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CIVIL ENGINEERING RESEARCH

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ANALYZING, EVALUATING, AND QUANTIFYING THE THERMAL ENERGY CONTRIBUTIONS OF THE PASSIVE SOLAR-HEATING ELEMENTS INCORPORATED IN THE DESIGN AND CONSTRUCTION OF THE PLUMBLEE RESIDENCE LOCATED IN ALAMANCE COUNTY, NC

Presented By

Mark A. Terrell
Graduate Student

Under the Direction of

Dr. Michael L. Leming
Associate Professor, Construction Engineering & Management

August 2004

DEPARTMENT OF CIVIL ENGINEERING
NORTH CAROLINA STATE UNIVERSITY

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ABSTRACT

Currently, nationwide efforts are being made to help policymakers, construction professionals and consumers become more aware of the benefits of incorporating sustainable energy principles in residential building design and construction (Miller 1996). Any success in applying these principles is the result of effective communication by design professionals to builders and homeowners in understanding cost benefit tradeoffs for using sustainable energies in homes. The Gordon and Janice Plumblee Residence, located on 1742 Routh Road in Burlington, NC, is an example of how passive solar-heating design elements, along with simple conventional construction techniques, have created a comfortable, affordable, and low-energy consumption home.

This report evaluates the passive solar and energy conservative elements incorporated in the Plumblee Home and quantifies the significance of each element energy contribution. A model of the thermal performance of the home is compared to the actual performance. The accuracy of the model is verified. The modeling software is used to perform a sensitivity study of the thermal performance. An analysis of the construction methods and materials used is presented.

ACKNOWLEDGMENTS

Sincere appreciation is extended to homeowner, Mr. Gordon Plumblee for his permission to use his home in this study. Mr. Plumblee, a former high school biology instructor, provided critical data on monthly electricity usage for his home over a period of eight years along with other information relating to the operational aspects of the home. Sincere gratitude is also extended to Dr. Herbert M. Eckerlin, PE and Professor of Mechanical & Aerospace Engineering for the technical review and assistance in analyzing the thermal performance of the home. Significant gratitude is also given to Mr. Rex S. Terrell, Contractor of Record, for providing construction details and cost estimates.

Special thanks are extended to Ms. Debra R. Coleman, AIA of Sun Plans Inc., Architect of Record, for the recommendation of which software program to use for modeling the home and to Ms. Dona Stankus, AIA of NC Solar Center for providing a copy of the software for the study.

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1. Introduction

Passive solar-heating elements used in residential home design and construction offer significant benefits in advancing to more sustainable energy usage nationwide. Capturing the free heat directly from the sun in a controlled environment of a passive solar home makes solar energy economically and environmentally more attractive (Chiras 2002). In addition, the natural sunlight brought in from large, south-facing windows brightens the interior. Passive solar features that utilize the benefits of sunlight aid in lower energy consumption of other nonrenewable energy sources and provide natural lighting as a delightful comfort for home occupants (Rucker 1992).

Passive solar design is based upon understanding the principles of heat transfer through various building surfaces. Residential homes experience heat gains or losses through elements such as windows, doors or chimneys, and through ceilings, walls, floors, and air infiltration. Determining whether the heat transfer is either a loss or a gain is a function of the seasonal changes in the motion of the earth around the sun. For the earth's northern hemisphere, the sun track is higher in the sky during the summer (cooling season) and lower during the winter (heating season). The seasonal location of the sun, combined with the construction details of the home, affect how much heat loss or solar gain is experienced. Designers understanding heat transfer concepts can incorporate passive solar-heating principles in the design of any style home (Chiras 2002).

The case study home in this report is the residence of Gordon and Janice Plumblee located in Alamance County, NC. The Plumblee Home is a "direct gain" passive solar home. This means that the house collects, stores, and distributes the solar heat throughout the house.

1.1. Professional Guidelines for Passive Solar Homes

Passive solar design applies energy-saving techniques using conventional design and construction practices as incorporated in the Plumblee Home. Debra Coleman, Architect for the Plumblee Home, prescribed the following passive solar design factors for creating a comfortable, low-energy consuming home (Rucker 1992):

1. Home orientation, shape, and floor plan.

   The floor plan is oriented with the elongation in the east-west direction allowing the long exterior walls to face north and south. Heat generating rooms such as the kitchen and laundry are located on the colder northern side. Living areas intended for more frequent use share the common south-facing wall. A rectangular configuration without projections from the south wall is preferred in order to place south-facing windows to receive winter sun. Any protrusion to the south will shade adjacent windows (Rucker 1992).

2. Window placement and shading.

   Passive solar homes benefit from receiving sunlight. The maximum recommended south-facing window area is 12% of the floor area. North, east, and west windows should not exceed 4% of the floor area (Chiras 2002). Special attention is required for designing roof overhangs including gutters. Overhang lengths without gutters vary from 3.5 feet in hot climates to only 12 inches for colder climates. The south eaves will shade the windows from high summer sun but allow low winter sun to penetrate deep into the home (Rucker 1993). Professional consultation is advised for specific situations.

3. Heat-absorbing materials.

   In order to moderate inside temperature changes and to prevent overheating of the home, thermal masses or heat-absorbing materials are utilized to collect or store heat from solar

gains. Brick chimneys or concrete floors covered with stone, decorative tile, or brick pavers serve as heat-absorbing thermal mass adding additional comfort and aesthetics to the home.

4. Insulation and air infiltration control.

   No additional insulation is required above current regulations. Prior to insulating all building-envelope surfaces, joints are carefully caulked around exterior walls and intersecting floors and ceilings. Exterior walls and ceiling receive a continuous vapor barrier sealed from any penetration or tear. Doors, windows, electrical boxes, and pipe penetrations are sealed and foamed around. Energy-efficient windows and inner doors separating entryways and main living spaces are recommended. These extra precautions minimize air infiltration (Rucker 1992).

5. Mechanical system.

   Passive solar homes require less heating because of south-glazing solar gains in the winter and less cooling due to overhang shading in the summer. A heating, ventilation, and air-conditioning (HVAC) system complementing these passive solar features is essential (Chiras 2002). Again, professional consultation is advised for specific situations.

6. Quality control of construction methods and materials.

   Respect and understanding of energy-efficient design and concepts is necessary during the construction phase of a passive solar home. A comfortable, low-energy home is only achieved by abiding to the details provided in blueprints and energy-efficient specifications (Rucker 1992).

1.2. Limitations of Passive Solar Design

Optimal performance and desired comfort are best achieved when the basic principles of passive solar design are applied under professional supervision. The ratio of south-facing

windows to thermal storage mass directly affects the overall thermal performance of the home. The auxiliary heating system may require additional runtime during the winter if the amount of south-facing windows is less than optimal. Otherwise, undersized thermal mass can cause daytime overheating. Although some remediation can be performed after construction, the basic shape, cross-sectional construction, and orientation of the home cannot easily be changed later. Therefore, having the home's insulation details, air infiltration control, and major axis oriented east-west are essential fundamentals for an effective passive solar home (Chiras 2002).

1.3. Description of Plumblee Home

Figure 1 – Southeast View of Plumblee Residence (photo by Gordon Plumblee)

The Plumblee Home located in central North Carolina is secluded by surrounding farmland and natural landscaping overlooking a private lake. The exterior façade is cypress beveled siding covered on the north and east sides by a wrap-around porch. This single-story home has an

abundance of south-facing windows with brick veneer covering the foundation and southwest corner along with the northwest garage wall.

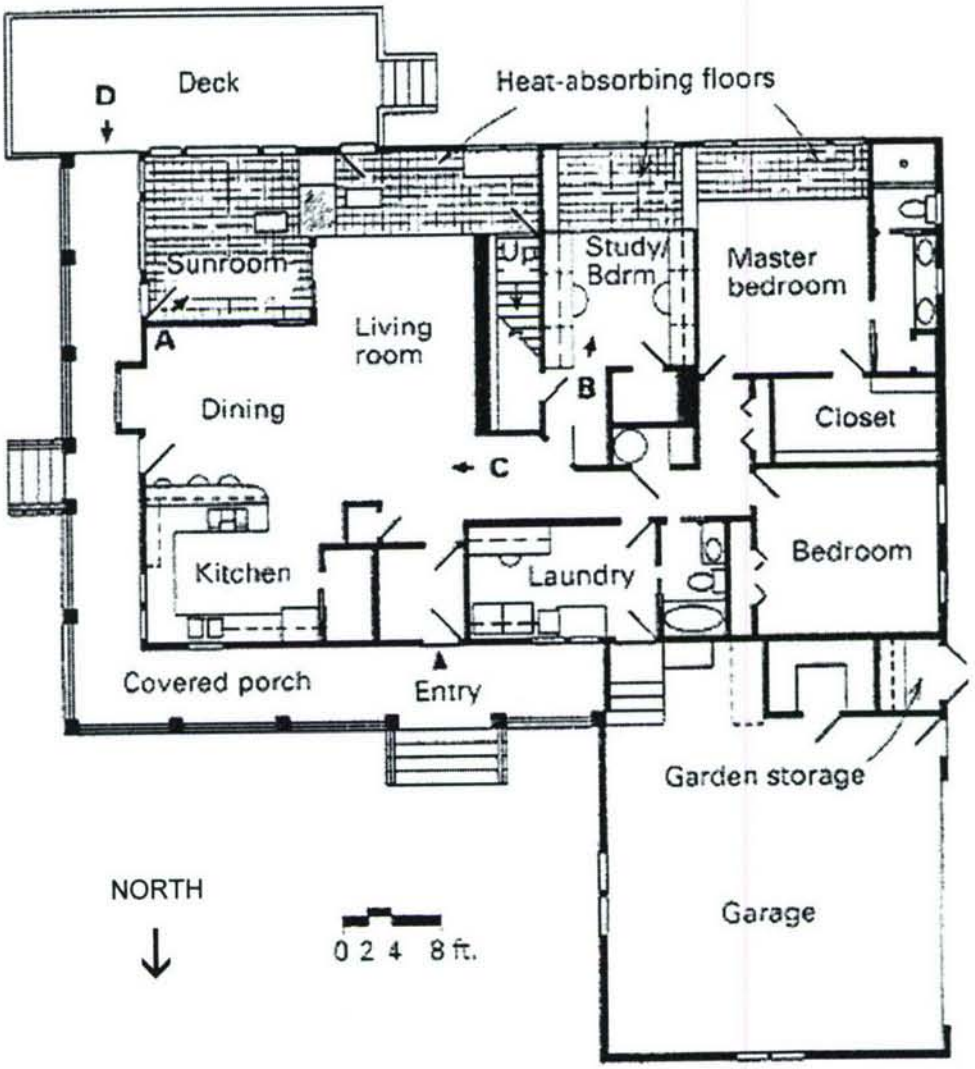

Figure 2 – Floor Plan of Plumblee Residence (Rucker 1993)

The 2160 square-feet home has its major axis oriented east-west to make the long south-facing wall available to the sun. Interior features include vaulted ceilings over kitchen and living space, hardwood floors, French doors, brick hearth, and brick pavers on the floor adjacent to the south-facing windows providing natural sunlight. The living room, study, master bedroom, and sunroom share the common south-facing exterior wall allowing the home occupants to

experience the view and desirable comfort provided by the windows. The kitchen, laundry, and other heat generating rooms are located on the colder northern side.

1.4. Design and Construction Professionals Involved

The successful completion and high energy-efficient performance of the Plumblee Home is a direct result of effective communication and comprehensive understanding of the design details and construction aspects by all parties involved in the building of the home. Debra R. Coleman, AIA provided the design documents and drawings based on the homeowner's desired characteristics. Harry Boody, PE of Guaranteed Energy Efficient Systems, Inc. was responsible for the insulation, caulking, vapor barrier, and mechanical system installation. Rex S. Terrell, a homebuilder from Burlington, NC, provided the quality construction supervision, adhering to the energy-conserving and comfort details desired by the homeowner (Rucker 1992).

1.5. Overview of Energy-10 Software

Energy-10 is a creditable software analysis program for conceptual design of energy-efficient buildings produced by the U.S. Department of Energy (DOE) at the National Renewable Energy Laboratory (NREL). The program allows professional solar designers to predict the energy performance of a small-size facility to achieve optimal comfort, performance, and economy (Chiras 2002).

The selection of using Energy-10 was recommended by Ms. Debra R. Coleman, AIA of Sun Plans Inc. Ms. Coleman, knowing the popularity of the software among passive solar designers, felt the thermal simulation analysis by Energy-10 would provide insight in the effects of passive solar and energy conservative features incorporated in the Plumblee Home.

2. Research Significance

The various passive solar features of the Plumblee Home have created a comfortable, low-energy use home (corresponding with the homeowner). The contributions of the various thermal energy features built into the home have not been fully quantified. This report provides an important addition to the body of knowledge of passive solar home performance and will be of significant value to the engineer, architect, planning commissions and other parties implementing effective passive solar and energy efficient home design. Unique, long term operating data on the energy consumption of the Plumblee Home is available from the homeowner. The completeness of this data makes the home an ideal candidate for further detailed analysis. Little information exists in the published literature which provides quantitative estimates of the effects of passive solar and energy conservative features incorporated into residential dwellings.

2.1. Research Objectives

1. Analyze and evaluate the actual thermal performance of the Plumblee Home.
2. Model the predicted thermal performance with a creditable energy efficiency software program for sustainable buildings.
3. Compare the actual thermal performance with the modeled thermal performance and verify the software output for general conformance.
4. Evaluate and quantify the thermal energy contributions of the various passive solar and energy conservative elements in the Plumblee Home.
5. Identify the effect of the various passive solar energy conservative elements in terms of cost savings.
6. Identify ways to improve the thermal performance of the Plumblee Home.

3. Methods Used for Resolution

In order to quantify the impact of each feature, the actual total thermal energy use was compared with the total projected use simulated in the software modeling program. The various solar and energy conservative features were then incorporated into the model to determine their effect to the overall house performance. The thermal energy contribution of each feature was ranked and evaluated.

The following procedures established the database used in this study:

1. Gather and classify information to establish the database.
    a. Collect actual energy use records from the homeowner and develop graphical representations suitable for analysis.
    b. Collect historical weather and climatologic data from the National Oceanic and Atmospheric Administration (NOAA) for Burlington, NC.
2. Select a creditable software analysis program which can simulate the thermal performance of a passive solar and energy conservative home.
3. Verify accuracy of the software modeling program for general conformance with actual data.
    a. Model and estimate the projected annual thermal energy performance of the passive solar home using the software program.
    b. Compare the actual annual energy use with the modeled annual energy use projected by the software program.
    c. Verify that the modeled performance is acceptable as a reasonable projection of annual energy use for the Plumblee Home.
4. Use the software modeling program to conduct sensitivity analyses of the thermal performance of the home.

a. Vary different passive solar and energy conservative features using the software program to quantify the significance of each element incorporated in the Plumblee Home.

4. Thermal Performance Derivations

The objective of obtaining a detailed energy use analysis of the Plumblee Home involves collecting the actual energy use consumed annually and modeling the projected annual energy use. The meticulous records kept by Mr. Gordon Plumblee, have provided critical information for modeling the thermal performance efficiency of the home. Monthly meter readings from separate meters for the total house electrical load and the HVAC system load were recorded by Mr. Plumblee for the first eight years of operation. Thus, the actual thermal performance was determined by simply separating the heating and cooling loads from the total house load.

However, modeling the thermal performance is not simple. Thermal performance modeling requires information on specific details of the home, as well as the living style of the home occupants, for input into the selected energy performance design software, Energy-10.

4.1. Summary of Data Entry for Energy-10

The Plumblee Home is a single-story dwelling of two occupants with 2160 square-feet of conditioned living space and 768 square-feet of unconditioned garage and storage. The home is heated and cooled with a heat pump based on an average electricity rate of $0.069 per kilowatt-hour of usage for the period of 1991 to 1994. All climatology and weather data used in Energy-10 for this analysis is from historical data reported in Greensboro, NC, the nearest reporting weather station to the actual home site in Burlington, NC.

The home is oriented with the main surface area of glazing due south. The south-facing windows account for 206 square-feet of glazing bordered by cypress trim-siding. The north and east exterior walls are constructed with the standard 2 x 4 stud frames, R-13 batt-insulation, and polyisocyanurate foam board. A covered porch finished with cypress siding also extends along the north and east façade. The western portion of the exterior including the garage is covered with brick veneer. The north, east and west glazing areas are 33, 79, and 25 square-feet respectively.

Roof construction for the home consists of trusses with attic storage space. R-30 batt-insulation is over the western portion of the home and R-30 blown-in insulation over the cathedral ceilings of the living room, dining room, and kitchen. The overhangs have 17 inches of eaves with a 4 inch gutter to provide adequate summer shading for this passive solar home. The covered porch extends 6 feet from the main house along the north entrance and east side of the house.

Floor construction is framed over a crawlspace block foundation. Basic floor construction is hardwood finish over plywood sub-flooring framed with 2x10 joists at 16 inches on-center spacing and R-19 batt-insulation. The laundry room and bathrooms are vinyl floors. Brick pavers cover 360 square-feet of floor space adjacent to the south-facing windows serving as thermal storage mass (along with the brick chimney and hearth). The floor construction under the brick pavers consists of 4 inches of concrete over 2x12 joists at 12 inches on-center spacing and R-19 batt-insulation.

The heat pump has a high coefficient of performance (COP) of 3.02 and a low COP of 2.14 for the heating season, with a seasonal energy efficiency ratio (SEER) of 10.1 for the cooling season. The air-handling unit and insulated ductwork for the heat pump are located in

the crawlspace. Thermostat comfort set-points are 68 degrees-Fahrenheit for the heating season and 77 degrees-Fahrenheit for the cooling season. The total conditioned house volume accounts for 18,653 cubic-feet of living space. The average air infiltration rate for the living space is 0.22 air-changes per hour (ACH), based on the blower door tests conducted by Duke Power Company in August 1993 (Plumblee 2004).

The internal gains affecting the overall thermal performance of the home are a function of the interior and exterior lighting loads, the occupancy schedule, the hot water usage, and other electrical loads from basic operating appliances. These loads given in peak watts per square-foot, with their associated hourly profiles and schedules, are listed in Appendix A along with a more detailed review of the building construction described above.

4.2. Modeling: Energy–10 Software Program

Energy-10 was validated using the BESTEST protocol. The BESTEST procedure was developed within the International Energy Agency Solar Heating and Cooling Program, and was adopted by DOE and the international community as the accepted basis for verifying the credibility of computer simulation programs. The procedure verified the simulation results of Energy-10 for two defined hypothetical buildings, a low-mass building and a high-mass building. The simulation is considered to be credible if the given results fall within or close to the range of results obtained using other simulation programs. Thermal simulations produced by Energy-10 were reported by the developers as performing "very well" in comparison to the BESTEST standards (Energy-10, Help Topics – Version 1.5, 2002).

The thermal performance model of Energy-10 incorporates heating energy, cooling energy, heat loss, and solar gain along with the effects of added thermal mass, shading design, glazing, building orientation, and air infiltration control. Simulated results involve calculating the home's

thermal performance relative to desired indoor temperature and overall heat transfer, including both losses and gains. The amount of useful solar energy provided to the home is dependent on solar radiation as well as conduction losses, air infiltration losses, and heat gains from internal loads. The auxiliary space heating or cooling required is the amount of the load not provided by solar energy or thermal storage.

The rate of heat loss is determined by the resistance to heat flow (R-value) of various building elements for the walls, floors, ceilings, windows, doors, etc. The overall coefficient of heat transfer (U-value) is determined for each exterior building surface as the reciprocal of the sum of the R-values. The rate of conduction heat loss is the total surface area multiplied by the calculated U-value of the surface and the temperature difference. Ultimately, the total space heat loss is then the sum of the conduction losses and air infiltration losses through the various building surfaces (Mazria 1979).

Energy-10 is intended to be used during the conceptual design phase before construction documents are prepared. For this research, the actual energy performance of the Plumblee Home had already been monitored and recorded as monthly electric power usage. Therefore, the projected model desired from Energy-10 is calibrated by actual performance data. Furthermore, the modeling capability of Energy-10 allowed the contribution of each passive solar and energy conservative feature to be estimated. The individual significance of each feature was evaluated by either adding or subtracting each solar element from the input data of the model simulated in Energy-10.

4.3. Actual Performance: Meter Readings Recorded by Homeowner

The actual thermal performance of the Plumblee Home was derived from the metered electricity usage recorded monthly for the total house load and the HVAC system load. The

HVAC system load is subtracted from the total house load to provide the power usage for the auxiliary appliances, lights, and other internal gains. The power usage recorded in terms of kilowatt-hours (kWh) was converted to thermal energy use in terms of British-thermal-units (BTU) using the conversion factor of one kWh is equal to 3,415 BTU. Bar graphs of the annual energy use for the home are provided in Appendix B showing the monthly HVAC system load and total house load.

The modeled output report from Energy-10 displays the annual energy use generating a bar graph of the heating load, cooling load, lighting load, other house loads, and total load. The output is in terms of thousand British-thermal-units of energy per square-feet of conditioned living space ($kBTU/ft^2$). In order to verify the modeled output for general conformance, the actual HVAC system load metered is divided into heating and cooling season loads for comparison to the model report. The homeowner reported that the thermostat was changed in October for the heating season and during April or May for the cooling season. Therefore, the heating season form the Plumblee Home runs from November to March and the cooling season from June to September. Climatology data from the National Climatic Data Center of the National Oceanic and Atmospheric Administration (NOAA) was retrieved online for the monthly annual heating degree days and cooling degree days and used as a guide for verifying the actual months of the heating and cooling seasons.

5. Discussion of Results

The results of the thermal analysis of the Plumblee Home, as modeled by Energy-10, correlated well with the actual thermal performance of the house. The effect of various passive solar and energy conservative measures on the performance of the home was evaluated. These measures were evaluated and ranked according to their heating contribution to the house.

5.1. Verification of Model

5.1.1. Data Evaluation and Analysis

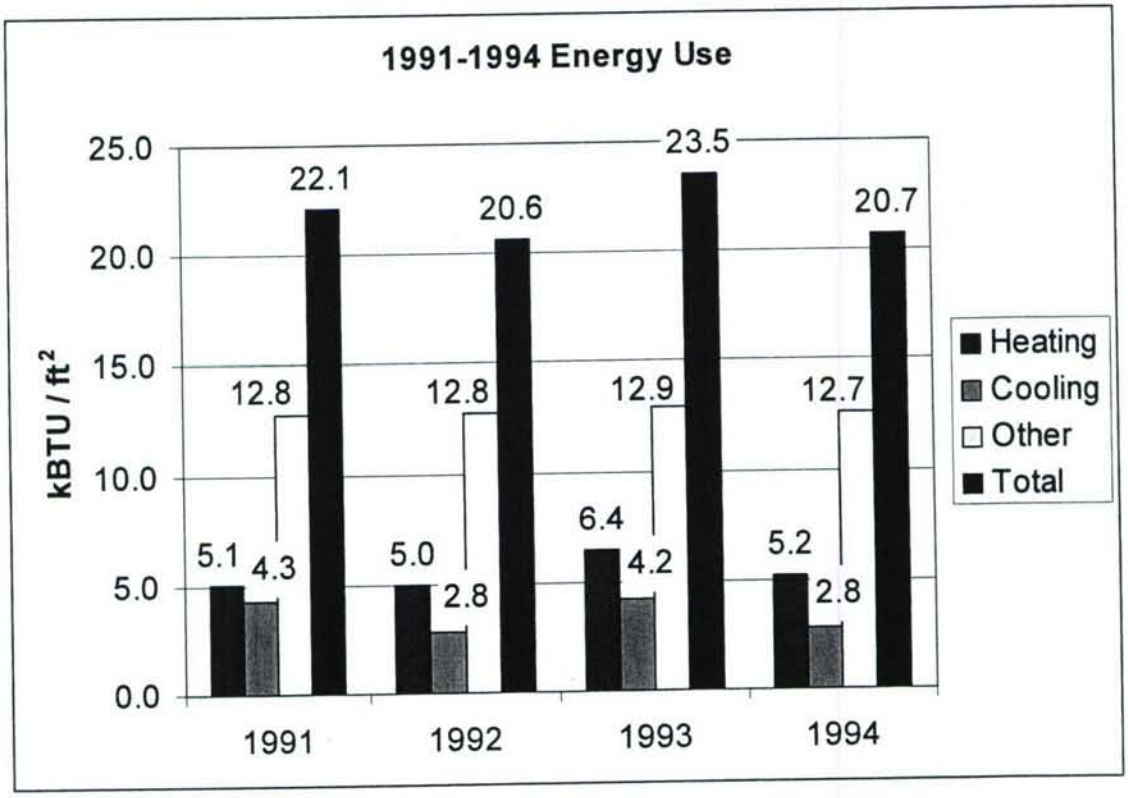

Figure 3 – Actual Energy Use of Plumblee Home

Actual operating data for the years 1991 through 1994 were selected as a basis for determining how the House actually performs. The living patterns of the Plumblees were very consistent during these years. This explains why the heating, cooling, lighting and other costs

were so consistent during the 1991 –1994 period. This fact was borne out in the very consistent energy-use data recorded for these years.

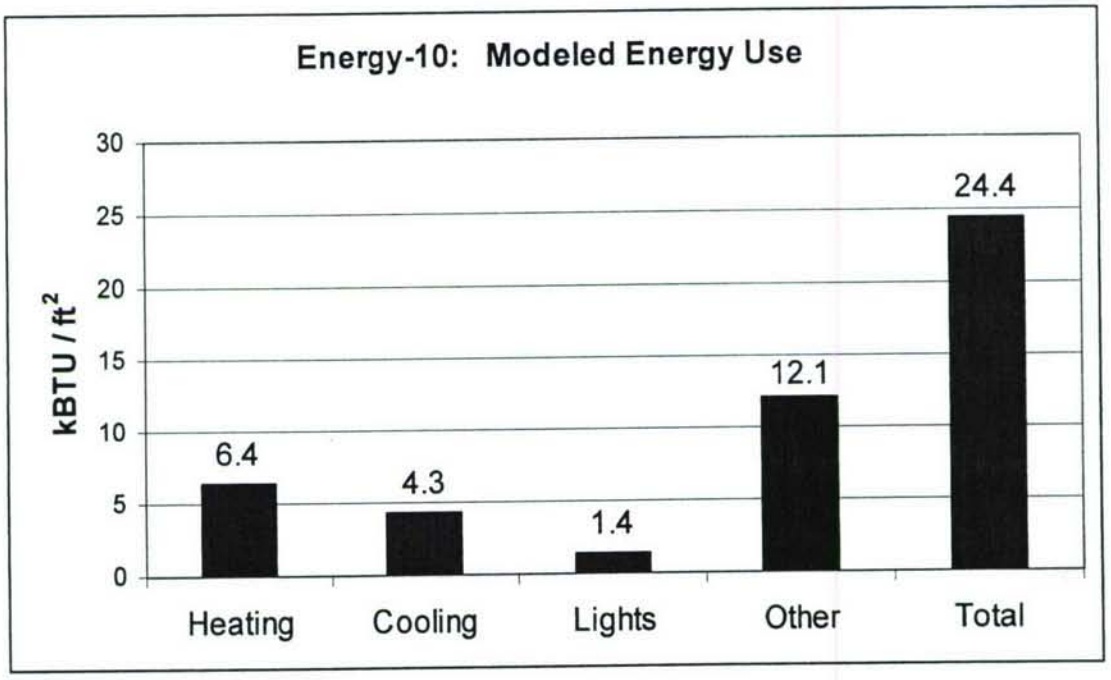

Figure 4 – Model of Energy Use (Energy-10)

Year	Heating	Cooling	Other	Total
1991	5.1	4.3	12.8	22.1
1992	5.0	2.8	12.8	20.6
1993	6.4	4.2	12.9	23.5
1994	5.2	2.8	12.7	20.7
Actual Average	5.4	3.5	12.8	21.7
Standard Deviation of Sample	0.68	0.80	0.10	1.39
Energy-10 Model Results	6.4	4.3	13.5	24.4
Model – Actual Avg / Std Dev	**1.43**	**0.96**	***6.83***	**1.92**
% of Actual	**118%**	**122%**	***106%***	**112%**

Table 1 – Verification of Model (units = kBTU/ft^2)

There are three important findings from this analysis. First, the Energy 10 model predicts the actual energy use quite well. The model appears to be conservative in predicting actual energy usage and is within about 12 percent of the total house energy use. Second, the model is sufficiently accurate since the modeled energy use for heating and cooling is less than two standard deviations from the actual average energy use. For the "other" category, the correlation between the model and the actual is even better (see Table 1). Based on these results, Energy-10 was found to be an acceptable vehicle for evaluating the effectiveness of various solar and energy conservation measures on the performance of passive solar residential structures.

