establishment costs and yearly maintenance costs for shrubs versus high energy landscape.

Energy escalation and inflation rate	Life period	Annual return on investment
0%	10 Yr.	40.1%
	20	41.5
10	10	49.6
	20	51.5
20	10	59.1
	20	61.4
30	10	68.4
	20	71.4

vegetation in the landscape, the engineering economic results are presented in Table 4. In this case, the yearly maintenance expenses were 35% of the expenses assumed for the non-native shrubs as discussed earlier.

The data in Tables 2-4 indicate that as the energy escalation and inflation rates increase, there is a corresponding dramatic increase in the effective annual returns on investment. Also as the life periods in the analyses increase from 10 to 20 years, there is a corresponding, but less dramatic, increase in returns on investment.

The results in Table 5 provide the effective annual returns on investment for various capital investments ranging from $1,000 to $6,000 for a residential building with a low energy landscape of native plantings compared to a high energy landscape. As indicated in Table 5, an invest-

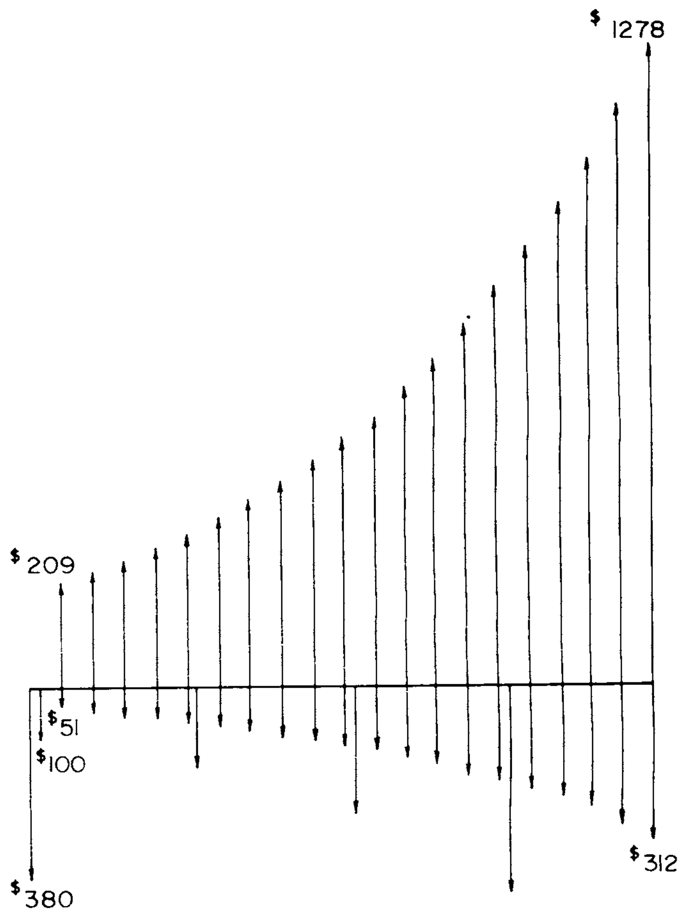

Fig. 4. Cash flow diagram for benefits of low energy landscaping with establishment and maintenance expenses of shrubs and once every five years expense for trees for a 10% annual energy cost escalation rate and inflation rate.

Table 3. Engineering economic analyses of the low energy landscape with first year establishment costs and yearly maintenance costs for shrubs and once every five years tree maintenance versus high energy landscape.

Energy escalation and inflation rate	Life period	Annual return on investment
0%	10 Yr.	27.9%
	20	30.4
10	10	36.7
	20	40.0
20	10	45.2
	20	49.4
30	10	53.6
	20	58.9

ment of $5000 for purchase of a low energy landscape yields a 15.2% return on investment over a 20 year life for an energy escalation rate of 20%.

It is readily apparent from all the analyses presented that an investment in a low energy residential landscaping becomes increasingly attractive as the prices of energy escalate in the coming years. Investment in landscaping materials today provide a "hedge" against the ever-increasing utility prices.

Summary

Landscaping features have been long recognized for their ability to reduce energy expenditures for comfort

Table 4. Engineering economic analyses of the low energy landscape with native plantings with first year establishment costs and reduced yearly maintenance costs for shrubs and once every five years tree maintenance versus high energy landscape.

Energy escalation and inflation rate	Life period	Annual return on investment
0%	10 Yr.	35.9%
	20	37.7
10	10	44.9
	20	47.3
20	10	53.8
	20	56.8
30	10	62.6
	20	66.4

Table 5. Engineering economic analyses of various capital investments for low energy landscape with native plants versus a high energy landscape over a 20 year life period.

Capital investment	Energy escalation and inflation rate	Annual return on investment
$1000	0%	18.4%
	10	28.2
	20	37.9
	30	47.5
2000	0	7.1
	10	16.5
	20	25.8
	30	35.1
3000	0	2.4
	10	11.5
	20	20.6
	30	29.7
4000	0	—
	10	8.5
	20	17.5
	30	26.3
5000	0	—
	10	6.4
	20	15.2
	30	24.0
6000	0	—
	10	4.8
	20	13.6
	30	22.1

conditioning buildings. The engineering economic analyses presented here provide the effective annual returns on investment of the low energy versus high energy landscapes for residential buildings. The purchase price and maintenance costs (pesticides, water, and fertilizer) are included in all the analyses.

Perhaps the most effective way to educate people of the need to conserve energy is to first convince them how they can save money by conserving energy. Therefore, the results presented in the manuscript should serve as a useful tool in promoting the use of plants for landscaping. In addition to reducing energy expenditures for comfort conditioning, a low energy residential landscape will generally enhance the aesthetic value of a residence.

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ECONOMICS OF RESIDENTIAL LANDSCAPING FOR ENERGY CONSERVATION—A STATEWIDE PROGRAM[1]

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Additional index words. Energy conservation, shading, vegetation effects.

Abstract. **Economic feasibilities of various landscaping designs are presented for a statewide program in Florida for nine locations throughout the state. The economic feasibilities of various: 1. shading levels on walls and roofs; 2. exterior colors of walls and roofs; and 3. building orientations for conserving energy in heating and cooling residential buildings are presented. The effectiveness of each landscaping feature for concrete block and wood-frame houses is evaluated on the basis of its present worth in terms of energy savings that accrue because of the adoption of the landscaping feature. Present worths are calculated for interest rates ranging from 5 to 20% and annual energy cost escalation rates ranging from 0 to 30% for 10 year and 20 year life periods. Detailed analyses are presented in this paper**

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