5.1.2. Research Limitation of Data Input Affecting Thermal Analysis

The actual date of change-over from seasonal operation of heating or cooling is unknown. Interpolations of the heating and cooling loads were calculated using the percent of heating or cooling degree days recorded in climatology data for the months of April, May, and October (NOAA). If the yearly turn-over between seasonal room temperature settings was known, then the conformance between the model and actual performance would likely be improved. Although the uncertainty exists, Energy-10 appears to be sufficiently accurate in the correlation between modeled and actual energy use.

5.2. Sensitivity Study of Passive Solar and Energy Conservative Features

5.2.1. Factors

Because of the excellent manner the Energy-10 model approximates the actual performance of the Plumblee House, it was decided that Energy-10 could effectively be used to evaluate the impact of various passive solar and energy conservation measures. The following heating performance measures were varied independently from the actual home construction to obtain predicted performance in order to identify those areas of design most critical to performance:

- House orientation rotated 15, 30, and 45 degrees east of true south.
- South-facing glazing surface area and type.
- Surface area of windows in east, west, and north walls.
- Roof-overhang lengths (including 4 inch gutter).
- Amount of thermal storage mass provided by brick pavers.
- Wall construction details; 2x4 to 2x6 exterior frames.
- Room temperature set-points.
- Air infiltration control.

5.2.2. Findings

(1) Orientation:

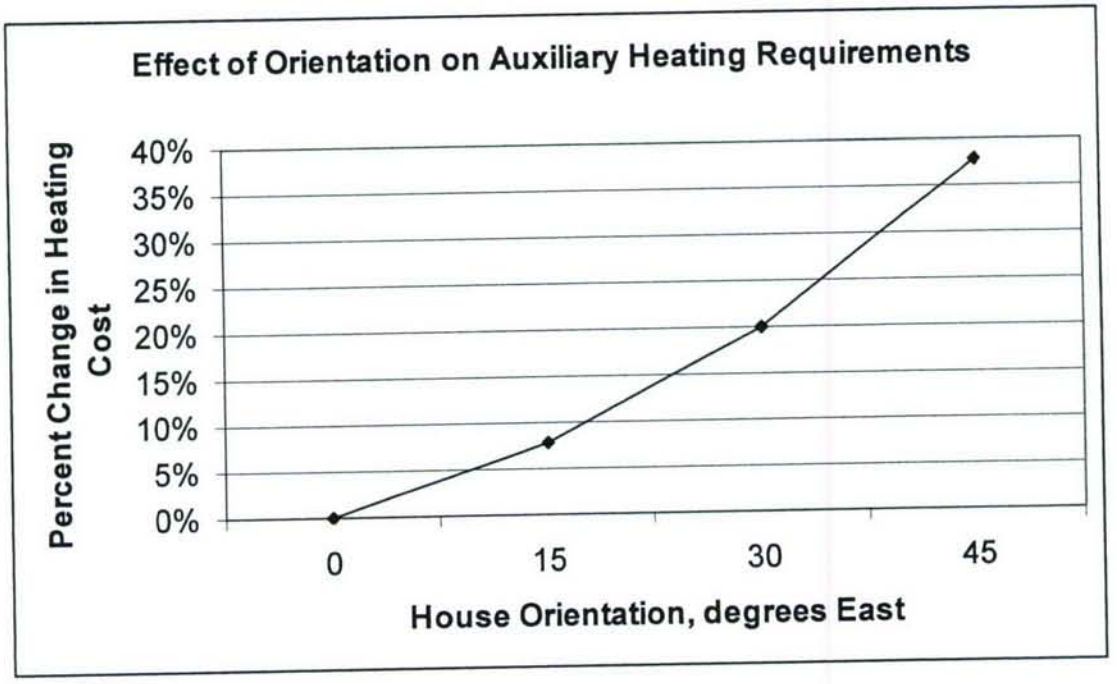

Figure 5 – Model of Orientation Effects (using Energy-10)

Additional heating is required when positioning the home orientation with the major axis in a direction other than east-west. A 15-degree east deviation from true south results into 7.3 percent of additional auxiliary heating required.

(2) Glazing:

Converting all south-facing windows from standard glass to Low-E glass provides a 6.5 percent cost savings in auxiliary heating required. Figures 6 and 7 below show the effect that increasing the south facing glazing has on (1) the "Auxiliary Heating Requirements" and (2) the "Cooling Requirements" of a house. As would be expected, an increase in glazing reduces the heating demand and increases the cooling load.

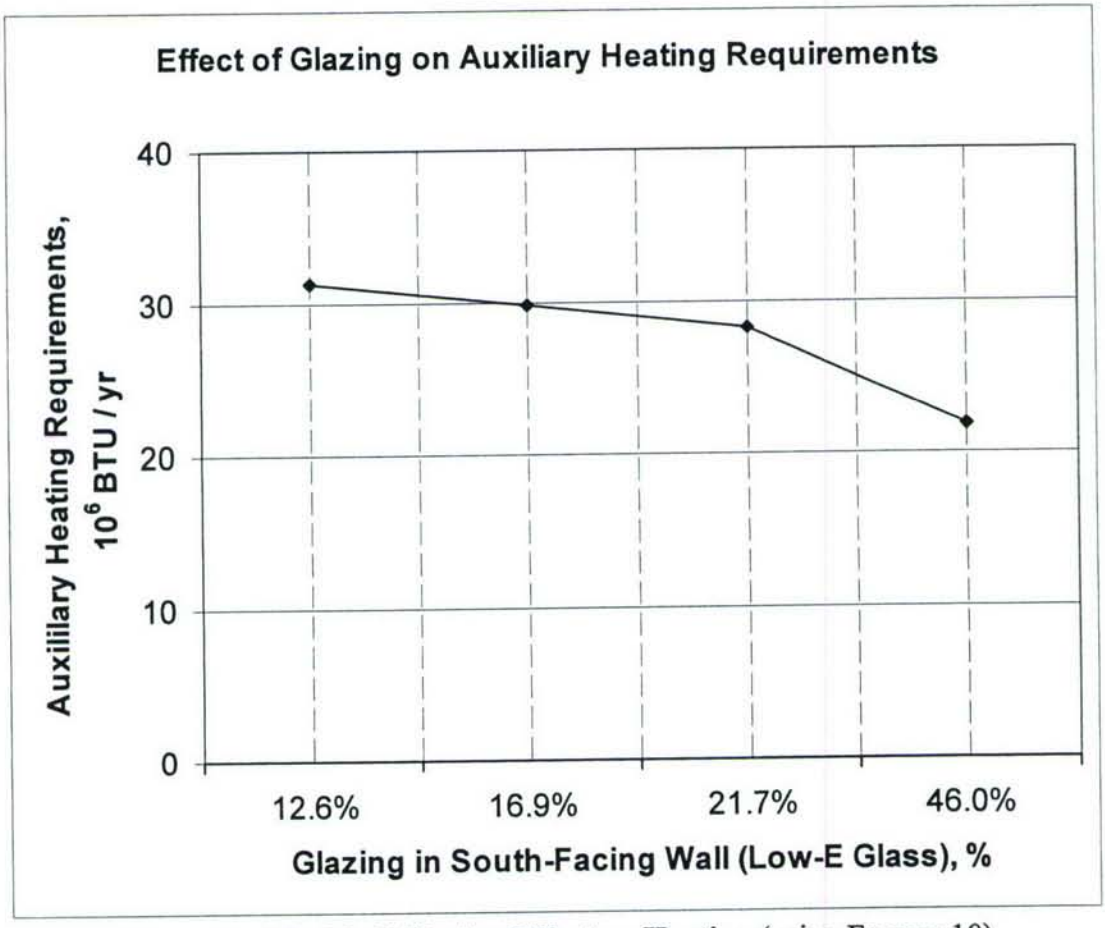

Figure 6 – Model of Glazing Effect on Heating (using Energy-10)

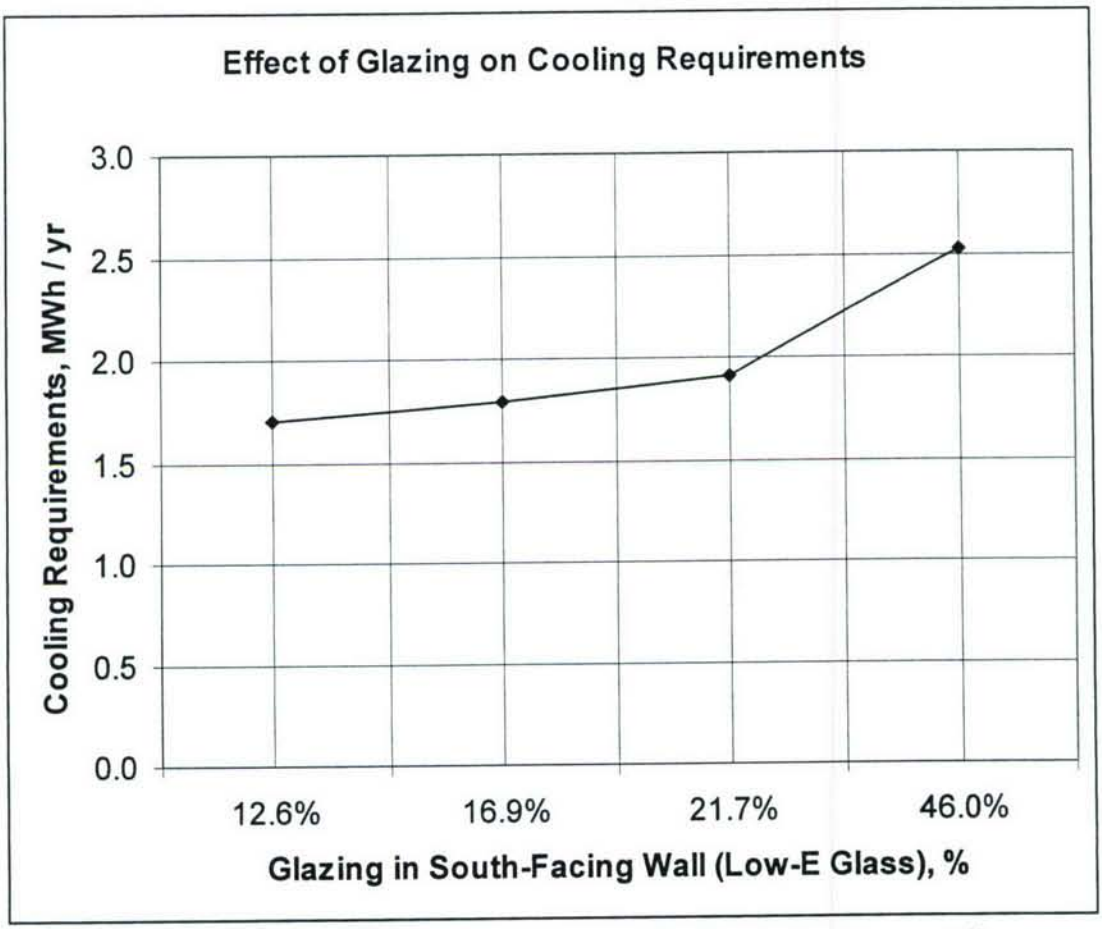

Figure 7 – Model of Glazing Effect on Cooling (using Energy-10)

(3) Roof Overhang:

The roof overhang length was varied from 24 to 12 inches of boxed eave with a 4 inch gutter. A reduction in overall overhang extension from 28 inches to 21 inches yields a 3.7 percent cost savings in auxiliary heating required.

(4) Thermal Mass Effects:

The additional thermal storage mass provided by the brick pavers and concrete in the floor area along the south-facing wall provides 5.2 percent of cost savings in auxiliary heating requirements. Any additional thermal mass may cause overheating during adverse weather.

(5) Wall Insulation:

Wall construction was varied in the thermal simulation by changing the 2x4 frame with R-13 batt-insulation to 2x6 with R-19 for the exterior walls. A 13.5 percent cost savings in auxiliary heating requirements is obtained by using 2x6 exterior walls.

(6) Temperature Set-point:

Setting back the thermostat comfort temperature from 70 degrees-Fahrenheit to 68°F in the heating season provides a 28.3 percent cost savings in auxiliary heating required.

(7) Air Infiltration Control:

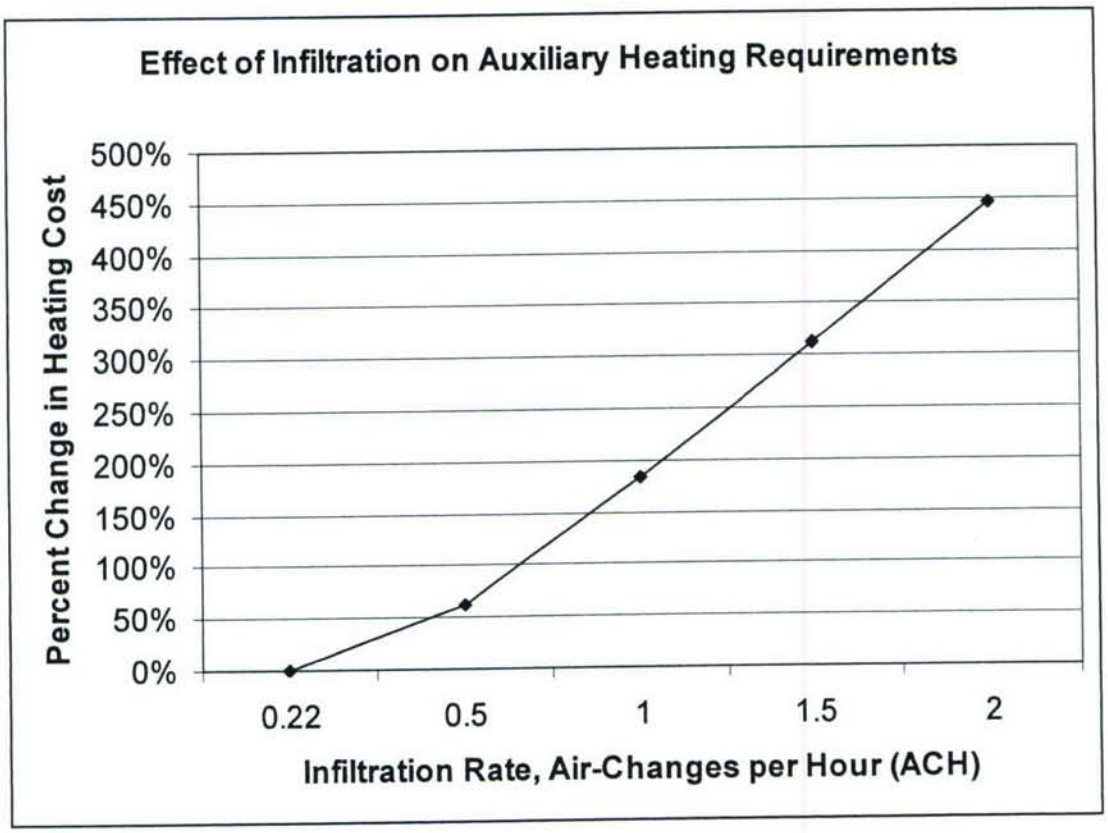

Figure 8 – Model of Air Infiltration Control (using Energy-10)

The default value of air infiltration rate commonly used in design is 1.0 air-change per hour (ACH). In this part of the study, air infiltration rates were varied from 0.5 ACH to 2.0 ACH. A cost savings of 43 percent in auxiliary heating requirements is achieved when reducing air

infiltration from 1.0 ACH to 0.5 ACH. The Plumblee Home has an average air infiltration rate of 0.22 ACH. The extra precautions of providing a continuous vapor barrier and sealing off all openings and penetrations during construction has produced a considerably effective, "air-tight" home.

5.2.3. Implications of Sensitivity Analysis of Plumblee Home

Air infiltration and room temperature control are considered to have a reasonably significant effect on the heating performance of the Plumblee Home. The amount of heat loss through the seams or cracks of windows, doors, walls, and ceilings is minimal as the result of having an "air-tight" home and a smaller temperature difference from outside to inside conditions.

Moderate changes in heating performance appear to be cost effective for changing 2x4 to 2x6 exterior wall construction and increasing the amount of Low-E glass in south-facing windows. The remaining features are considered to be marginal in the effect of heating performance and could be implemented in the "fine-tuning" of the conceptual design.

The following is a summary of the effectiveness of various passive solar and energy conservative features for improving the heating performance of the Plumblee passive solar-heated home:

Control Measure Implemented	Percent Cost Savings
• Make the house tighter. (i.e., reduce the infiltration from 1 ACH to 0.5 ACH)	43.0%
• Reduce room temperature by 2°F (e.g., from 70°F to 68°F).	28.3%
• Increase south-facing Low-E glazing by 10 percent.	15.0%
• Change from 2x4 to 2x6 wall construction.	13.5%
• Reduce window area in east, west and north wall by 50%.	7.7%
• Orient the house 15° more toward true south.	7.3%

- Convert south-facing glazing from standard glass to low-e glass. 6.5%
- Increase thermal mass (brick pavers) in floor from 0% to 17%. 5.2%
- Reduce roof overhang (from 28 in. to 21 in.). 3.7%

Based on construction methods and material costs, the most efficient, energy conservative measures for improving heating performance in order of cost savings, are (1) controlling air infiltration by making the house tighter, (2) setting back room temperature, and (3) laying out the house in the beginning with the major axis in the east-west direction. Room temperature is controlled by the home occupants and little can be done by the professional to modify this parameter. House orientation can clearly be addressed early as part of the design cost, but lot or site constraints may limit options. The sensitivity analysis indicates that the additional time, materials, and labor for installing a vapor barrier and caulking cracks or seams around windows, doors, walls, and ceilings to minimize infiltration are clearly worthwhile and should be included in all residential construction. The sensitivity analysis suggests that the effect of air infiltration rate on energy use is sufficiently important. Changes in the building code which would result in the reduction of the air infiltration rate should be considered for all new construction. Although not included in this case study, a more thorough cost analysis of the thermal performance and energy conservative measures is recommended.

6. Conclusions and Recommendations

- Energy-10 provided a conservative model of the thermal performance of this particular passive solar-heated home and was considered to be valid for conceptual design of similar energy efficient buildings.
- Modeled thermal performance simulated by Energy-10 is a reasonably accurate projection of the actual thermal performance experienced by the Plumblee Home.
- Energy-10 appears to be sufficiently accurate in the correlation between modeled and actual energy use, considering the uncertainty of the actual date of change-over from seasonal operation of heating or cooling for the Plumblee Home is unknown.
- Energy-10 provided a reasonable prediction of the effectiveness of passive solar and energy conservative features incorporated in the Plumblee Home.
- Home orientation, window placement, insulation details, air infiltration control, room temperature setting, and quality construction are the considerably significant design factors for creating a comfortable, low-energy consuming passive solar-heated home.
- Air infiltration and room temperature control are considered to have a reasonably significant effect on the heating performance of the Plumblee Home.
- A thorough cost analysis of the thermal performance and energy conservative measures is recommended.
- Additional studies are recommended to compare other similar passive solar homes to the Plumblee Home.

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   Rucker, Debra G. "A Sun Inspired Home," *Carolina Sun*. North Carolina Solar Energy Association (NCSEA), Volume 15 No. 2, Summer 1992.
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7. Mazria, Edward. "The Passive Solar Book," Rodak Press, 1979.
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http://www.ncdc.noaa.gov/oa/ncdc.html

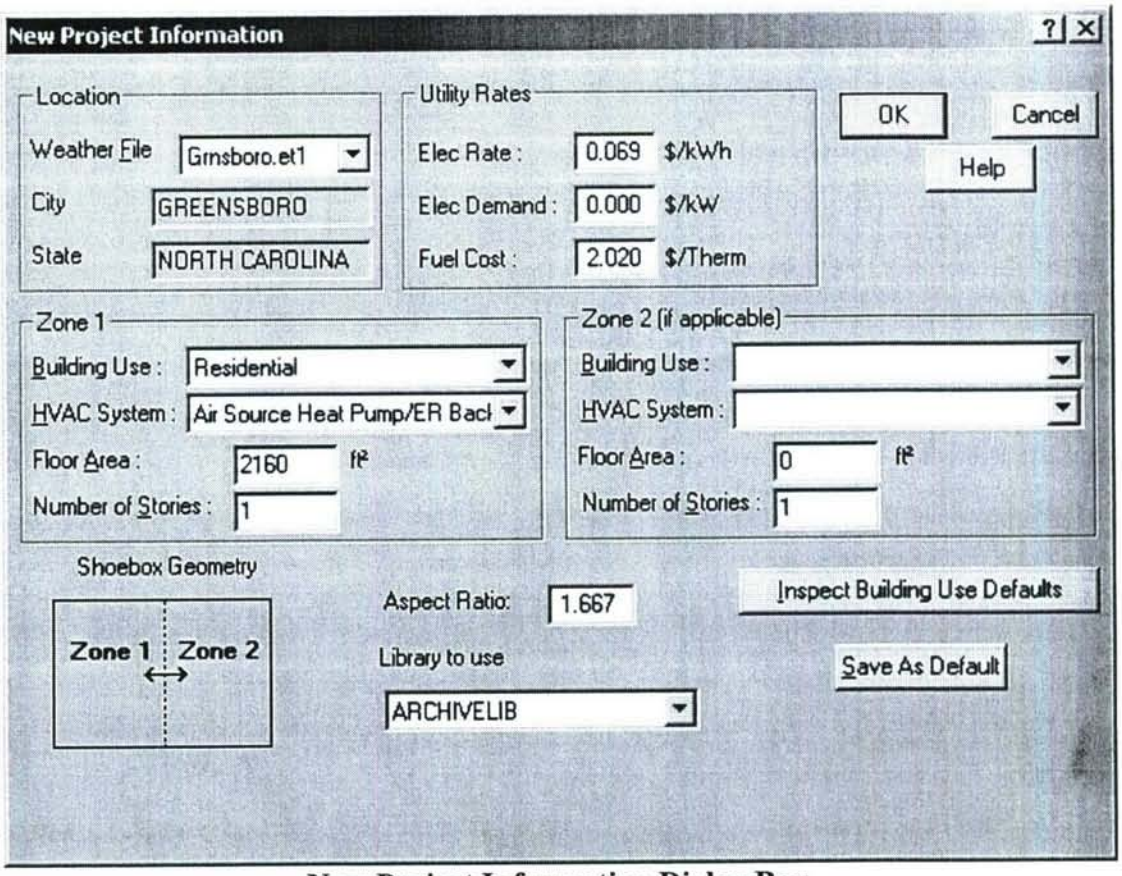
APPENDICES

APPENDIX A

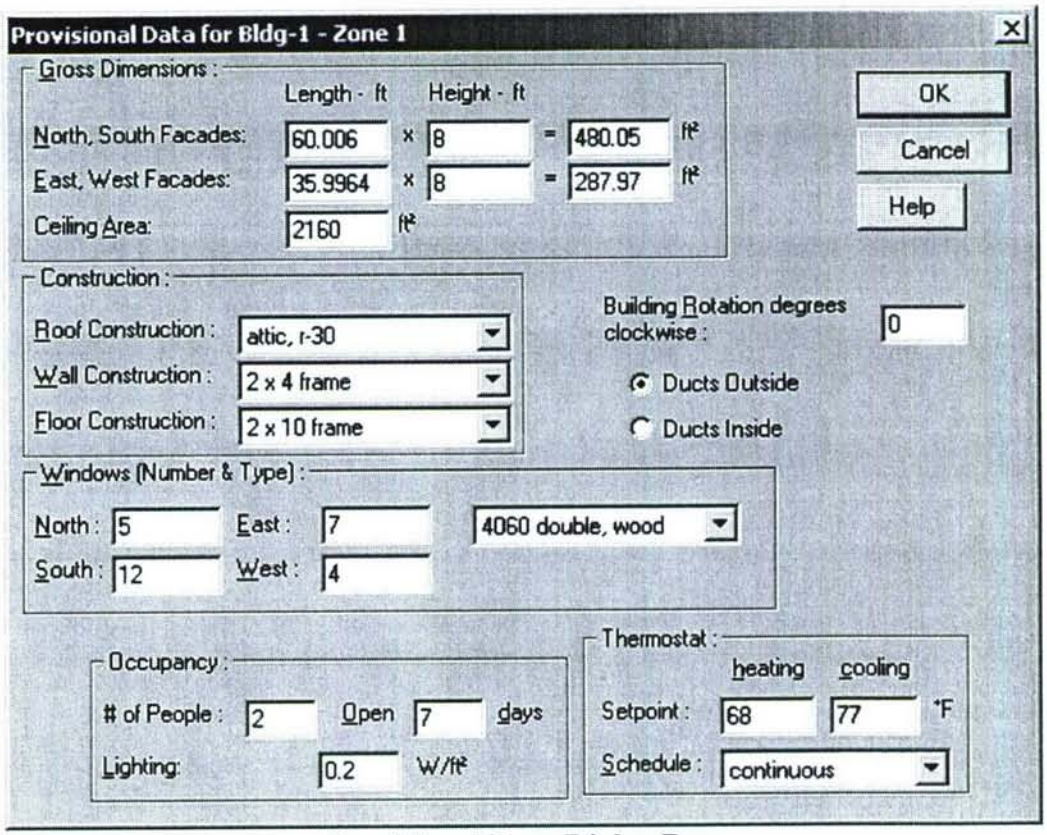
{Energy-10: Program Input}

Energy Efficient Case

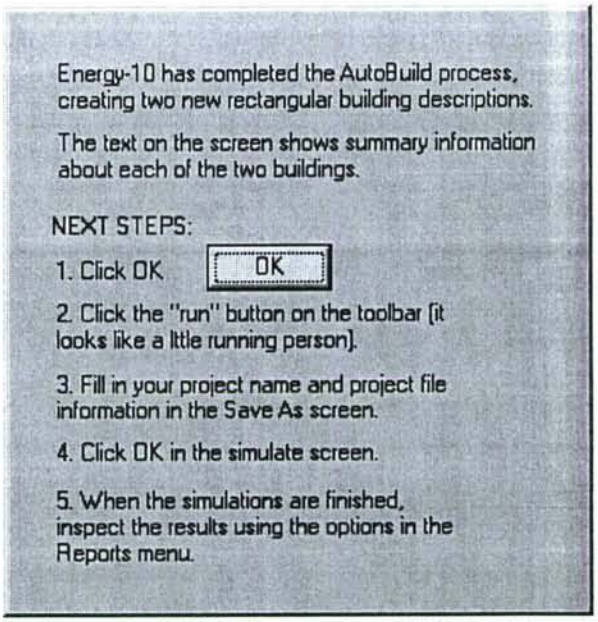
Input reflects actual construction details and conditions experienced at the Plumblee Home.



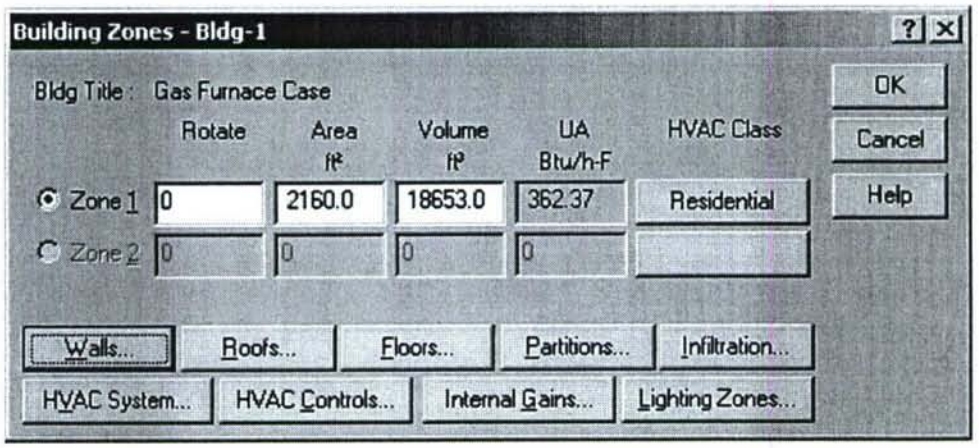
New Project Information Dialog Box



Provisional Data Dialog Box



"AutoBuild" Informational Dialog Box



Building Zones Dialog Box

Walls - Zone 1

Name	Wall Type	Gross Area ft²	R-value h-ft²-F/Btu	UA Btu/h-F	Solar Abs	Orient	Tilt	Windows / Doors
North Porch	2 x 4 cypress	275.58	14.53	14.61	0	0	90	5/1
East Porch	2 x 4 cypress	287.97	14.53	11.96	0	90	90	7/1
South	2 x 4 cypress	480.05	14.53	15.44	0.5	180	90	13/0
West	2 x 4 brick	287.97	13.18	19.30	0.1	270	90	4/0
North Garag	2 x 4 garage	204.92	10.39	19.72	0	0	90	0/0
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
	Sum :	1536.49		81.0				

OK Cancel Help

Walls Dialog Box

Wall Construction - North Porch

Wall Type : 2 x 4 cypress

R-value to Use
- Derived R-value 14.5268 h-ft²-F/Btu
- User-supplied R-value h-ft²-F/Btu

OK Cancel New Modify Remove Help

Wall Cross Section - 1

% of Wall Area : 80 R: h-ft²-F/Btu 16.65

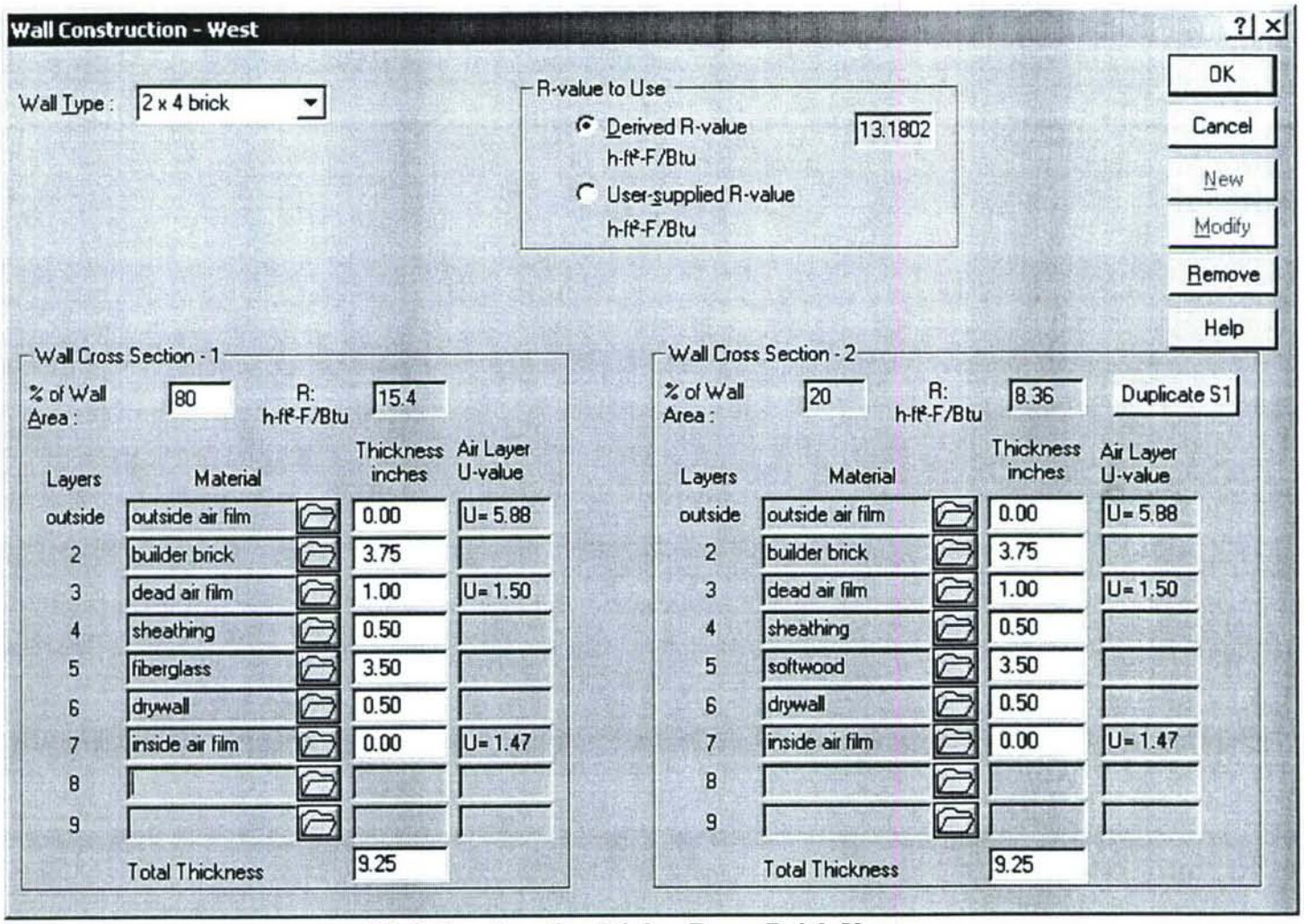
Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.63	
3	polyiso foam	0.50	
4	fiberglass	3.50	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	5.13	

Wall Cross Section - 2

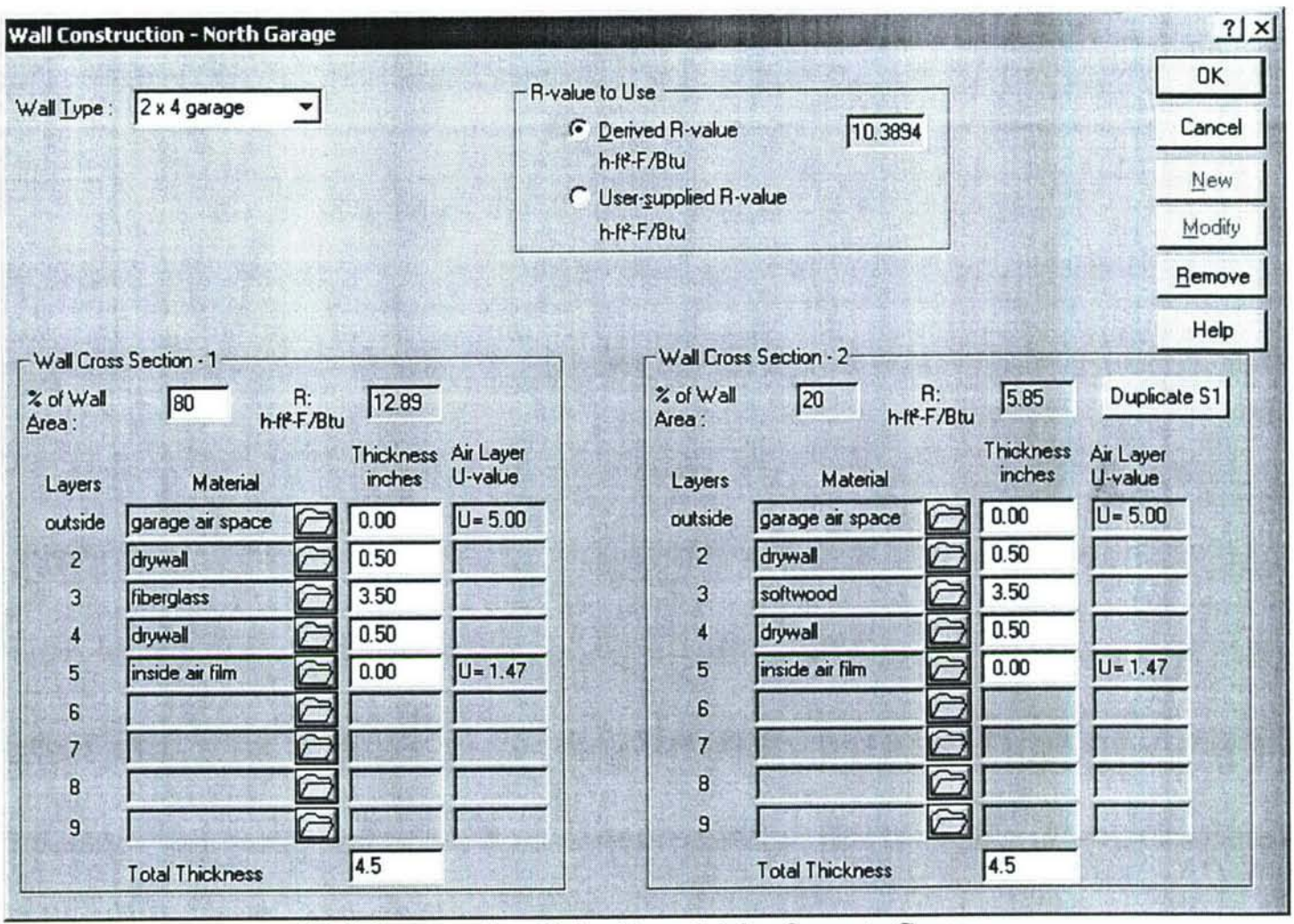
% of Wall Area : 20 R: h-ft²-F/Btu 9.62 Duplicate S1

Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.63	
3	polyiso foam	0.50	
4	softwood	3.50	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	5.13	

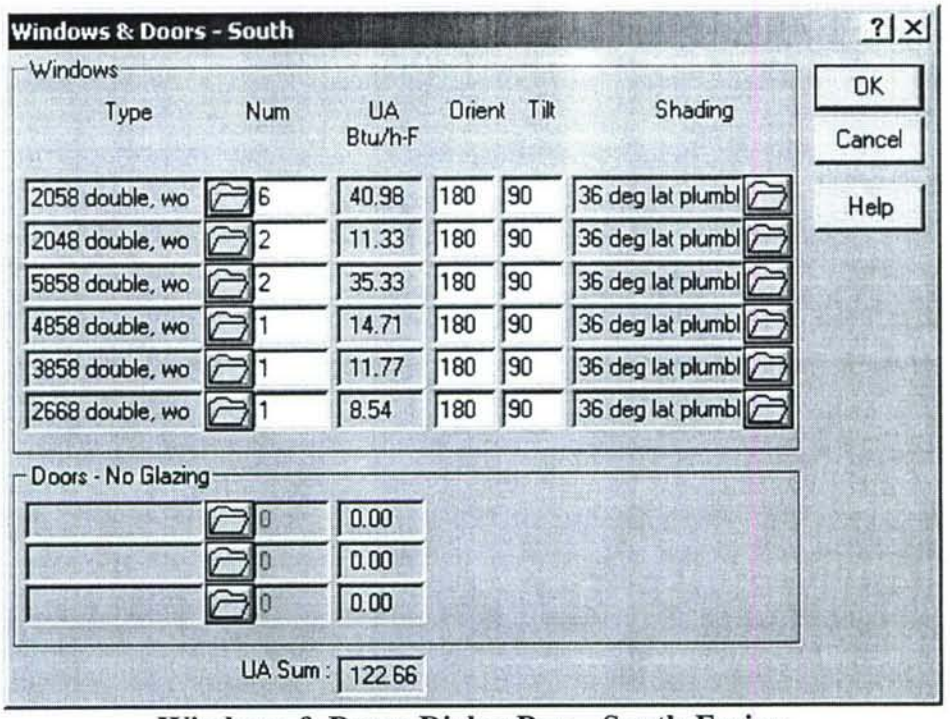
Wall Construction Dialog Box – Cypress Siding



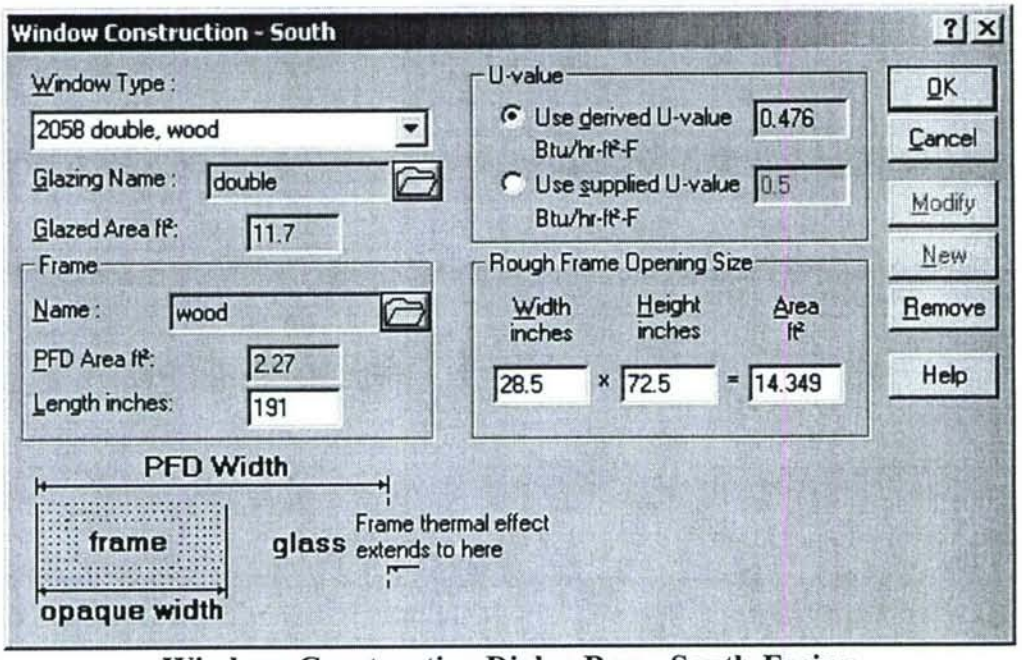
Wall Construction Dialog Box – Brick Veneer



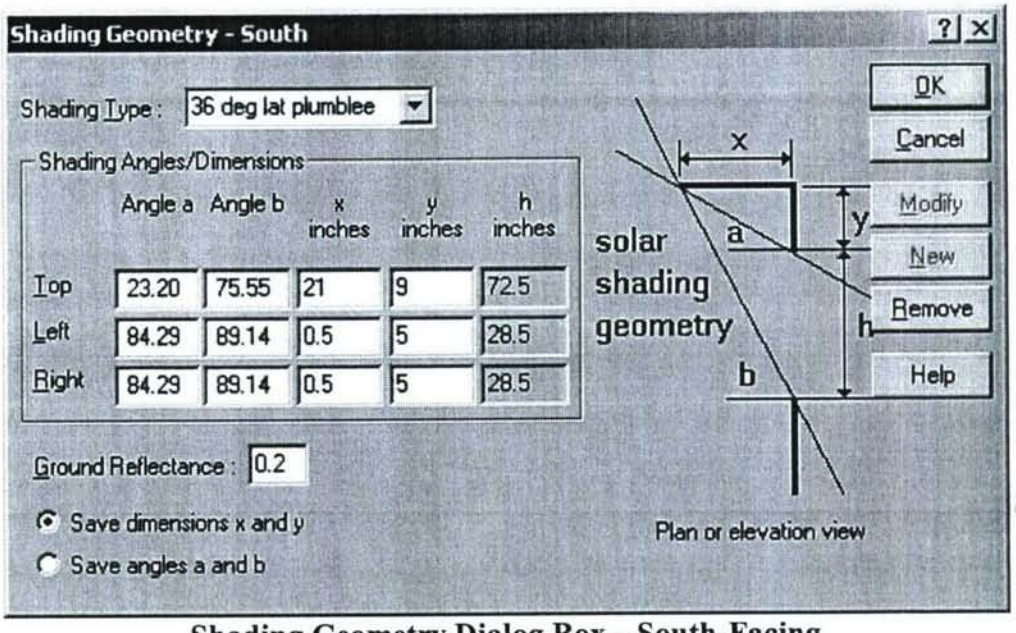
Wall Construction Dialog Box – Living Space to Garage



Windows & Doors Dialog Box – South-Facing



Windows Construction Dialog Box – South-Facing



Shading Geometry Dialog Box – South-Facing

Roofs - Zone 1

Name	Roof Type	Gross Area ft²	R-value h-ft²-F/Btu	UA Btu/h-F	Solar Abs	Orient	Tilt	Windows
North Roof	shingle, attic, r-	1080.00	30.50	35.41	0.15	0	27	0
South Roof	shingle, attic, r-	1080.00	30.50	35.41	0.5	180	27	0
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
	Sum :	2160.00		70.8				

OK Cancel Help

Roofs Dialog Box

Roof Construction -

Roof Type : shingle, attic, r-30

R-value to Use
- Derived R-value h-ft²-F/Btu: 29.0447
- User-supplied R-value h-ft²-F/Btu: 30.5

OK Cancel New Modify Remove Help

Roof Cross Section - 1

% of Roof Area : 81 R: h-ft²-F/Btu 36.02

Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.50	
3	ceiling air space	0.00	U= 1.00
4	fiberglass	10.00	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	11	

Roof Cross Section - 2

% of Roof Area : 19 R: h-ft²-F/Btu 15.91 Duplicate S1

Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.50	
3	ceiling air space	0.00	U= 1.00
4	softwood	10.00	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	11	

Roof Construction Dialog Box

Floors - Zone 1

Name	Floor Construction	Area ft²	R h-ft²-F/Btu	UA Btu/h-F	Floor Type	Perimeter ft	f Factor Btu/h-F-ft
Hardwoods	2 x 10 hardwo	1800	19.87	11.06	Crawl Space	125.995	0.1
Brick Pavers	2 x 12 pavers	360	20.9718	4.82	Crawl Space	66.995	0.1
		0	0			0	0
		0	0			0	0
		0	0			0	0
		0	0			0	0
		0	0			0	0
		0	0			0	0
	Sum :	2160.0		15.88			

OK Cancel Help

Floors Dialog Box

Floor Construction -

Floor Type : 2 x 10 hardwood

R-value to Use
- Derived R-value h-ft²-F/Btu: 19.8652
- User-supplied R-value h-ft²-F/Btu

OK Cancel New Modify Remove Help

Floor Cross Section - 1

% of Floor Area : 80 R: h-ft²-F/Btu 22.03

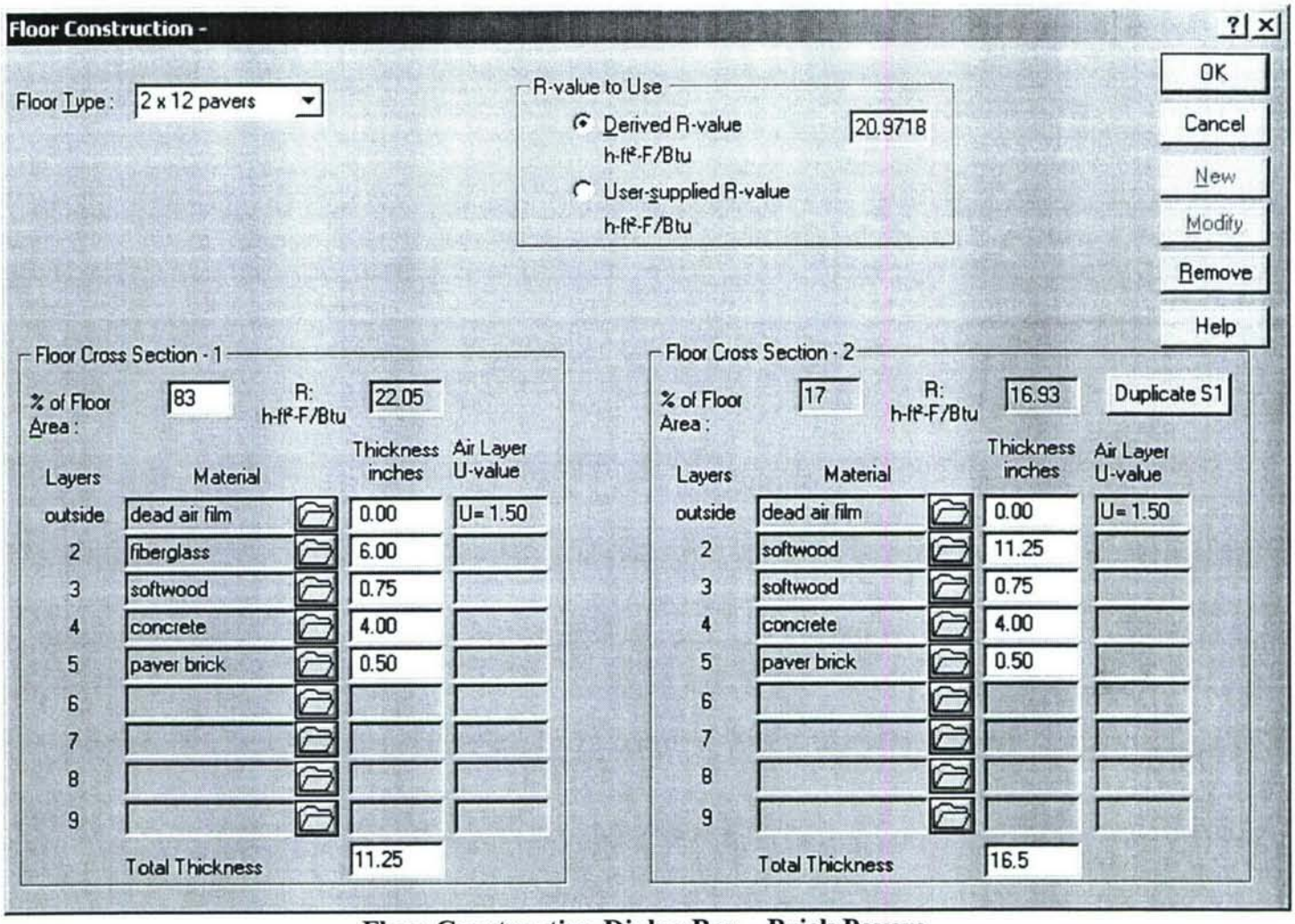
Layers	Material	Thickness inches	Air Layer U-value
outside	dead air film	0.00	U= 1.50
2	fiberglass	6.00	
3	softwood	0.63	
4	hardwood	0.75	
5			
6			
7			
8			
9			
Total Thickness		7.38	

Floor Cross Section - 2

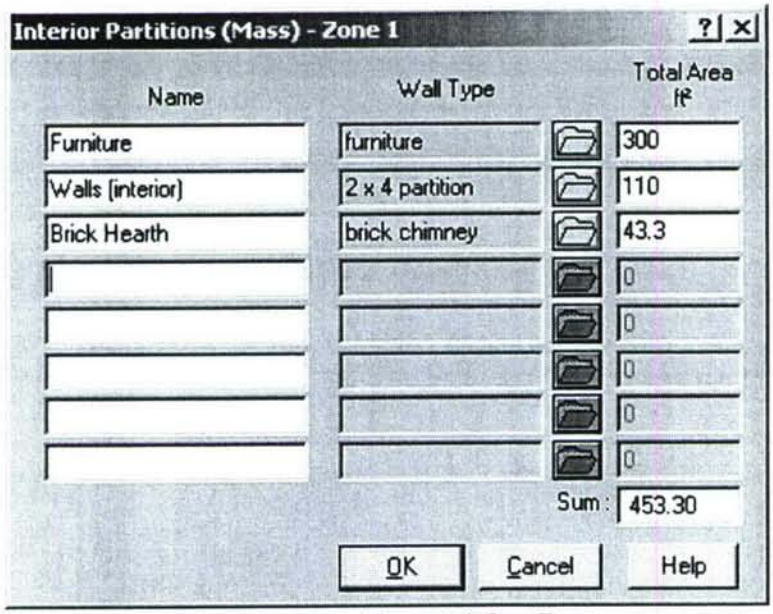
% of Floor Area : 20 R: h-ft²-F/Btu 14.26 Duplicate S1

Layers	Material	Thickness inches	Air Layer U-value
outside	dead air film	0.00	U= 1.50
2	softwood	9.25	
3	softwood	0.63	
4	hardwood	0.75	
5			
6			
7			
8			
9			
Total Thickness		10.63	

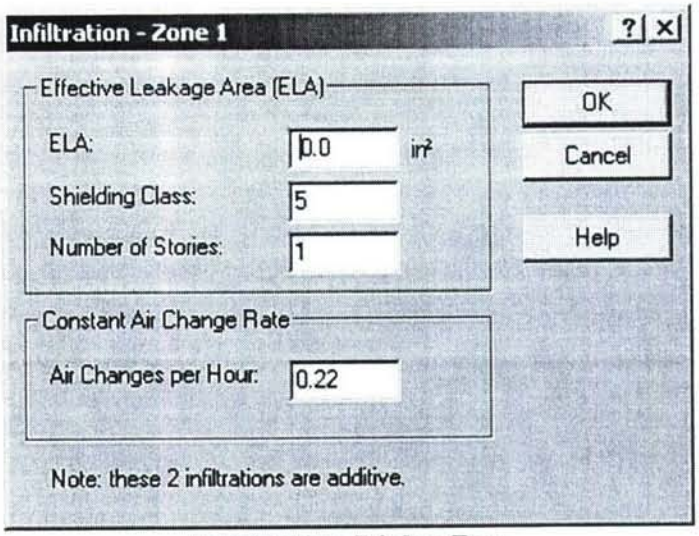
Floor Construction Dialog Box - Hardwood



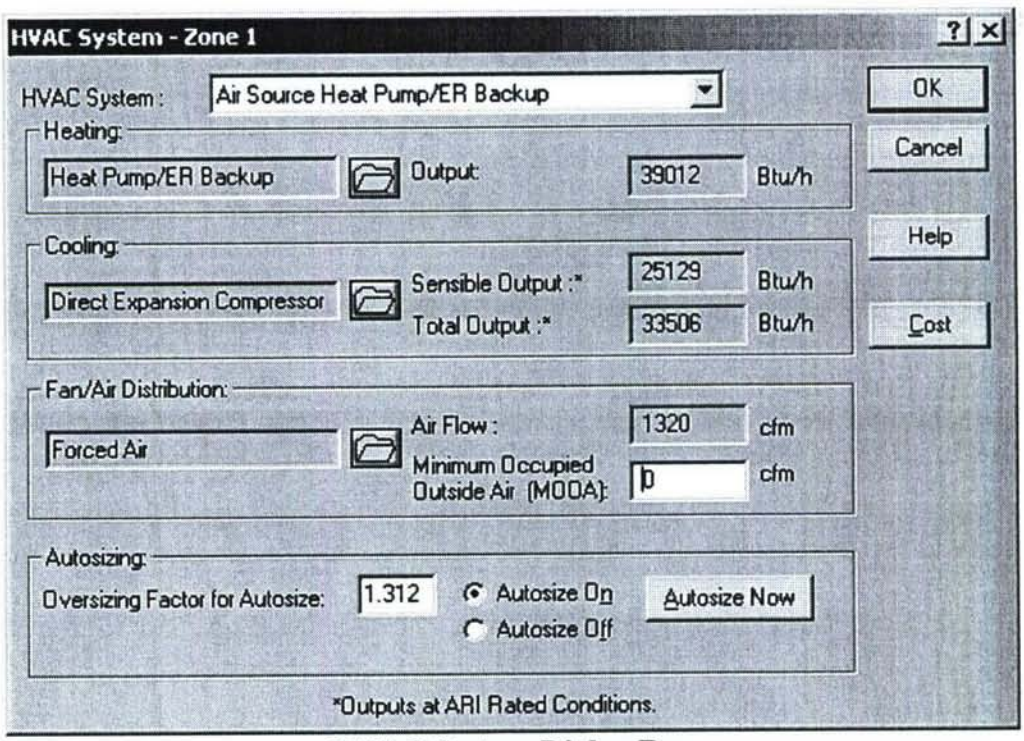
Floor Construction Dialog Box – Brick Pavers



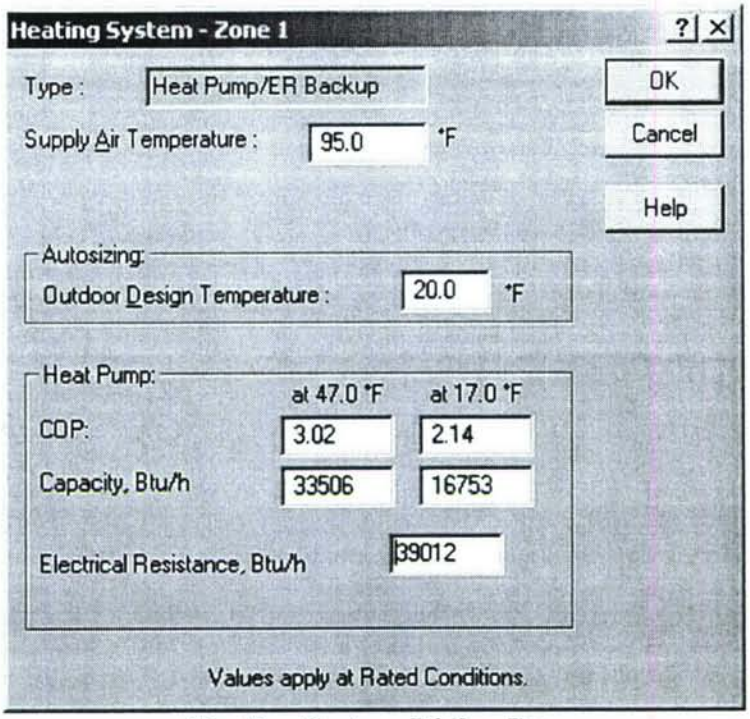
Interior Partitions Dialog Box



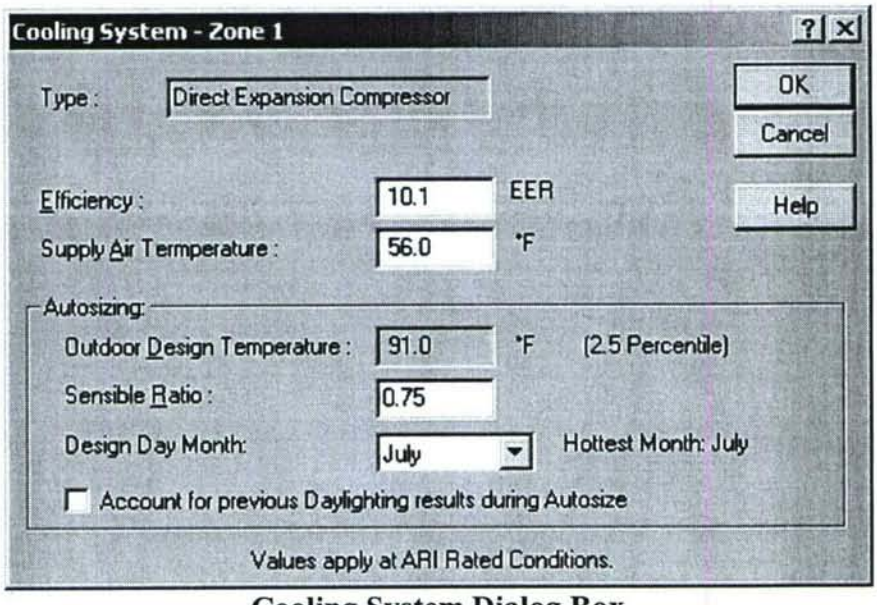
Infiltration Dialog Box



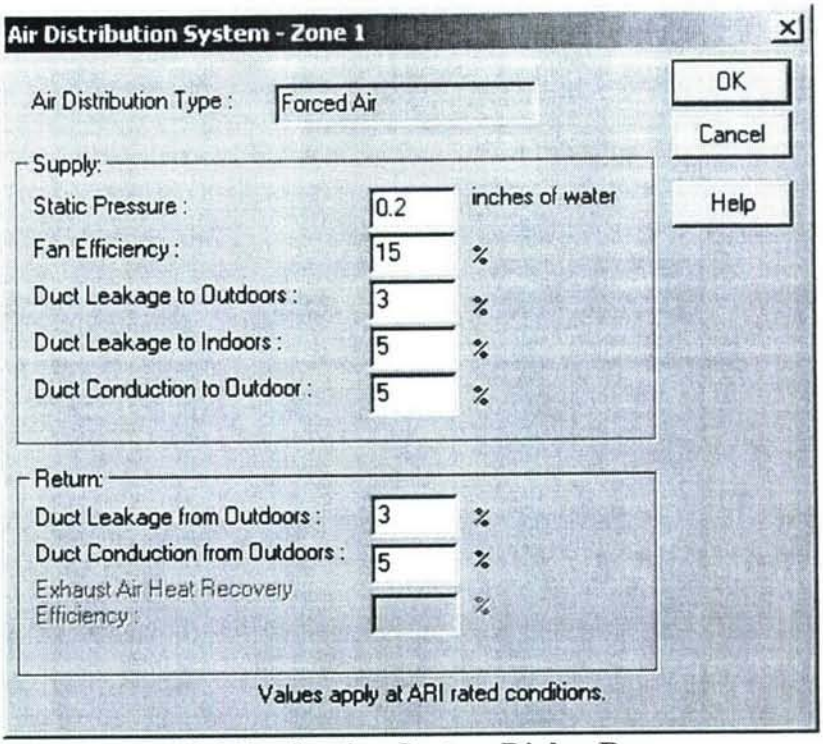
HVAC System Dialog Box



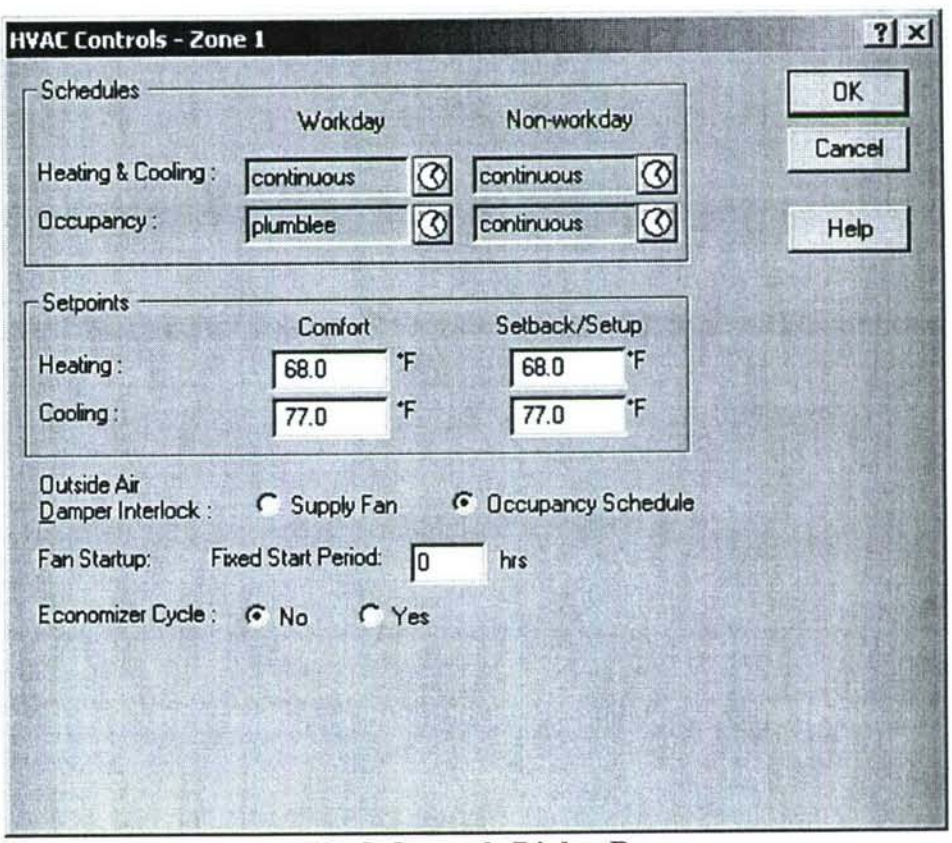
Heating System Dialog Box



Cooling System Dialog Box

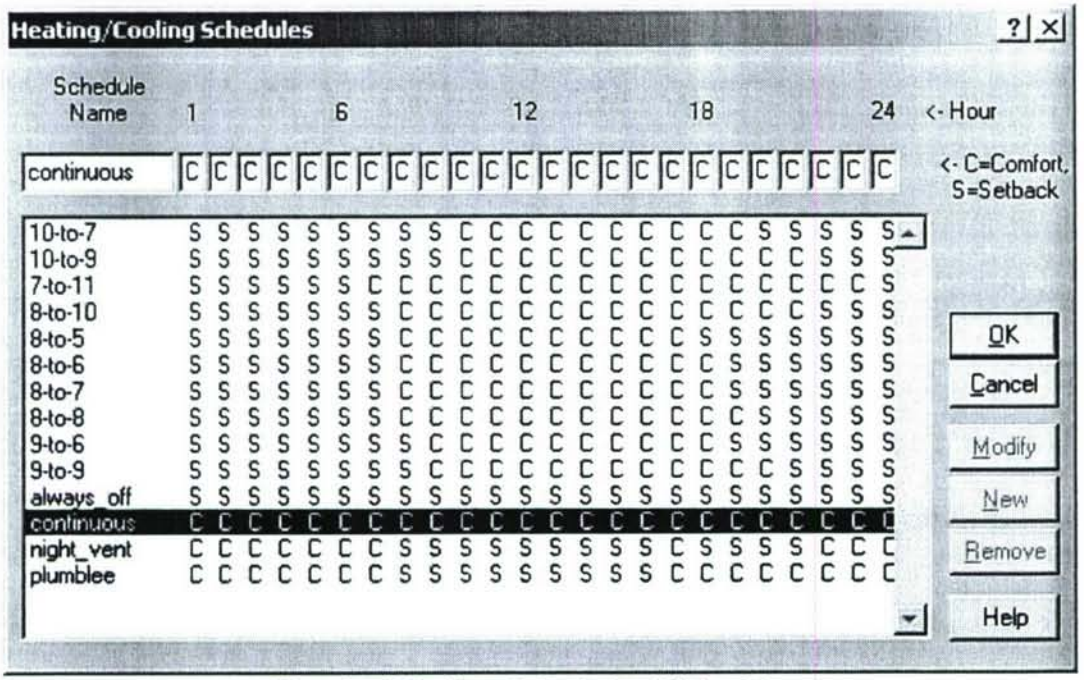


Air Distribution System Dialog Box

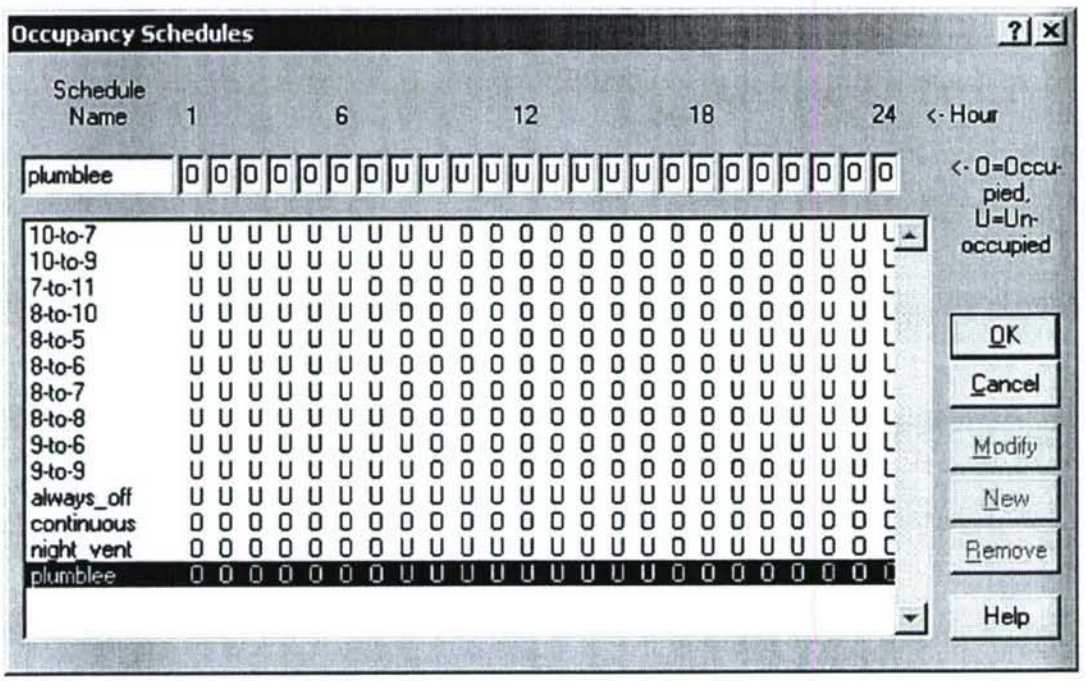


HVAC Controls Dialog Box

Appendix A

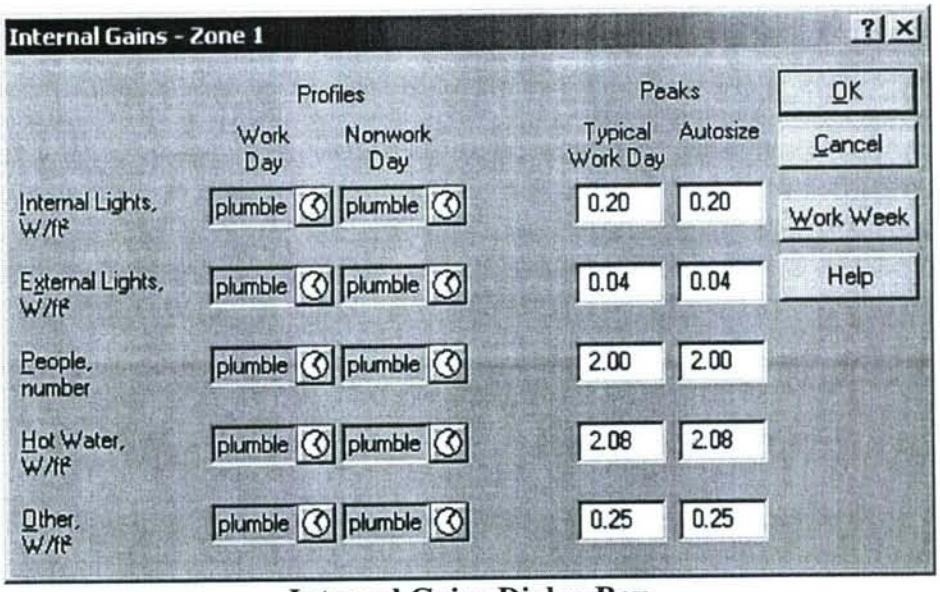


Heating/Cooling Schedules Dialog Box



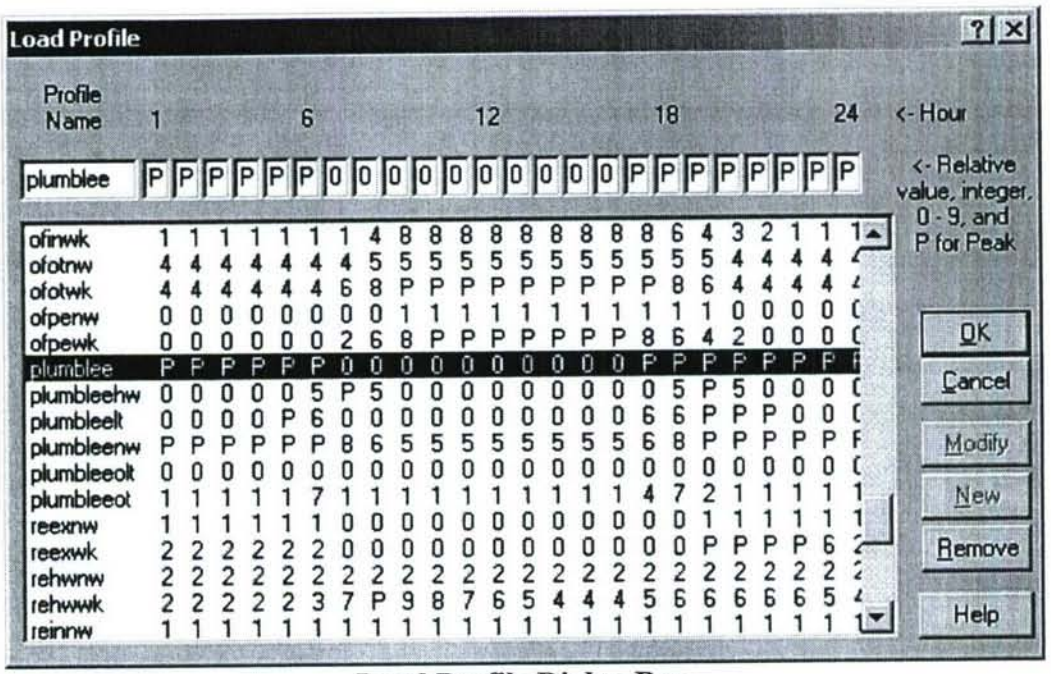
Occupancy Schedules Dialog Box

Note: The above Occupancy Schedule is only used for Temperature Set-backs. See Internal Gains for actual Occupancy Profiles.

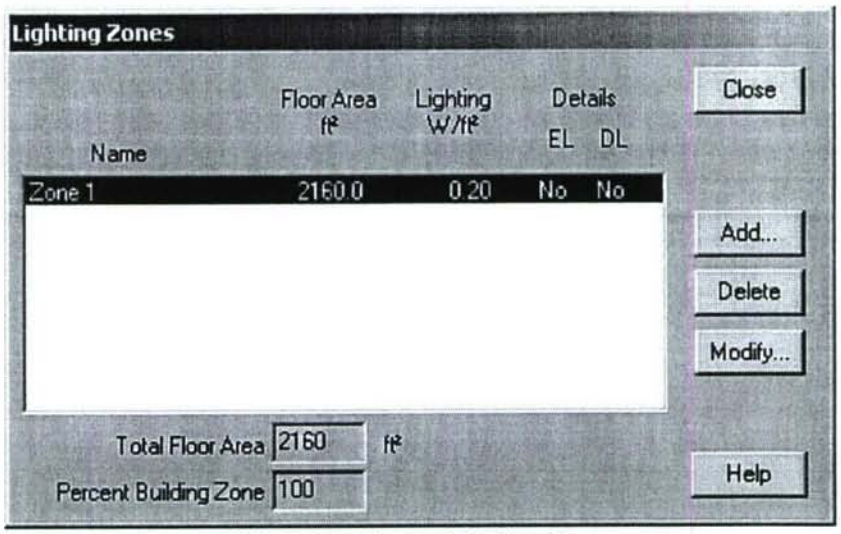


Internal Gains Dialog Box

	Work Day Profile	Nonwork Day Profile
Internal Lights	plumbleelt	plumbleelt
External Lights	plumbleeolt	plumbleeolt
People	plumblee	plumbleenw
Hot Water	plumbleehw	plumbleehw
Other	plumbleeot	plumbleeot



Load Profile Dialog Box



Lighting Zones Dialog Box

Note: Daylighting Dialog Boxes not used in this case study of the Plumblee Home. {Typical Daylighting Controls are only used in non-residential applications.}

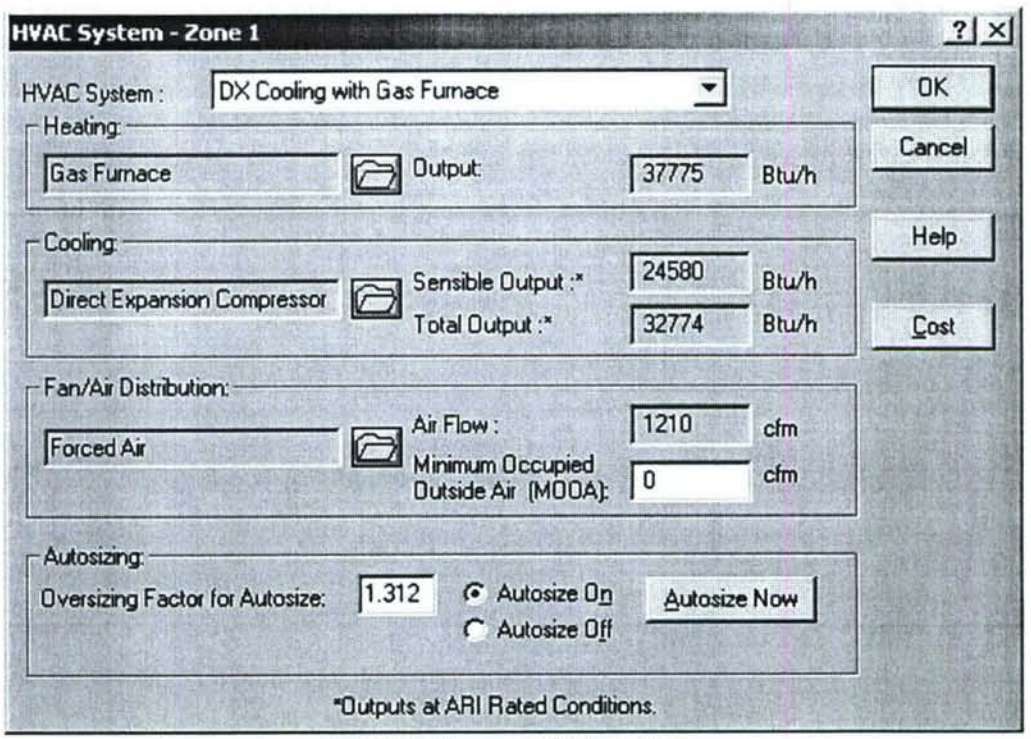
Gas Furnace Case

Equivalent Heating Case using Gas Furnace
in lieu of Heat Pump with Electric Heating.

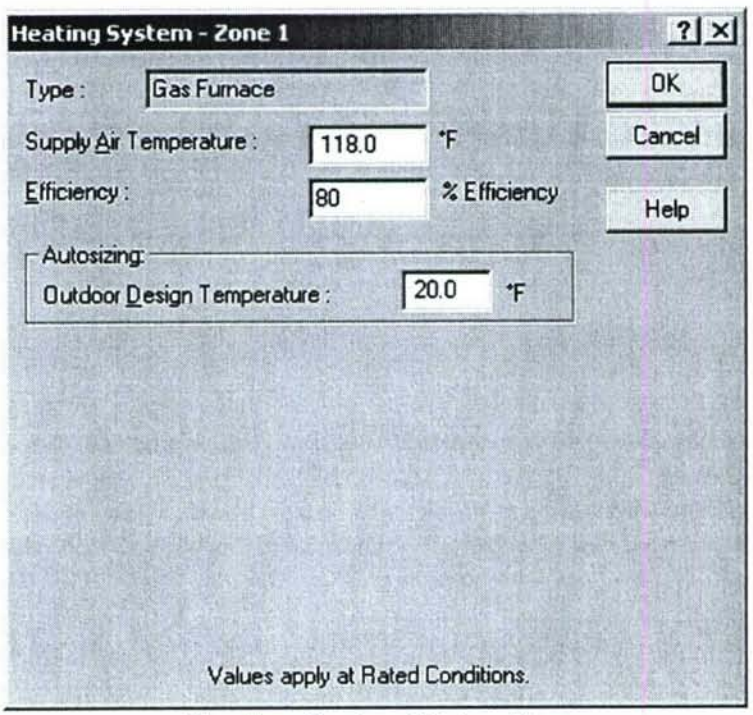
Note:

The Gas Furnace Case input is the base for all other varied cases.

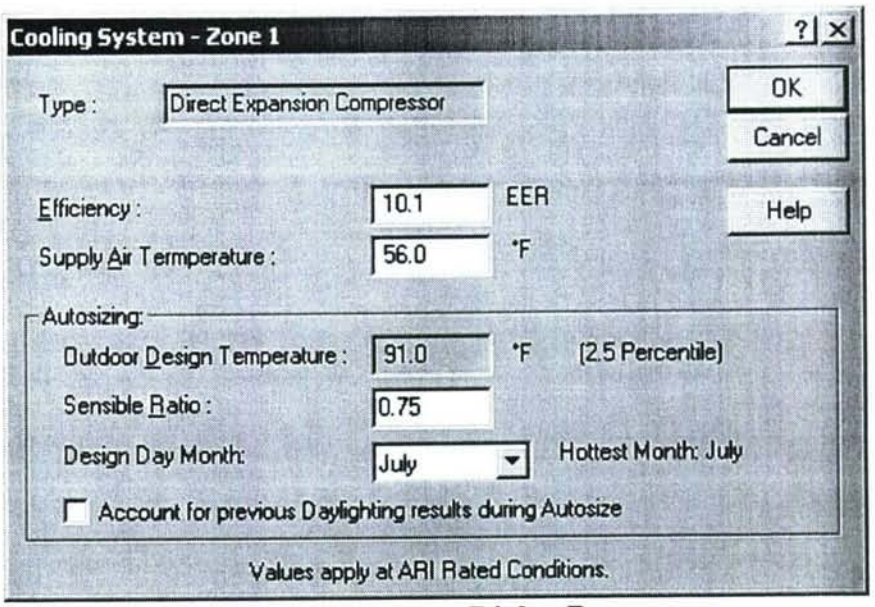
{Only Dialog Boxes with Changed Input Presented}



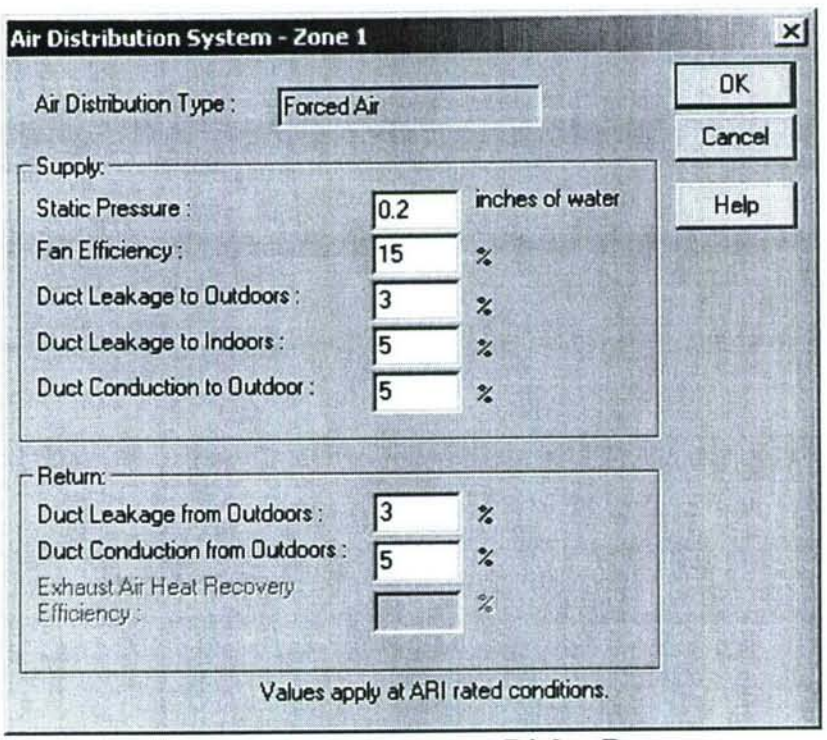
HVAC System Dialog Box



Heating System Dialog Box

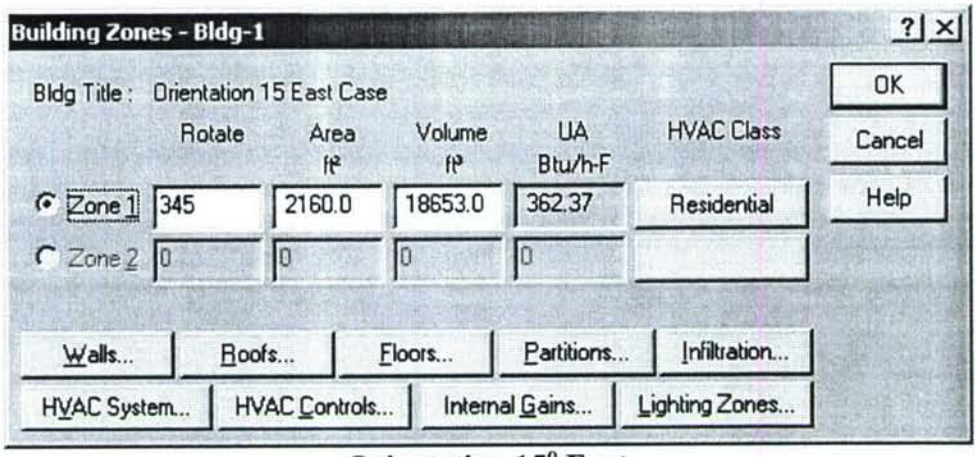


Cooling System Dialog Box

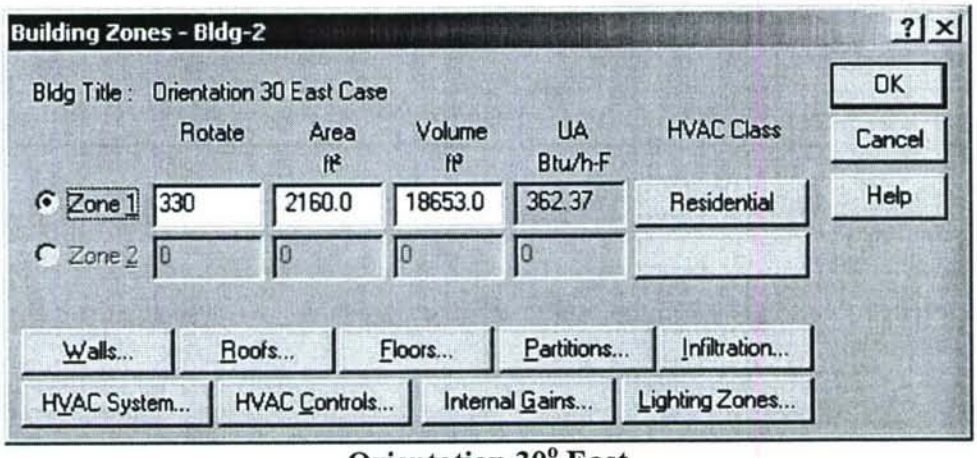


Air Distribution System Dialog Box

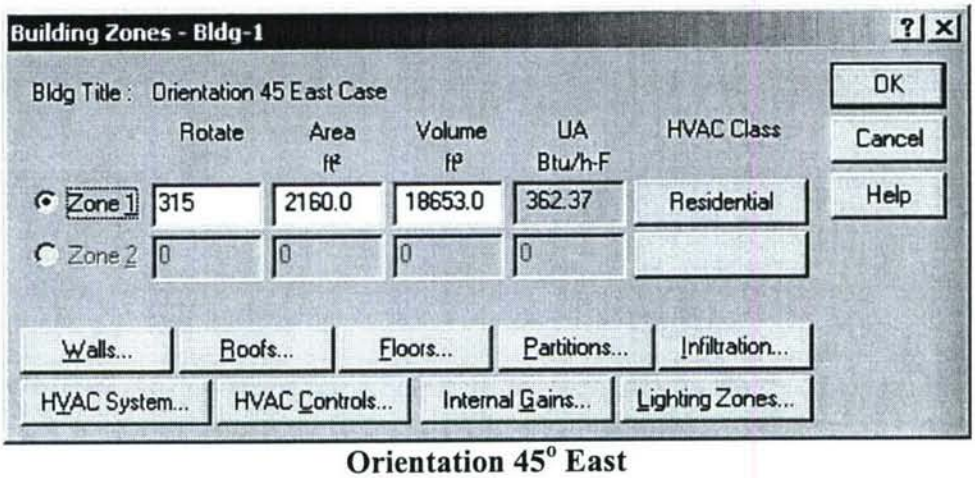
Orientation Cases



Orientation 15° East



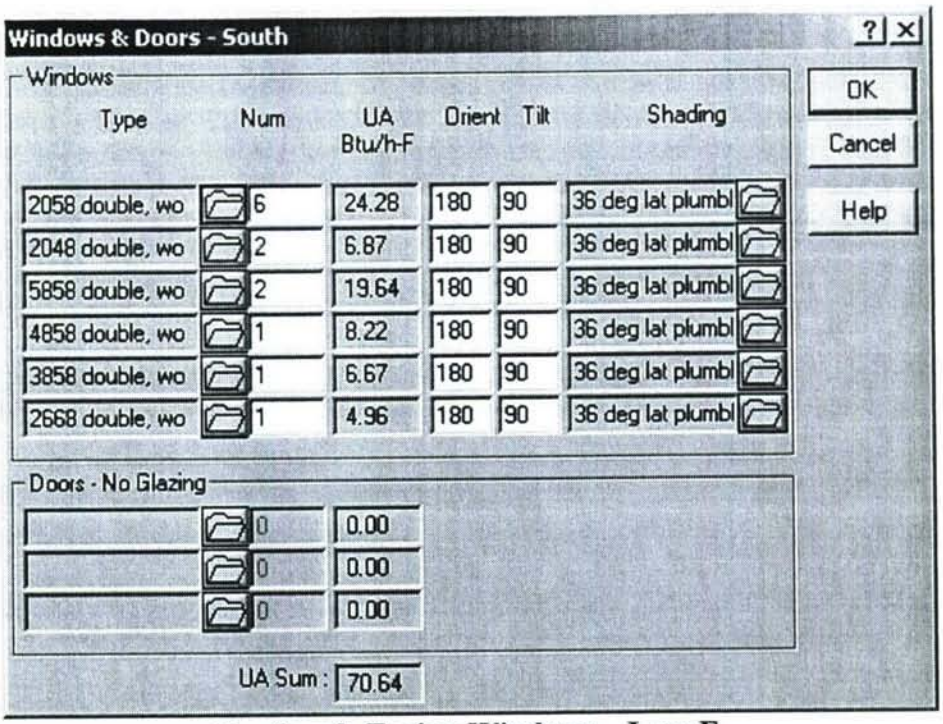
Orientation 30° East



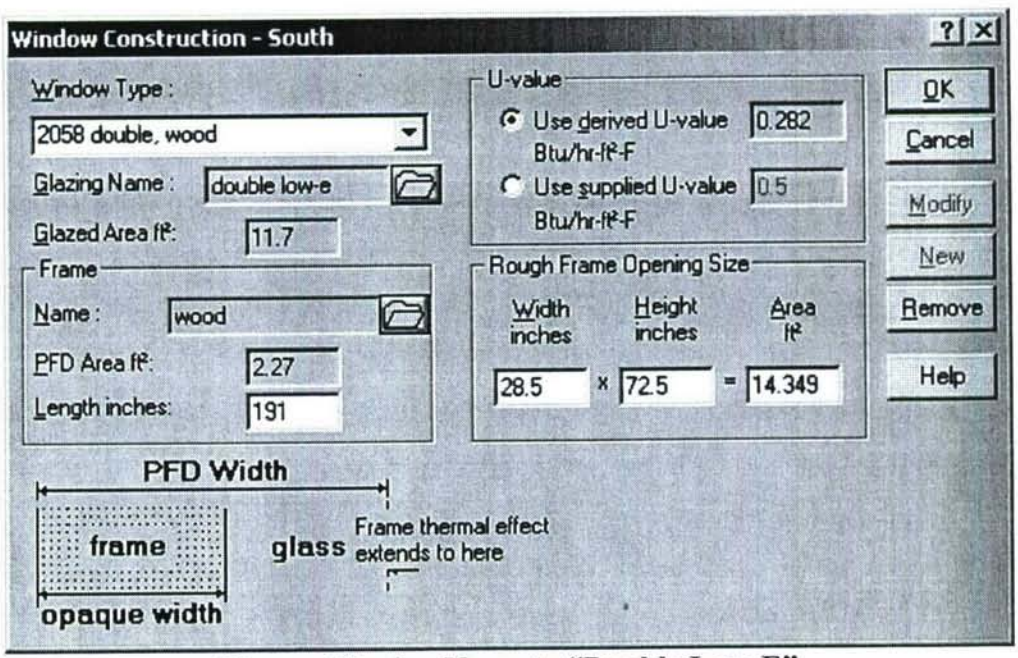
Orientation 45° East

Window Placement Cases

Case 1 – All south-facing windows changed to Low-E glass.

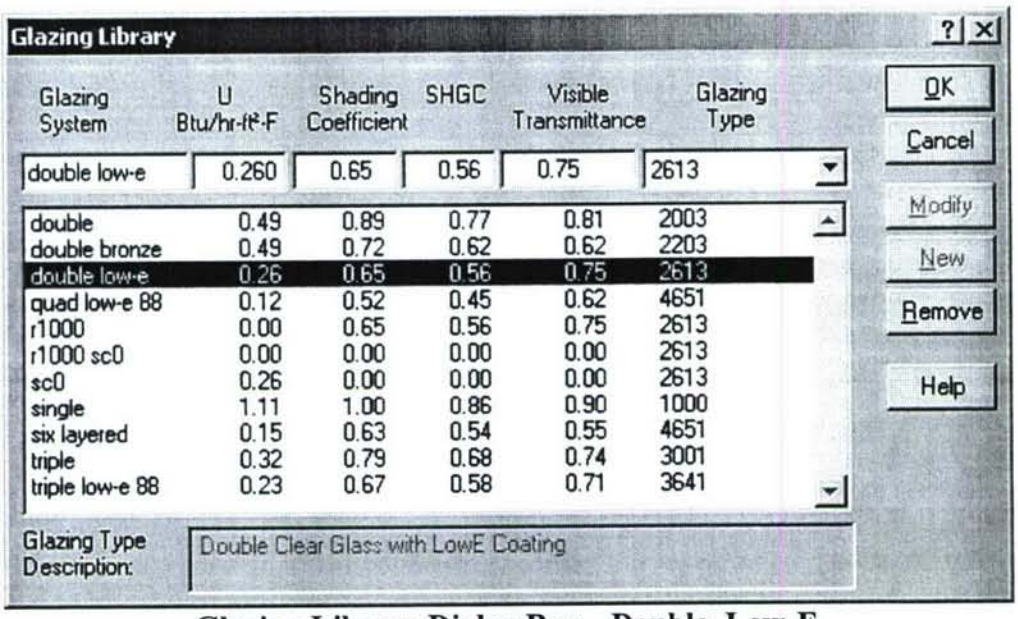


For South-Facing Windows – Low-E



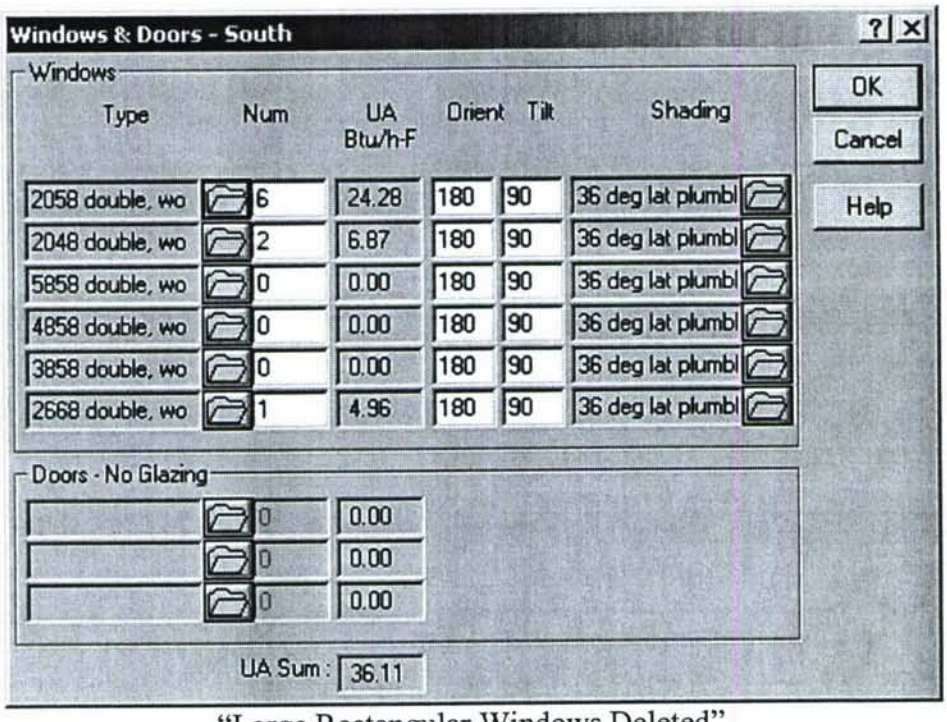
Change Glazing Name to "Double Low-E"

Appendix A



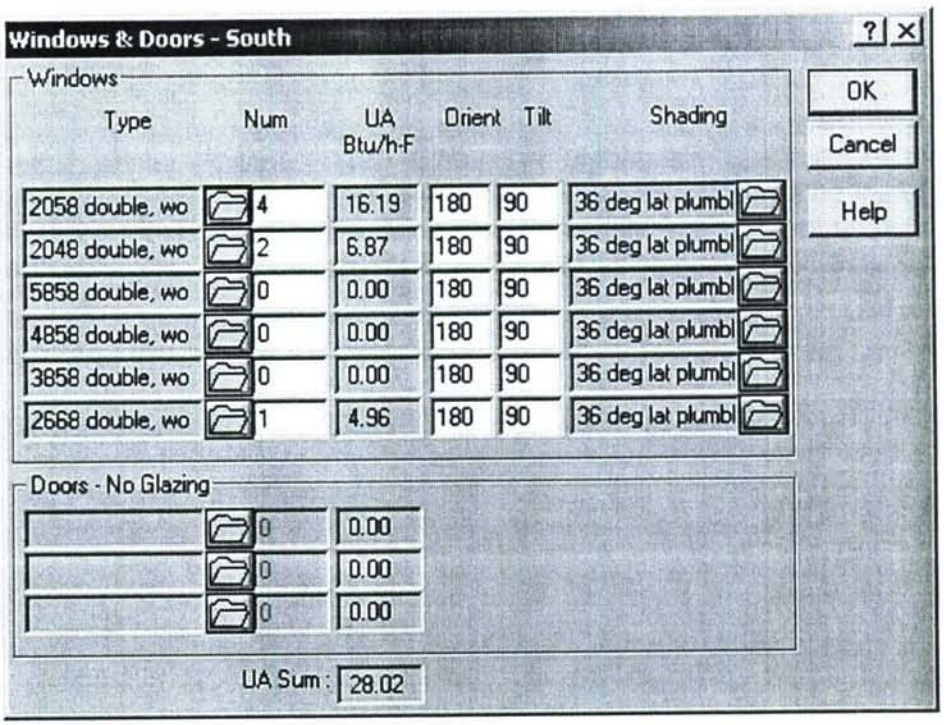
Glazing Library Dialog Box – Double, Low-E

Case 2 – Used 8 south-facing, Low-E windows.

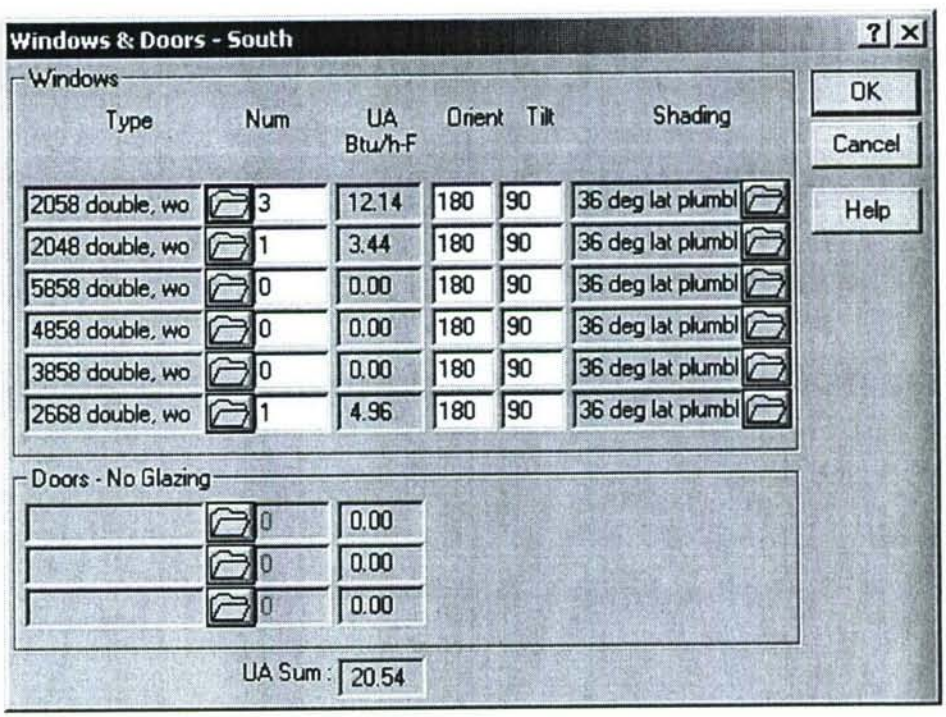


"Large Rectangular Windows Deleted"

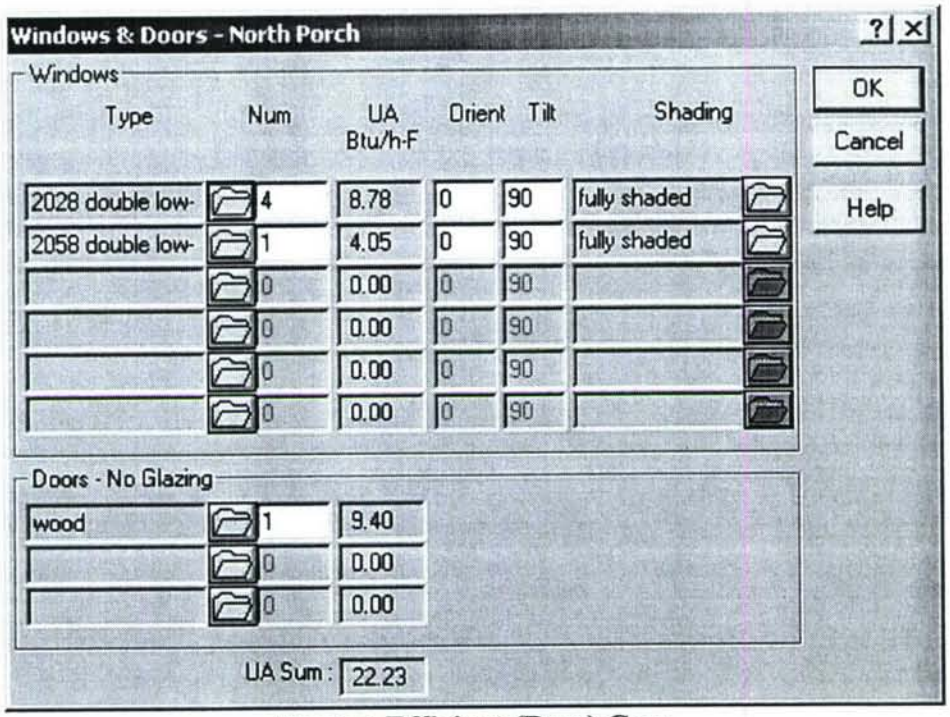
Case 3 - Used 6 south-facing, Low-E windows.



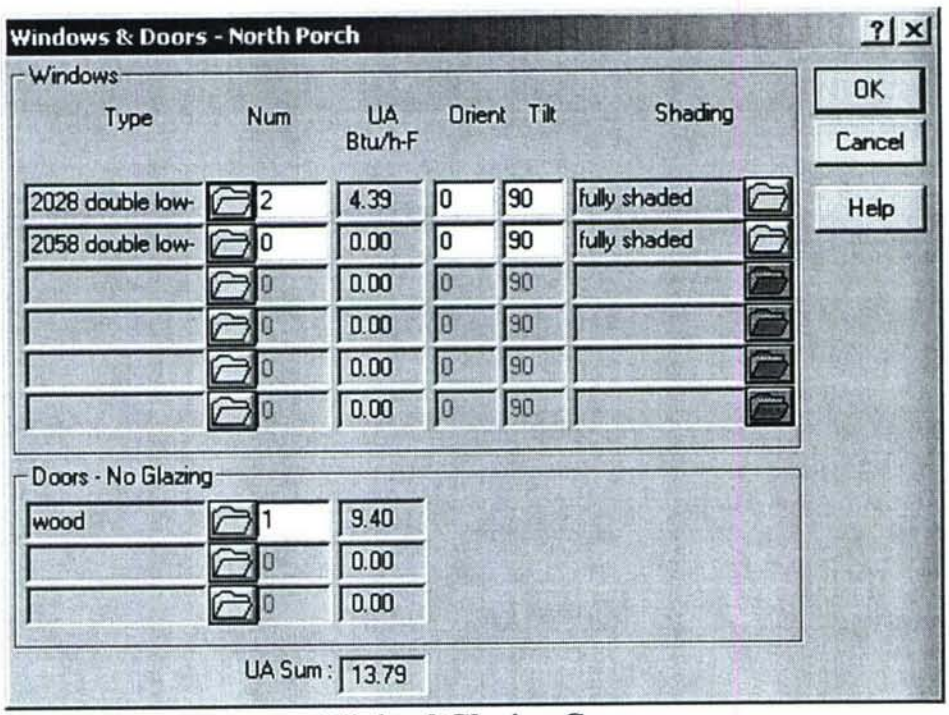
Case 4 - Used 4 south-facing, Low-E windows.



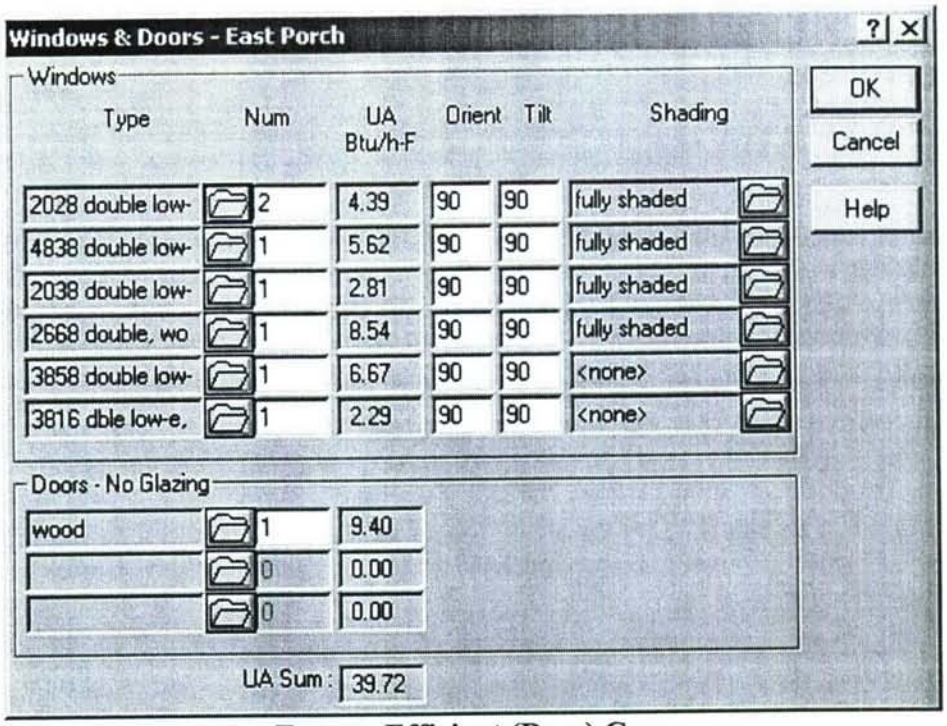
Case 5 – Used minimal glazing on North, East, and West exterior walls.



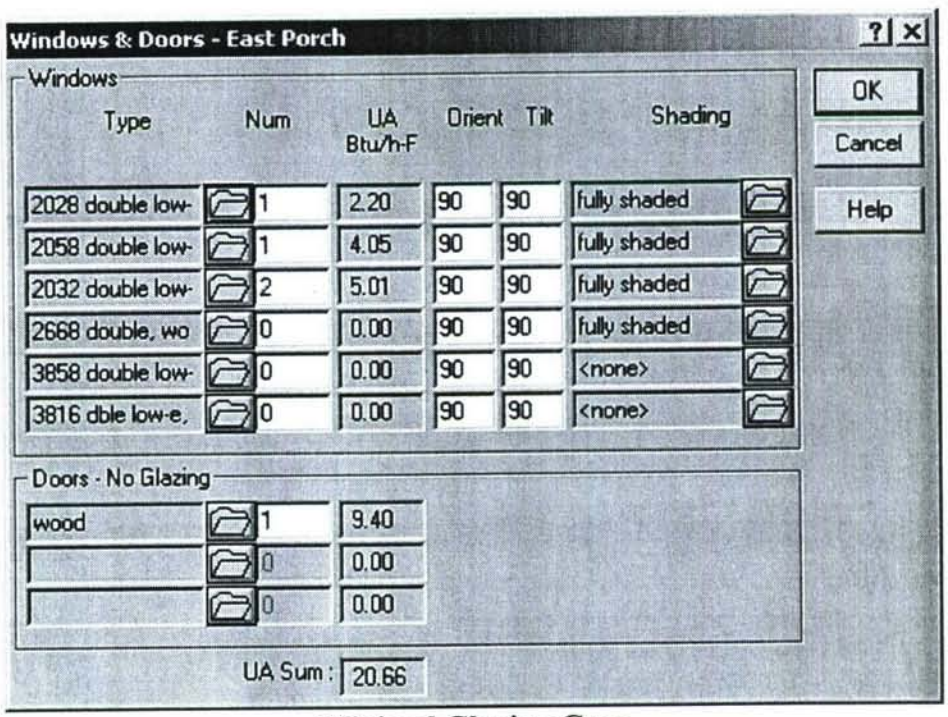
Energy-Efficient (Base) Case



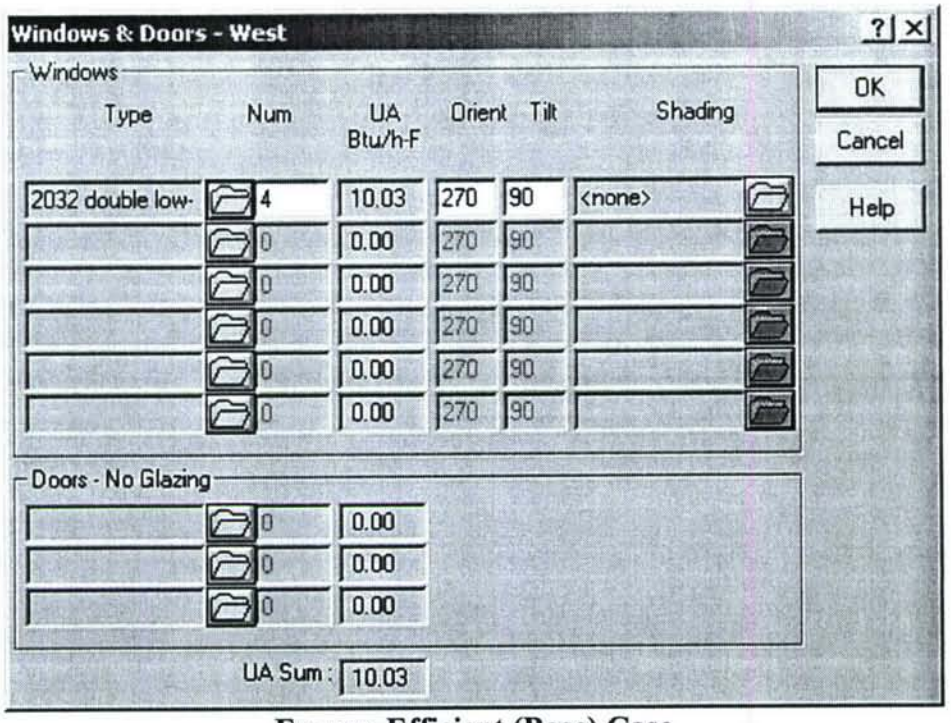
Minimal Glazing Case



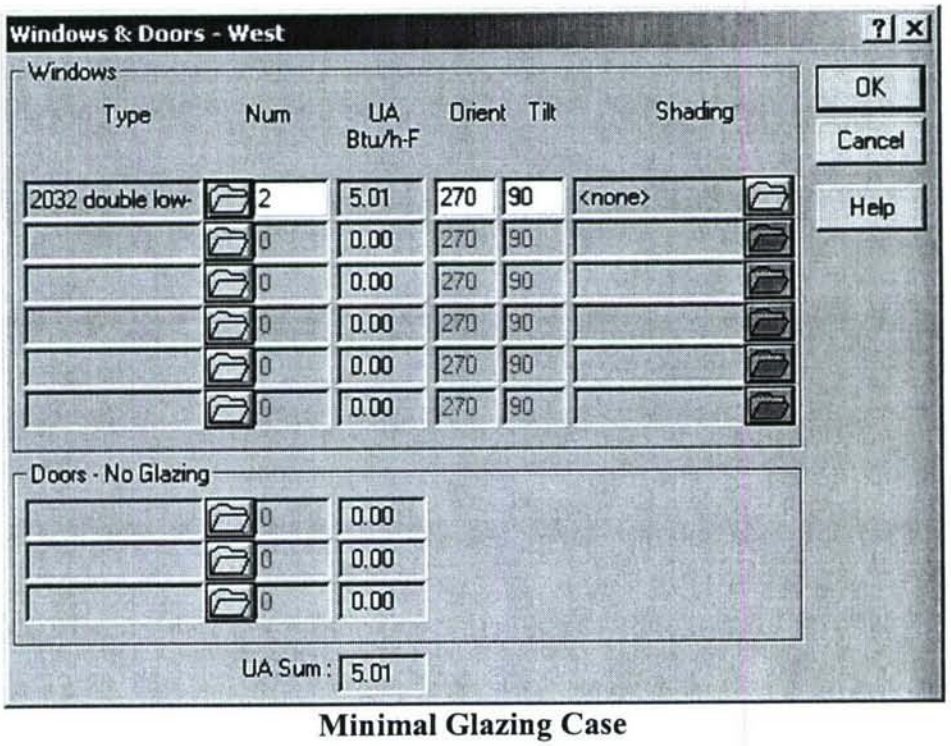
Energy-Efficient (Base) Case



Minimal Glazing Case



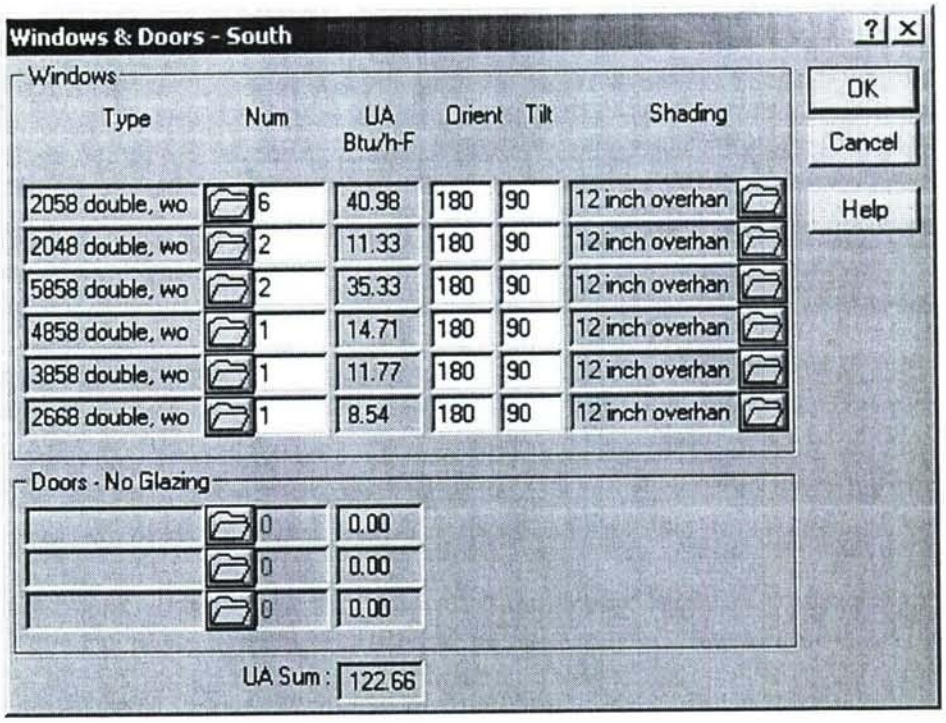
Energy-Efficient (Base) Case

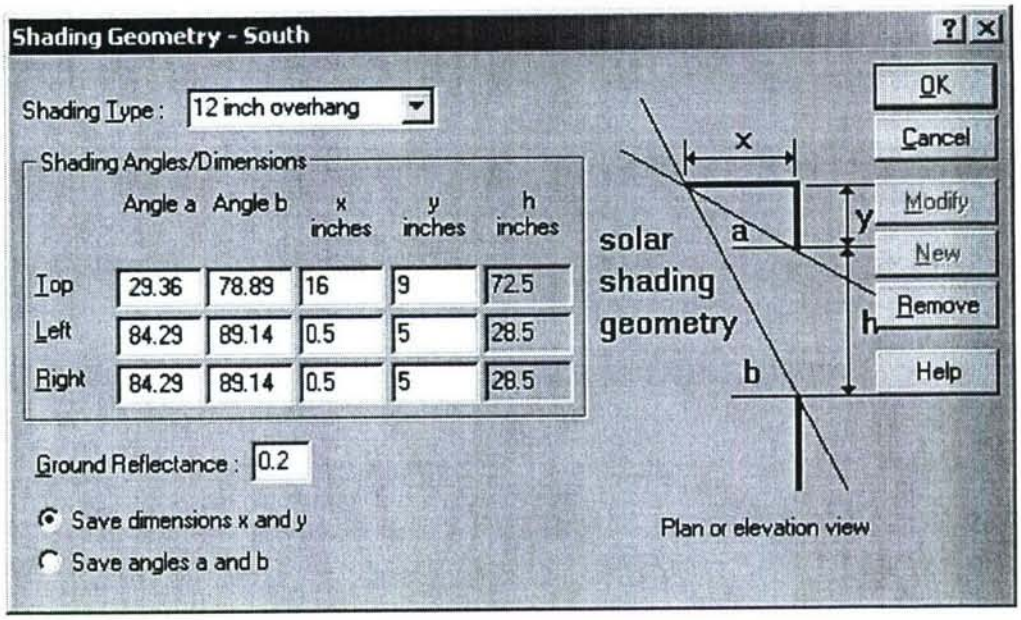


Minimal Glazing Case

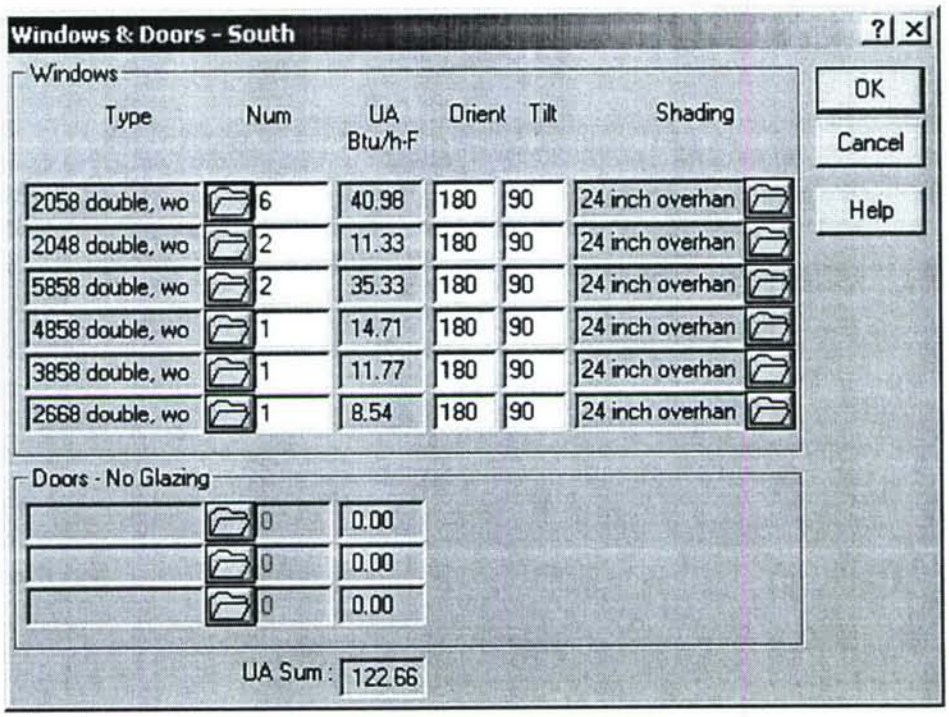
Shading Cases

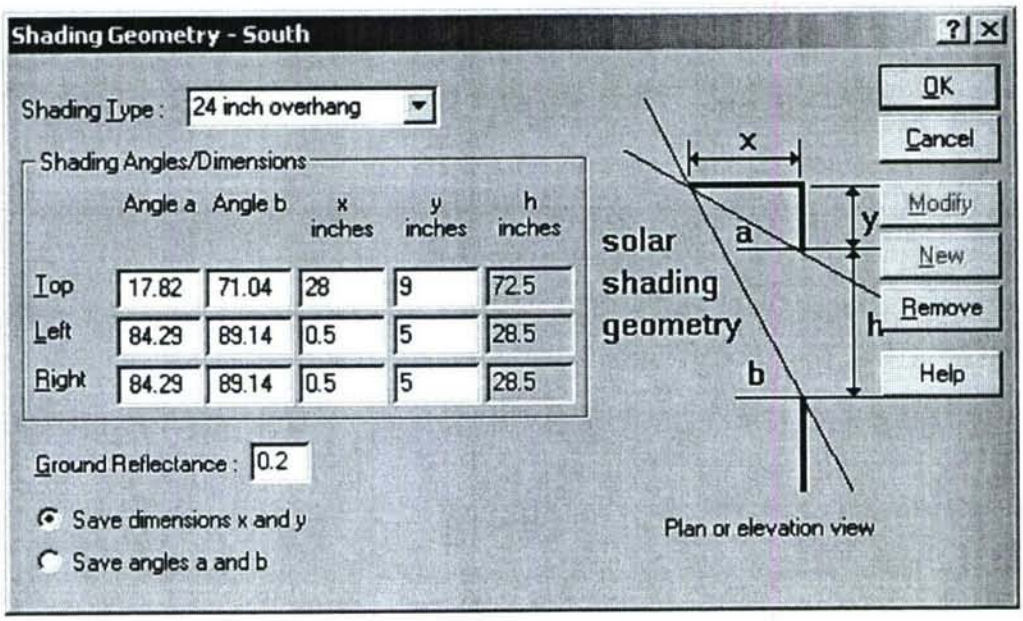
Case 1 – Overhang Design: 12 inch eave with 4 inch gutter.





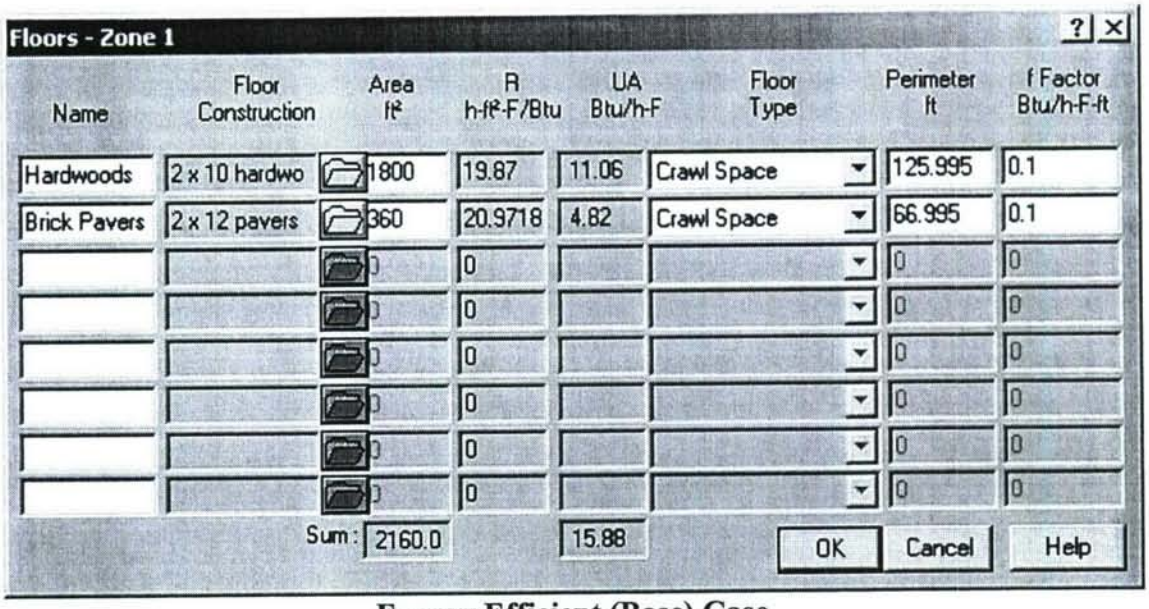
Case 2 – Overhang Design: 24 inch eave with 4 inch gutter.



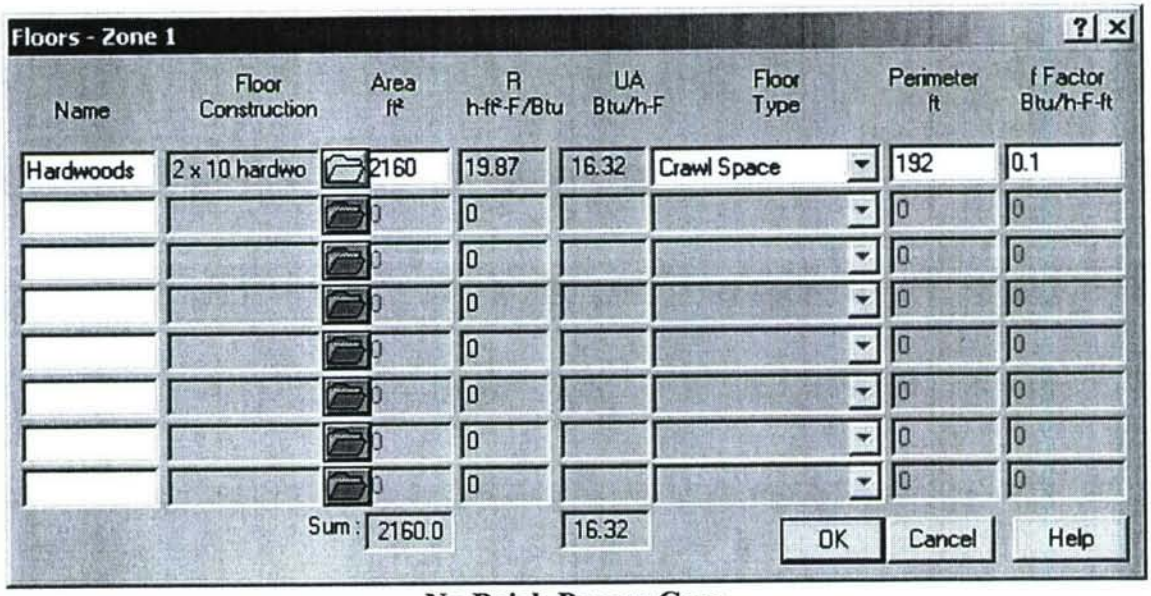


Heat Absorbing Material Case

Case 1 – Deleted thermal mass: No brick pavers and concrete floor sections.



Energy Efficient (Base) Case



No Brick Pavers Case

Insulation Case

Case 1 – Replaced 2x4 exterior framing and R-13 batt-insulation with 2x6 and R-19.

Walls - Zone 1

Name	Wall Type	Gross Area ft²	R-value h-ft²-F/Btu	UA Btu/h-F	Solar Abs	Orient	Tilt	Windows / Doors
North Porch	2 x 6 cypress	275.58	19.76	10.75	0	0	90	5/1
East Porch	2 x 6 cypress	287.97	19.76	8.79	0	90	90	7/1
South	2 x 6 cypress	480.05	19.76	11.35	0.5	180	90	13/0
West	2 x 6 brick	287.97	18.38	13.84	0.1	270	90	4/0
North Garag	2 x 6 garage	204.92	15.51	13.21	0	0	90	0/0
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
		0	0	0.0	0	0	0	
	Sum :	1536.49		57.9				

OK | Cancel | Help

Wall Construction - South

Wall Type : 2 x 6 cypress

R-value to Use
- (•) Derived R-value h-ft²-F/Btu: 19.7556
- ( ) User-supplied R-value h-ft²-F/Btu

OK | Cancel | New | Modify | Remove | Help

Wall Cross Section - 1

% of Wall Area : 80 — R: h-ft²-F/Btu : 23.32

Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.63	
3	polyiso foam	0.50	
4	fiberglass	5.50	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	7.13	

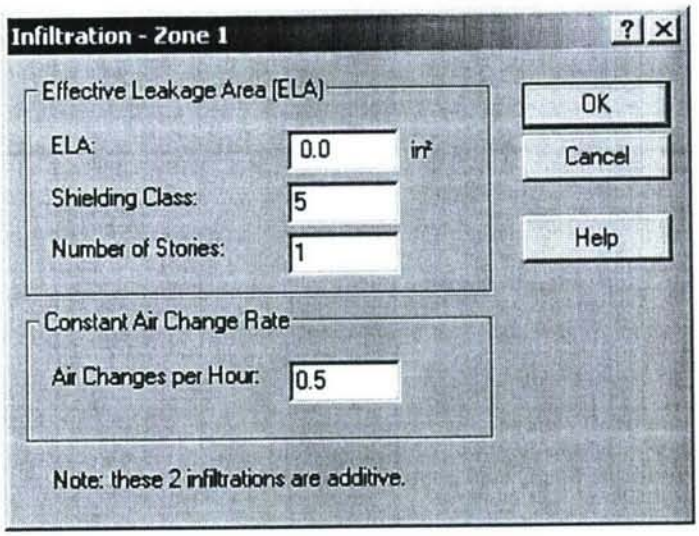
Wall Cross Section - 2

% of Wall Area : 20 — R: h-ft²-F/Btu : 12.26 — Duplicate S1

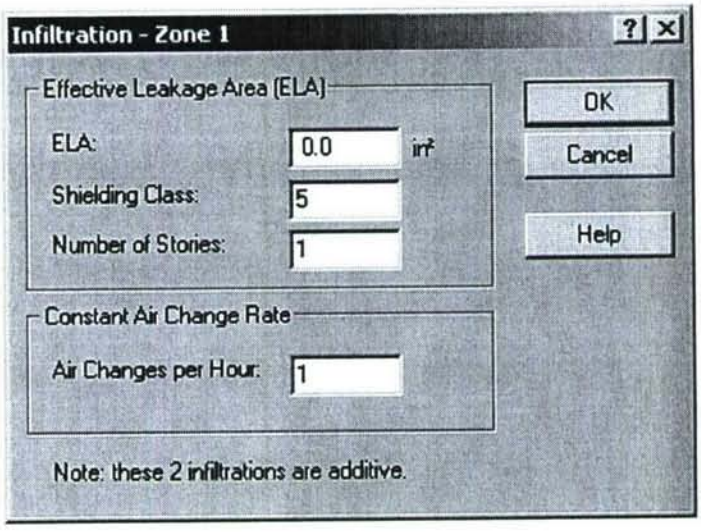
Layers	Material	Thickness inches	Air Layer U-value
outside	outside air film	0.00	U= 5.88
2	softwood	0.63	
3	polyiso foam	0.50	
4	softwood	5.50	
5	drywall	0.50	
6	inside air film	0.00	U= 1.47
7			
8			
9			
	Total Thickness	7.13	

Air Infiltration Control Cases

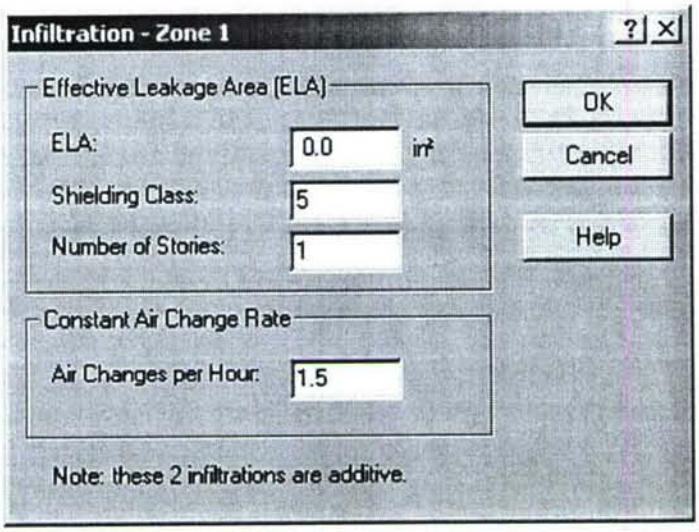
Case 1 – Used 0.5 Air-Changes per Hour (ACH).



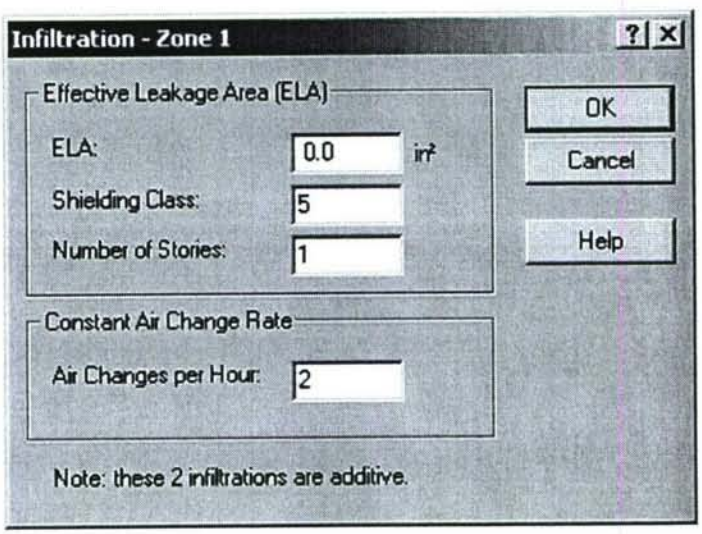
Case 2 – Used 1.0 Air-Change per Hour (ACH).



Case 3 – Used 1.5 Air-Changes per Hour (ACH).

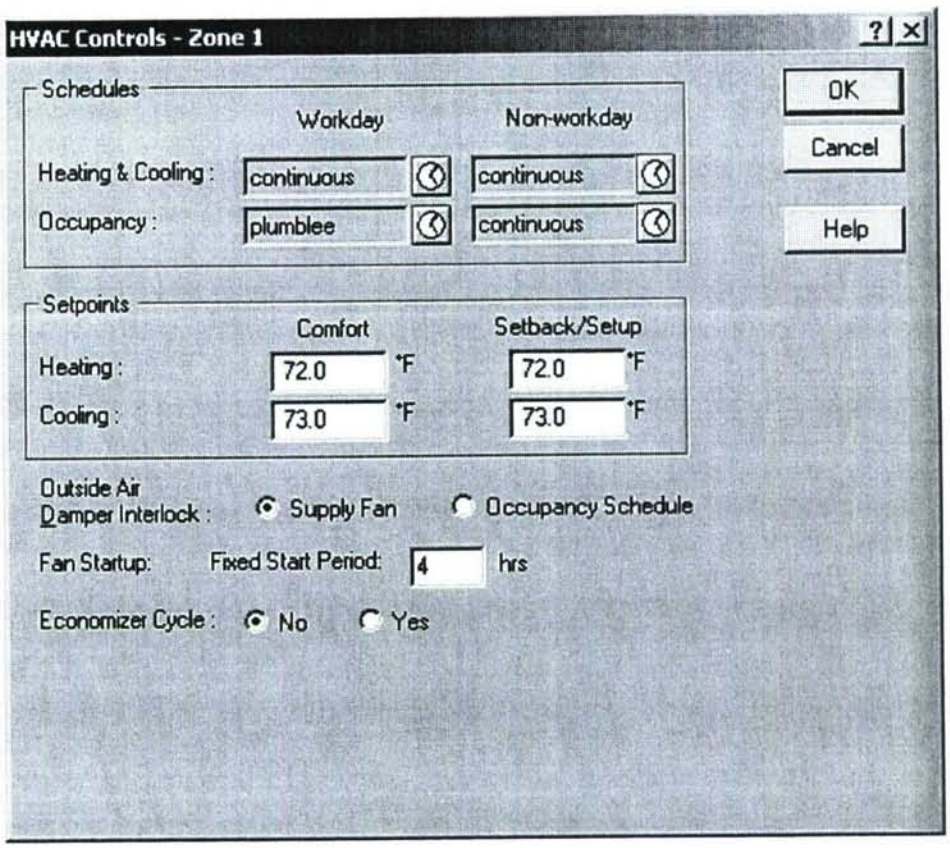


Case 4 – Used 2.0 Air-Changes per Hour (ACH).



Indoor Air Temperature Control Cases

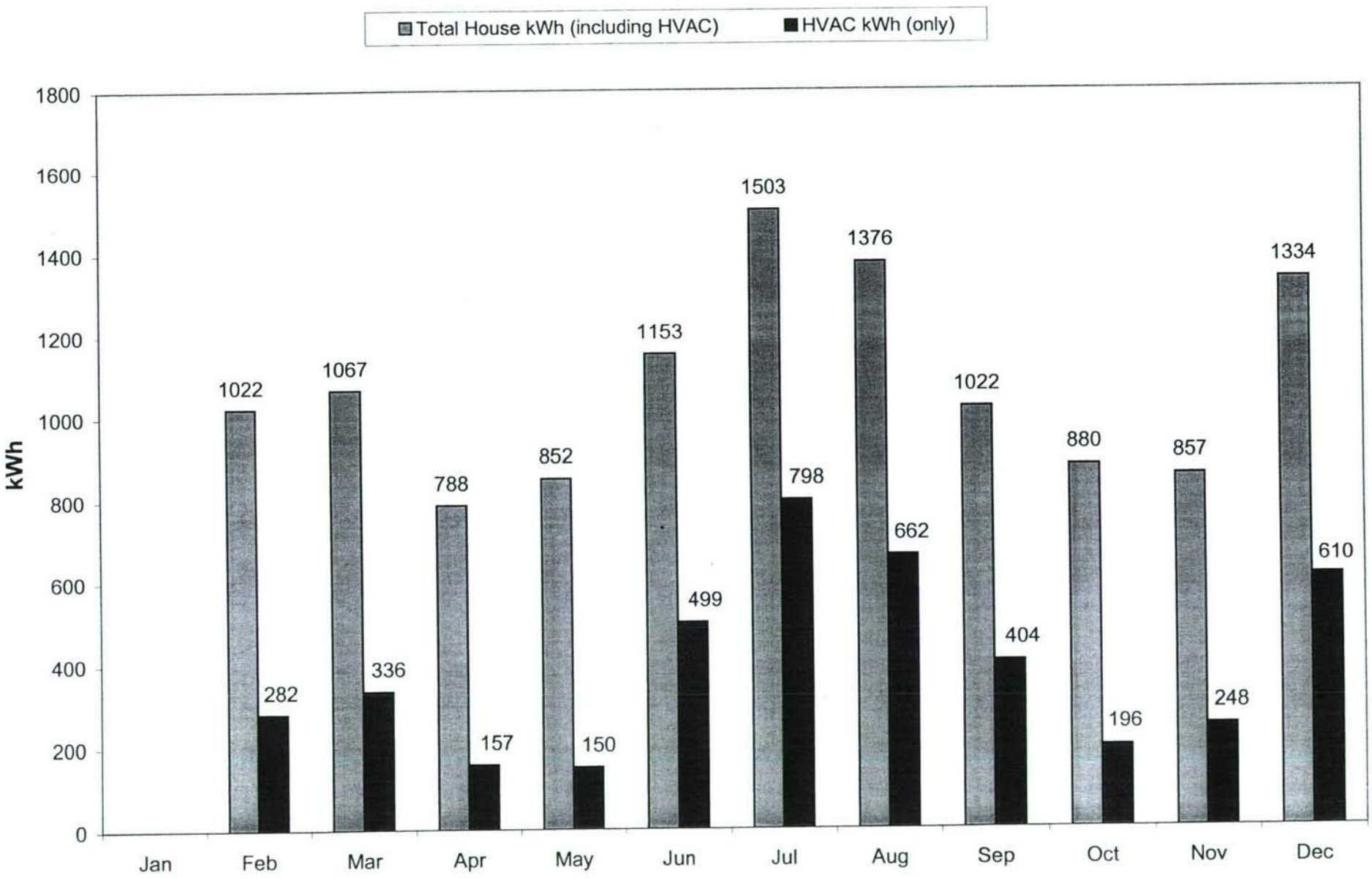
Case 1 – Winter Comfort Set-point: 72 °F
Summer Comfort Set-point: 73 °F



APPENDIX B

{Plumblee Home: Annual Monthly Energy Use}

1990 Monthly Electric Use

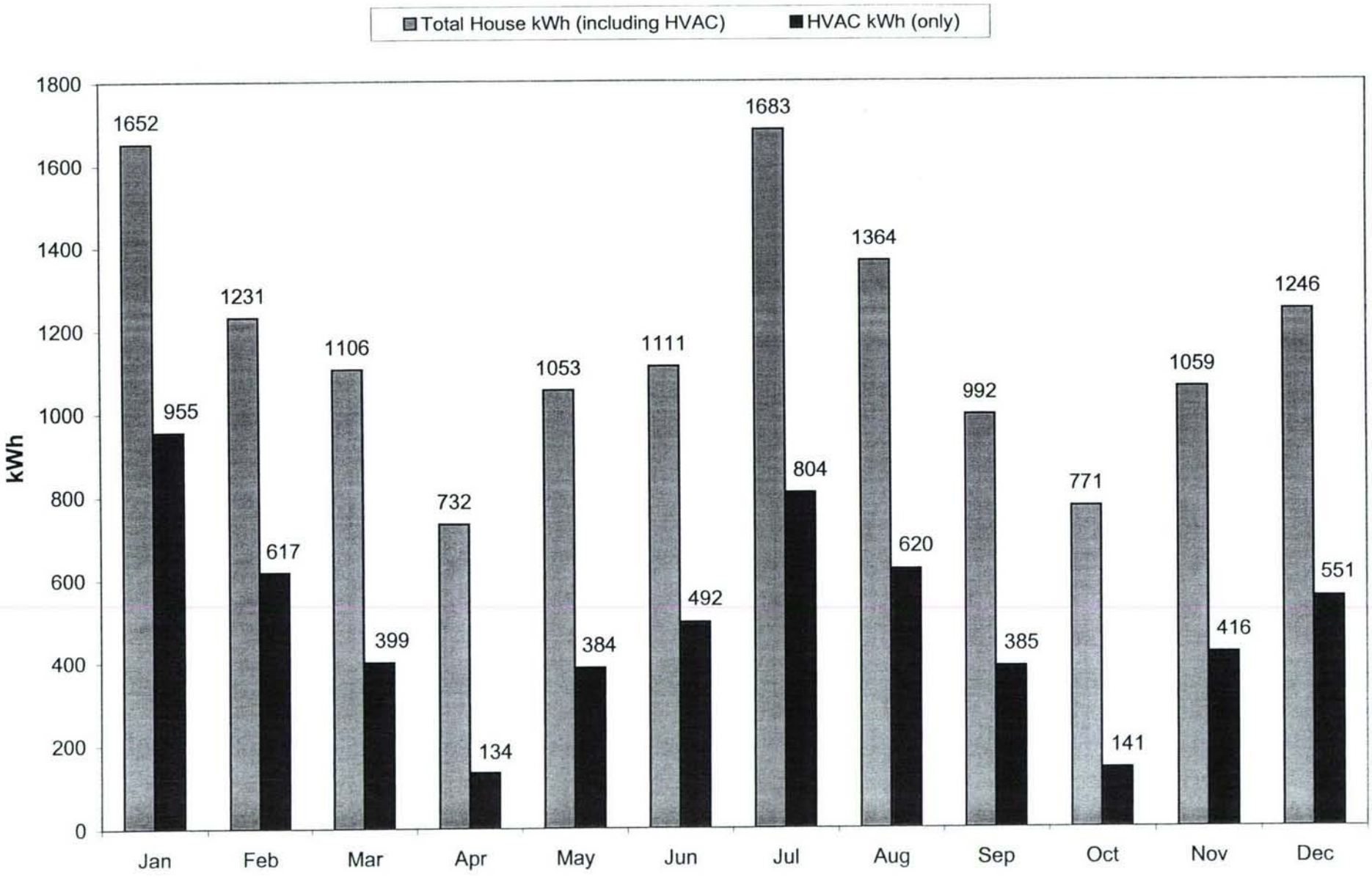


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1991 Monthly Electric Use

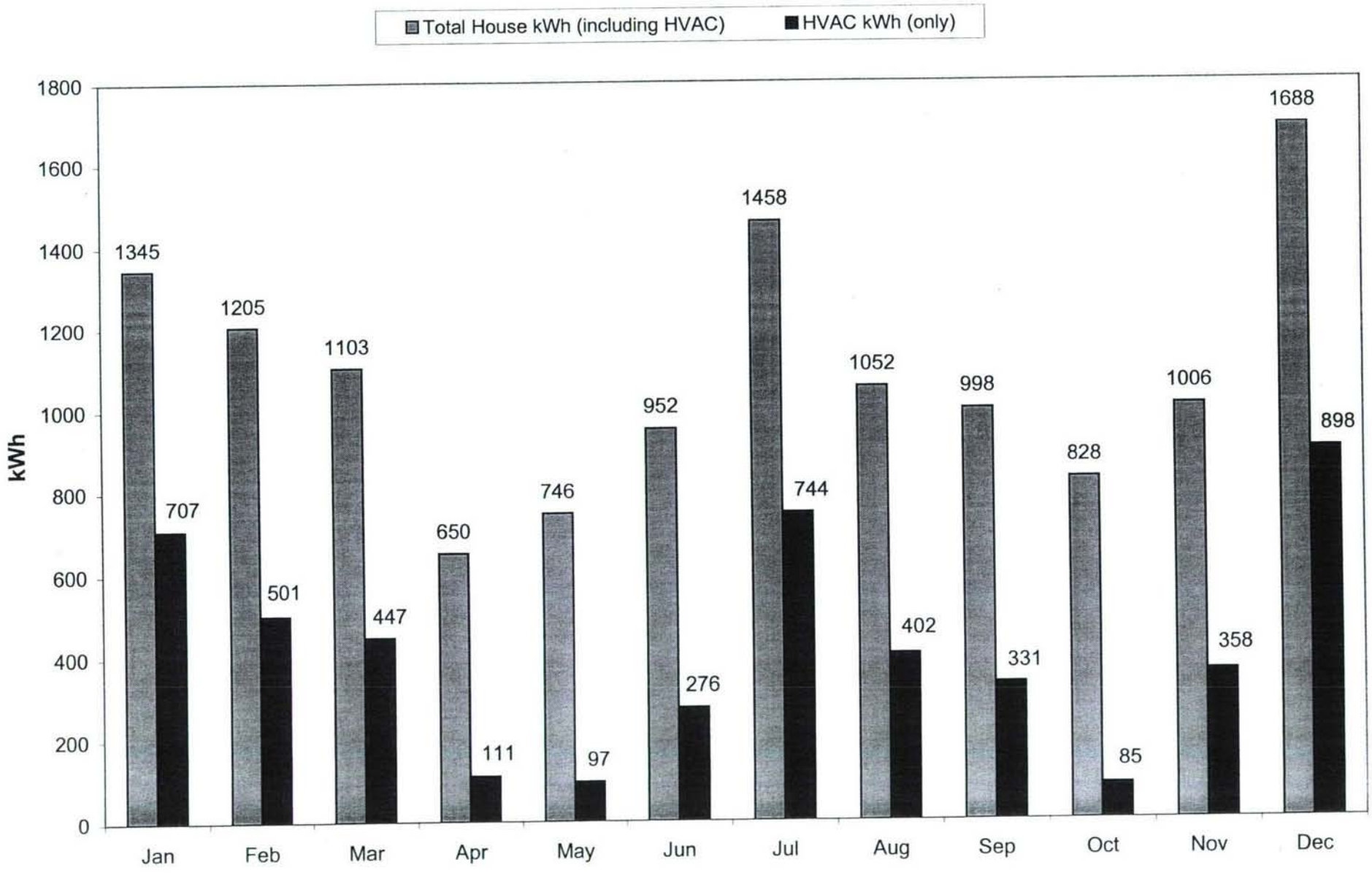


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1992 Monthly Electric Use

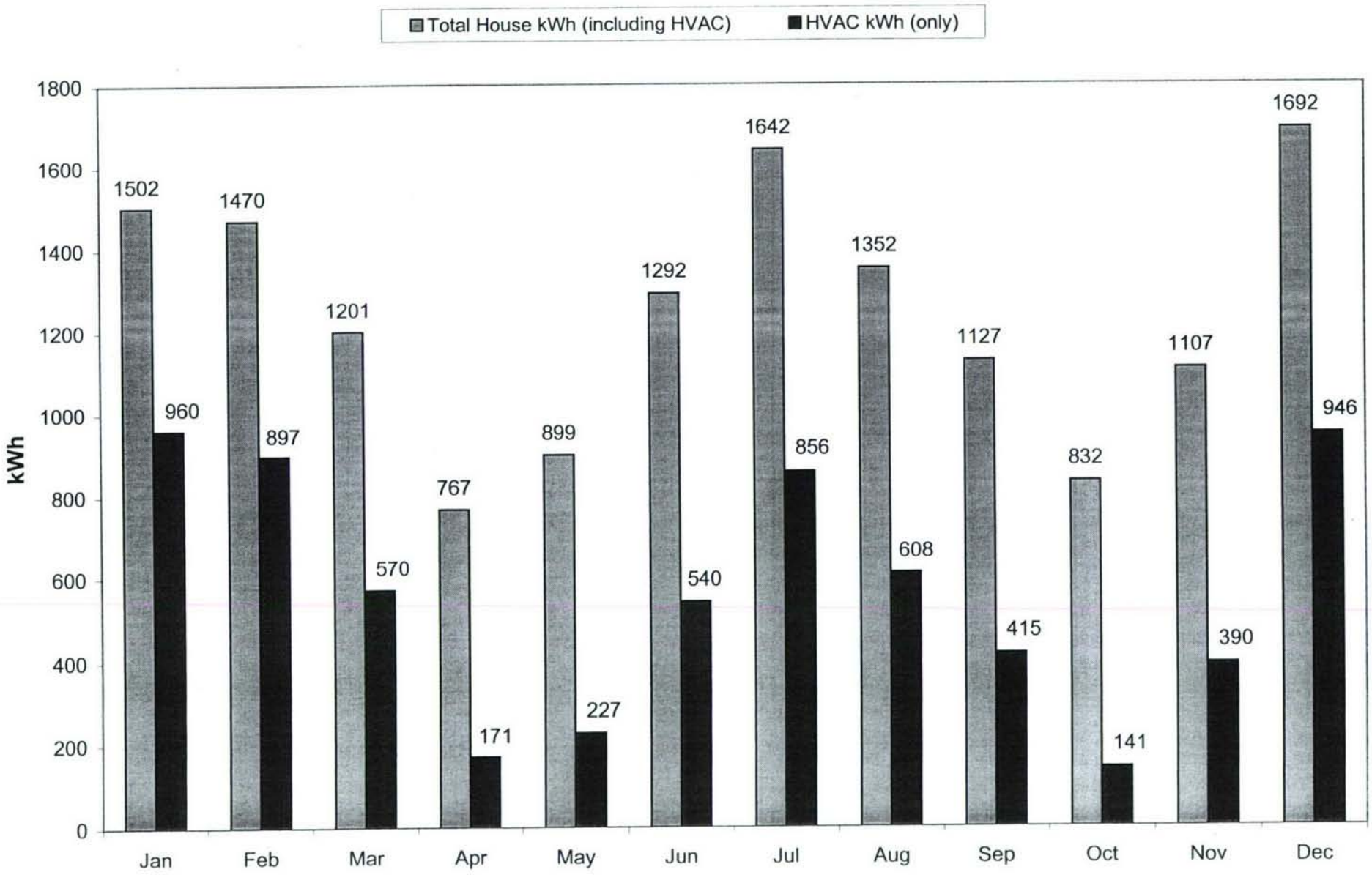


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1993 Monthly Electric Use

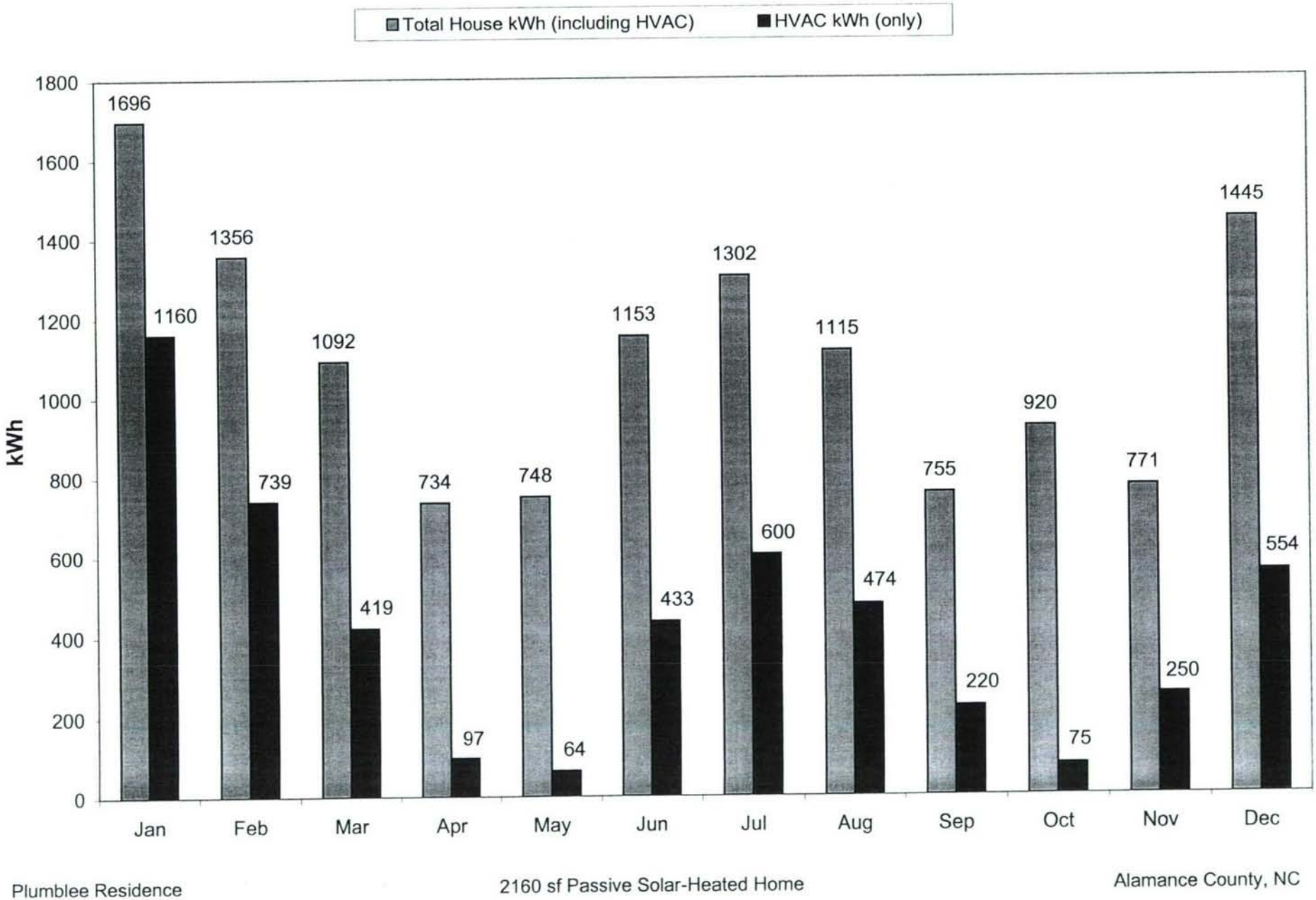


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1994 Monthly Electric Use

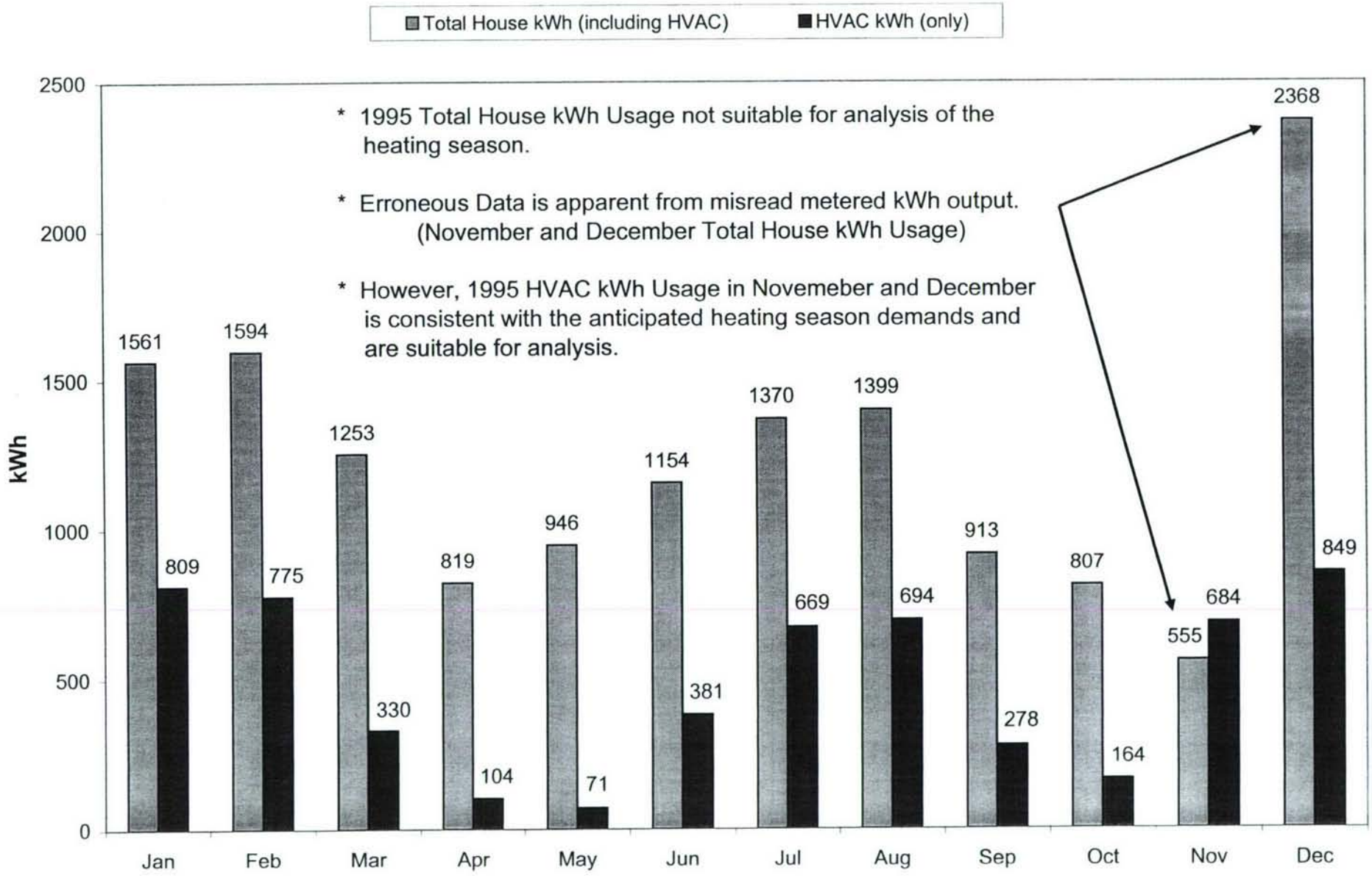


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1995 Monthly Electric Use

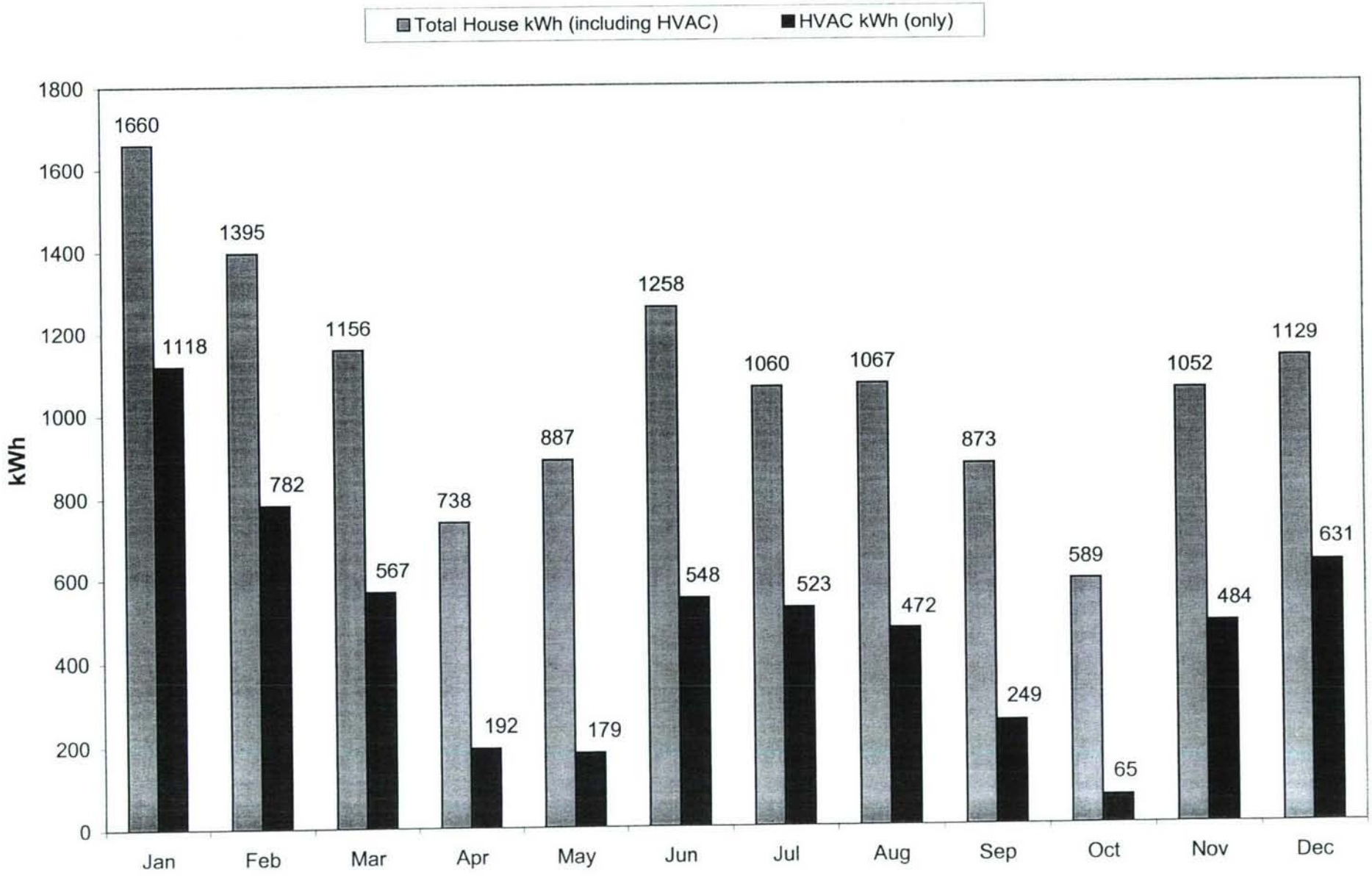


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1996 Monthly Electric Use

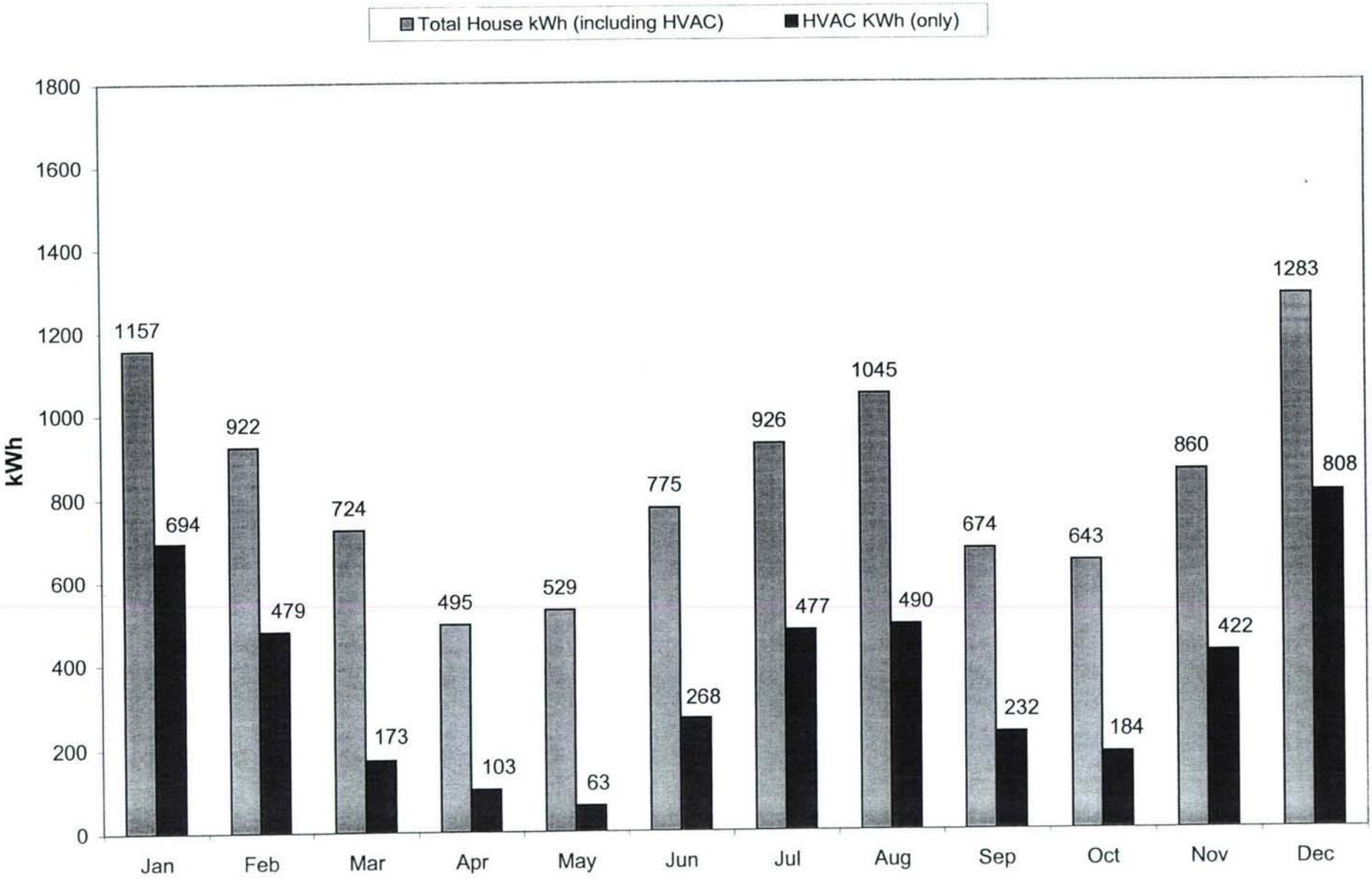


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1997 Monthly Electric Use



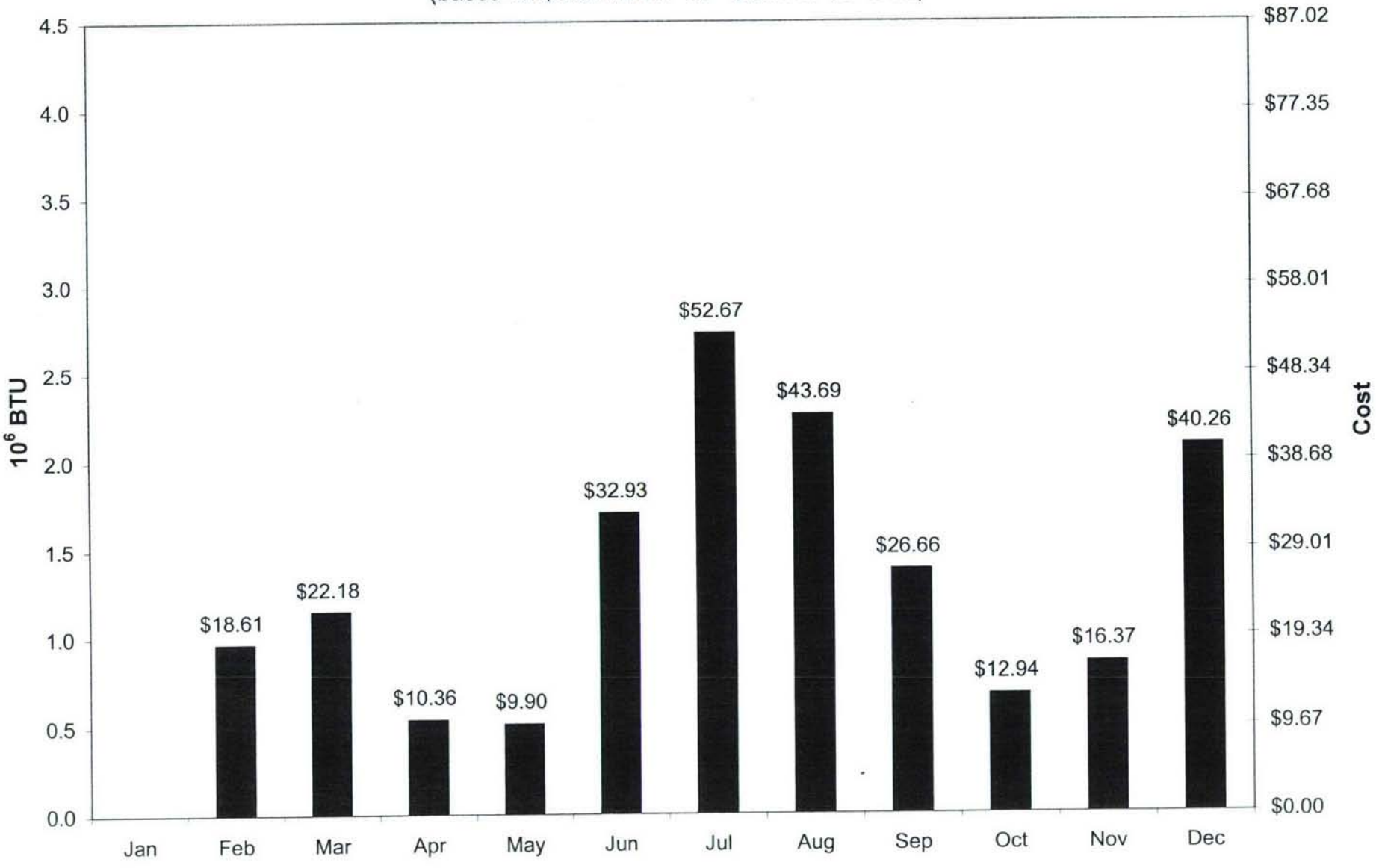
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1990 Monthly HVAC Energy Use / Cost

(based on $.066 / kWh or $19.34 / 10^6 BTU)



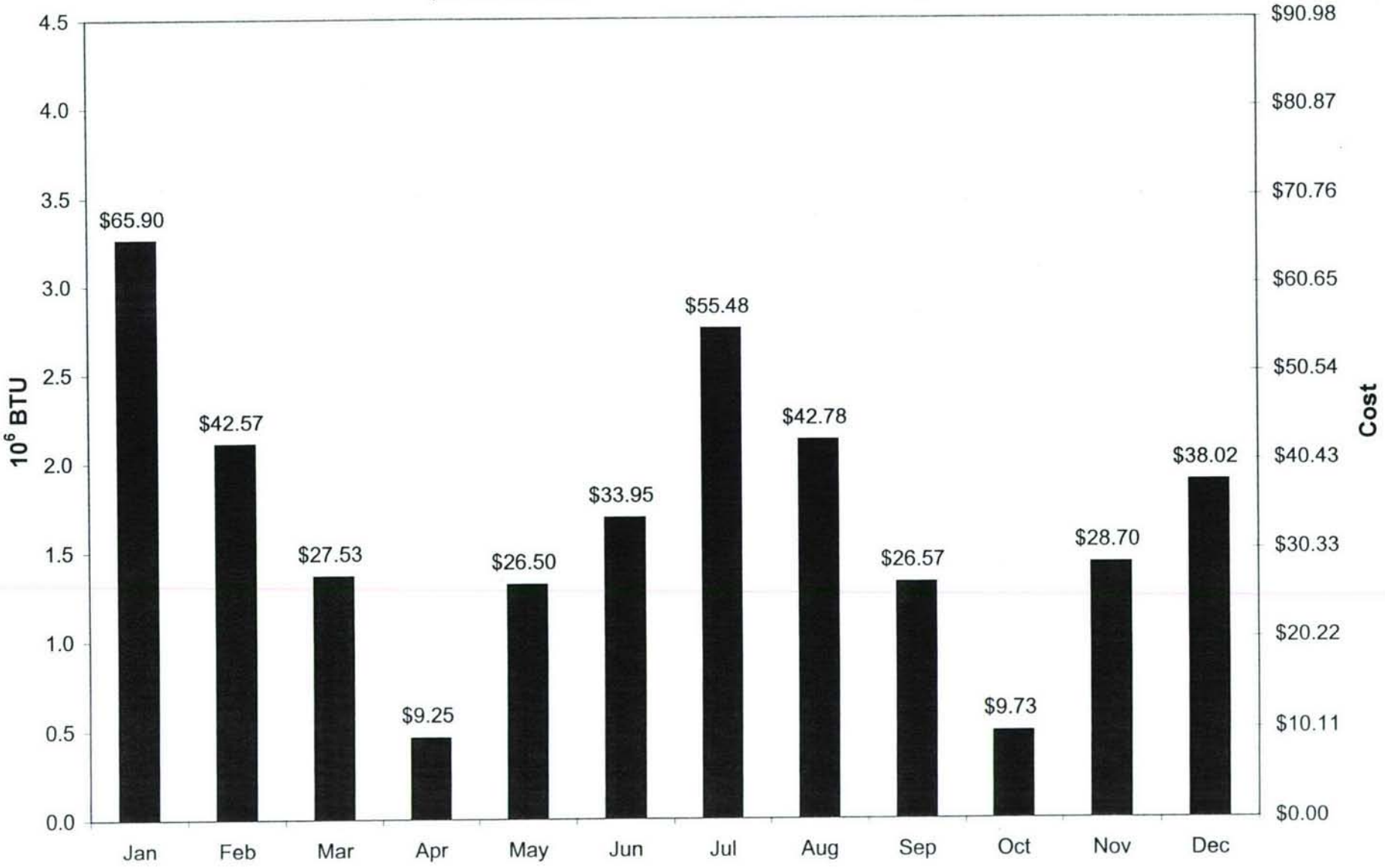
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1991 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



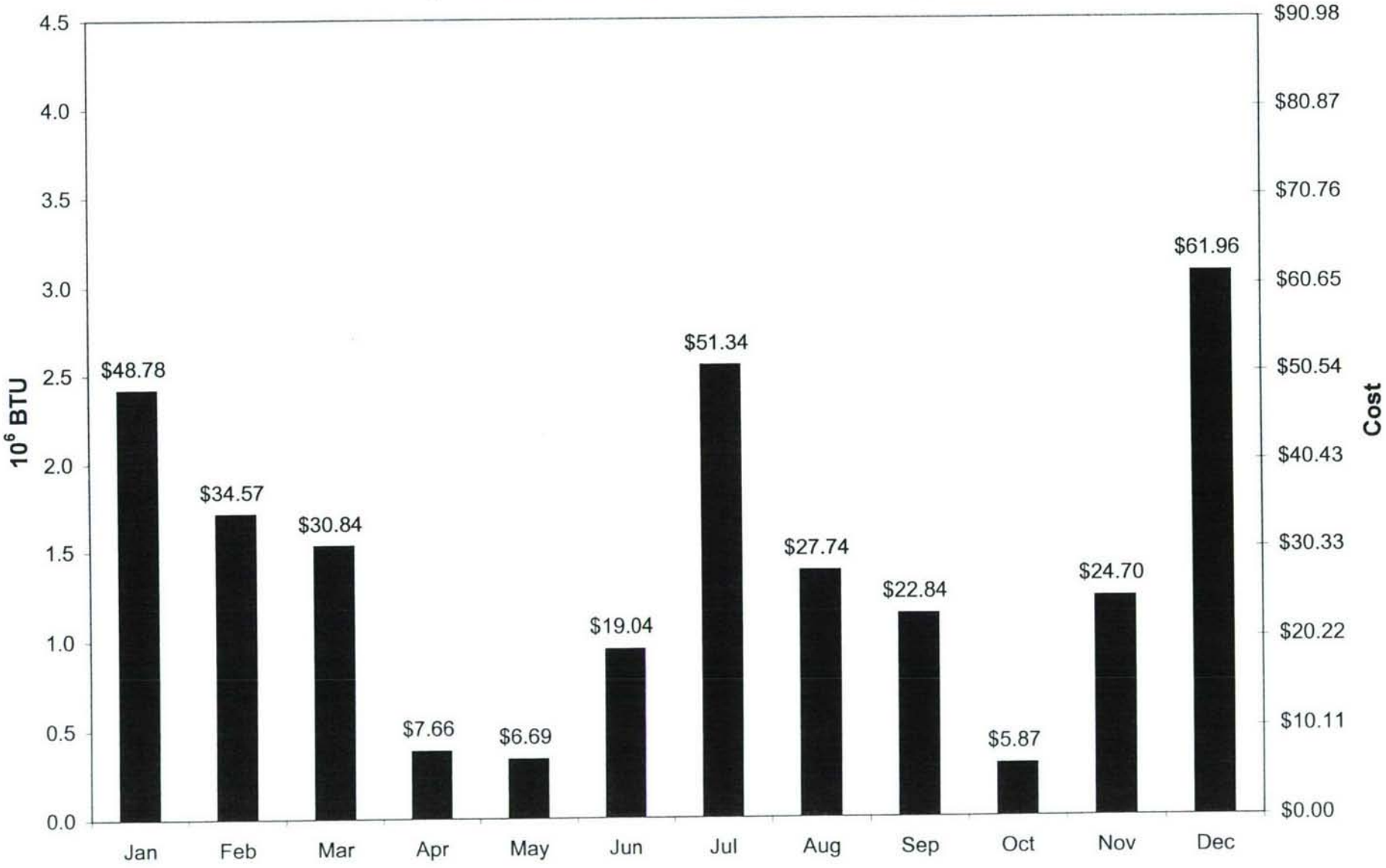
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1992 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



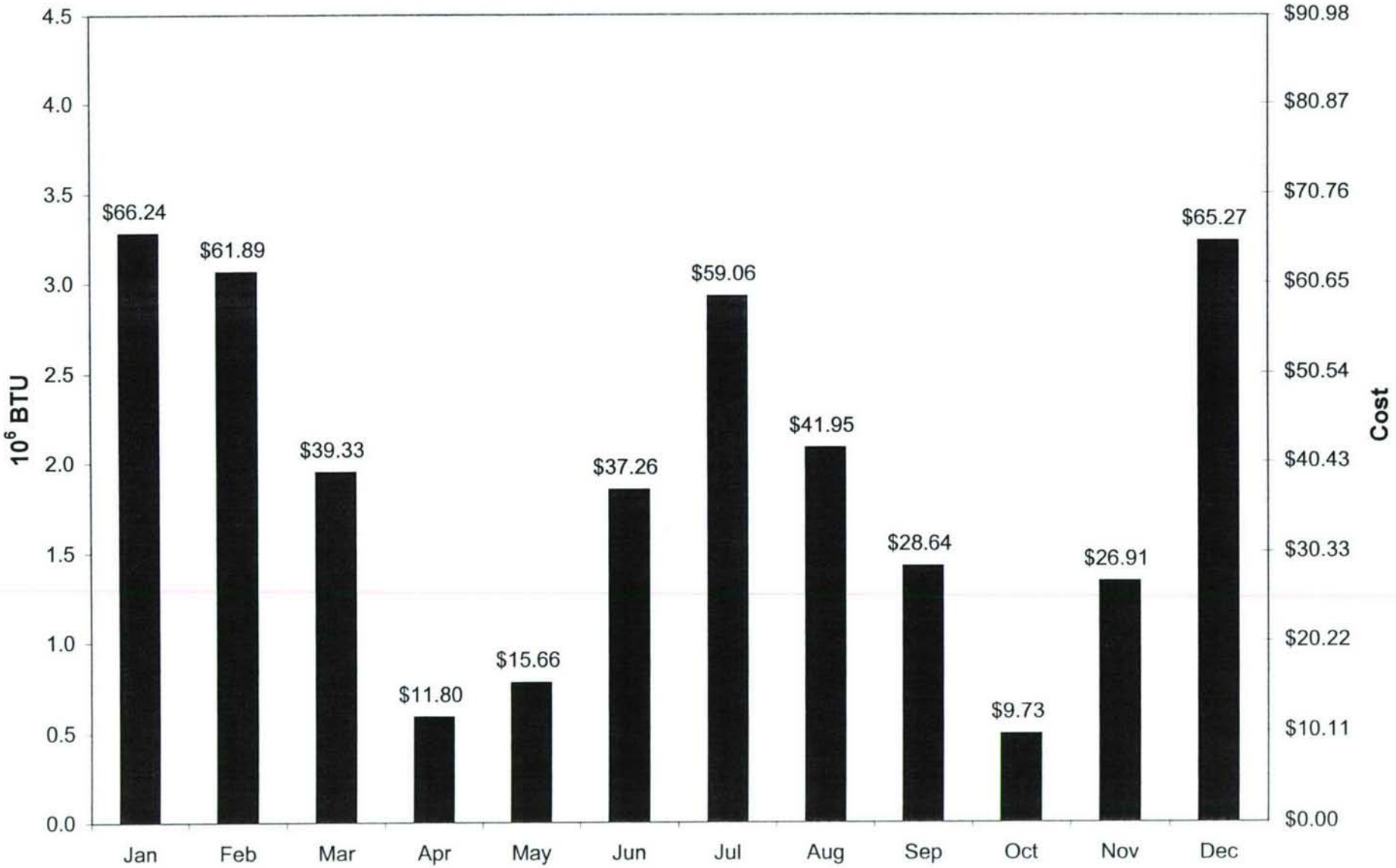
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1993 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



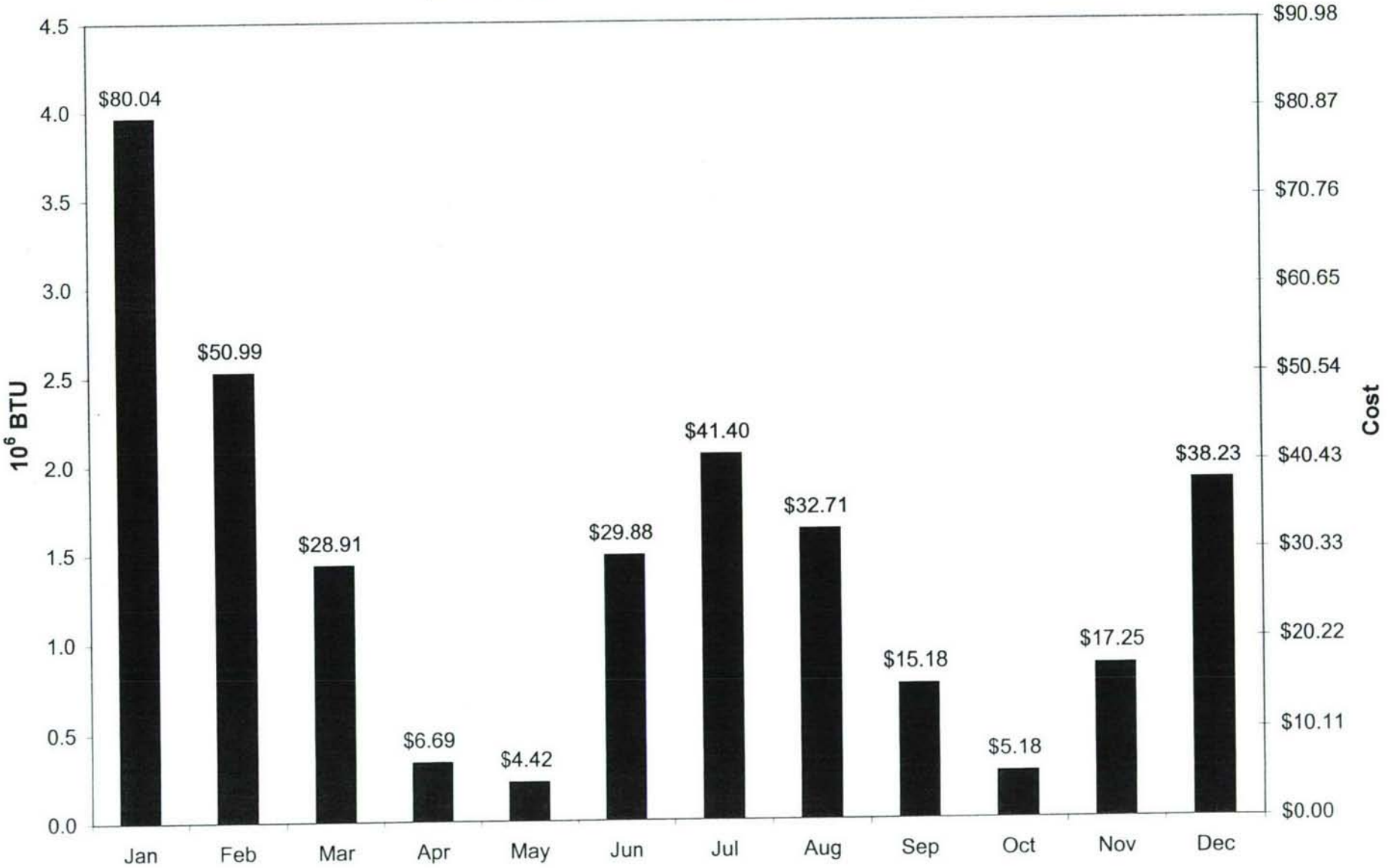
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1994 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



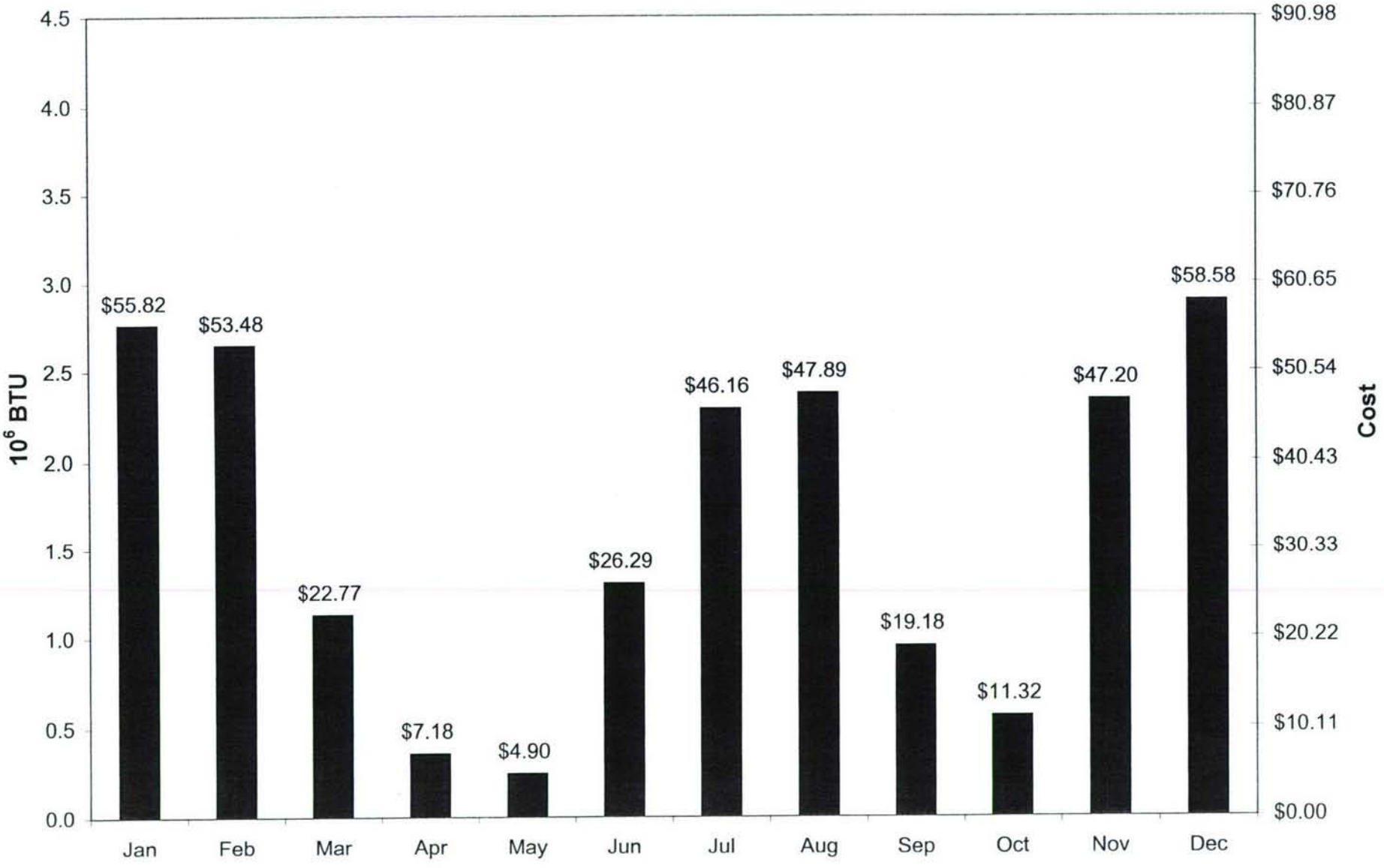
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1995 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



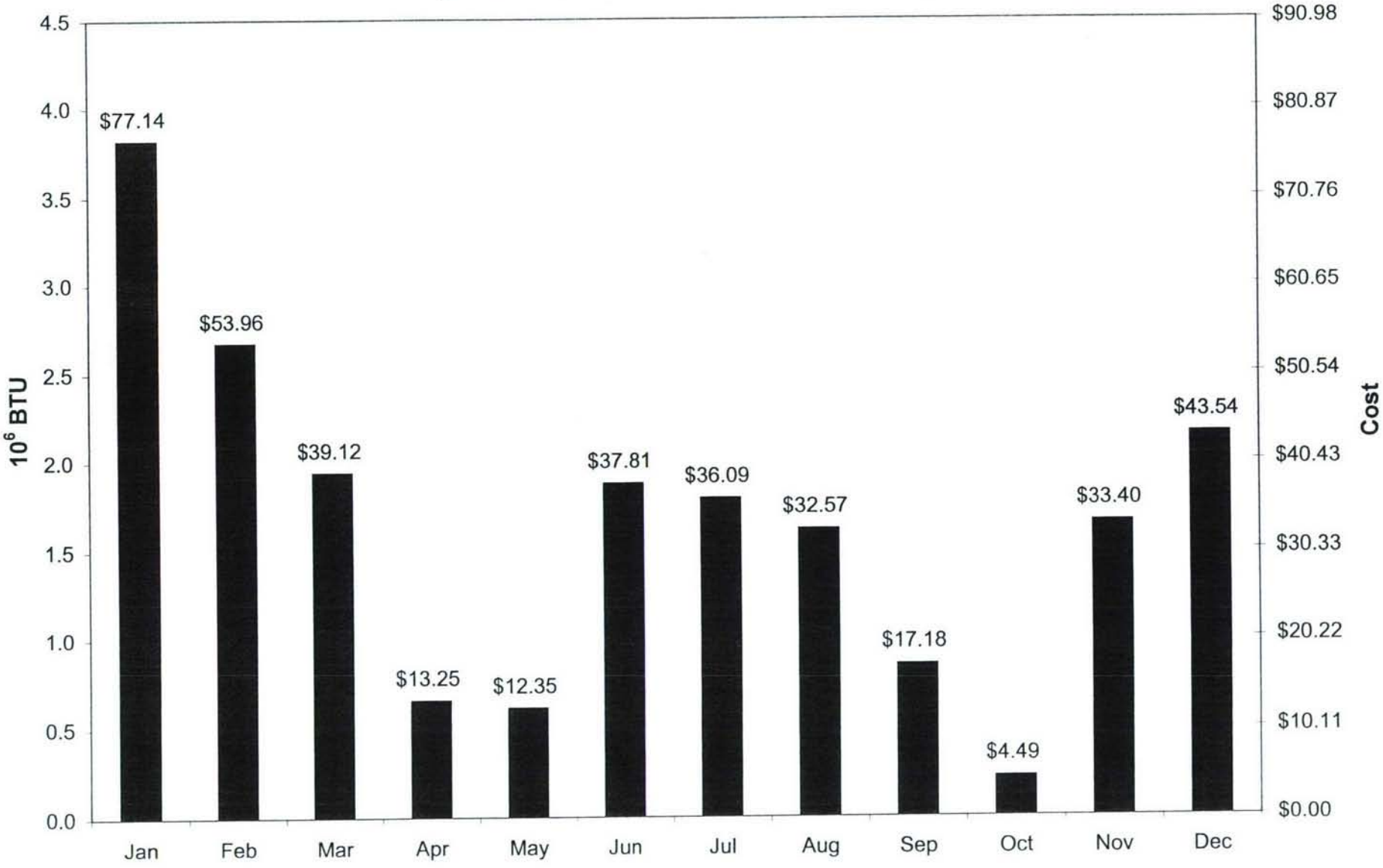
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1996 Monthly HVAC Energy Use / Cost

(based on $.069 / kWh or $20.22 / 10^6 BTU)



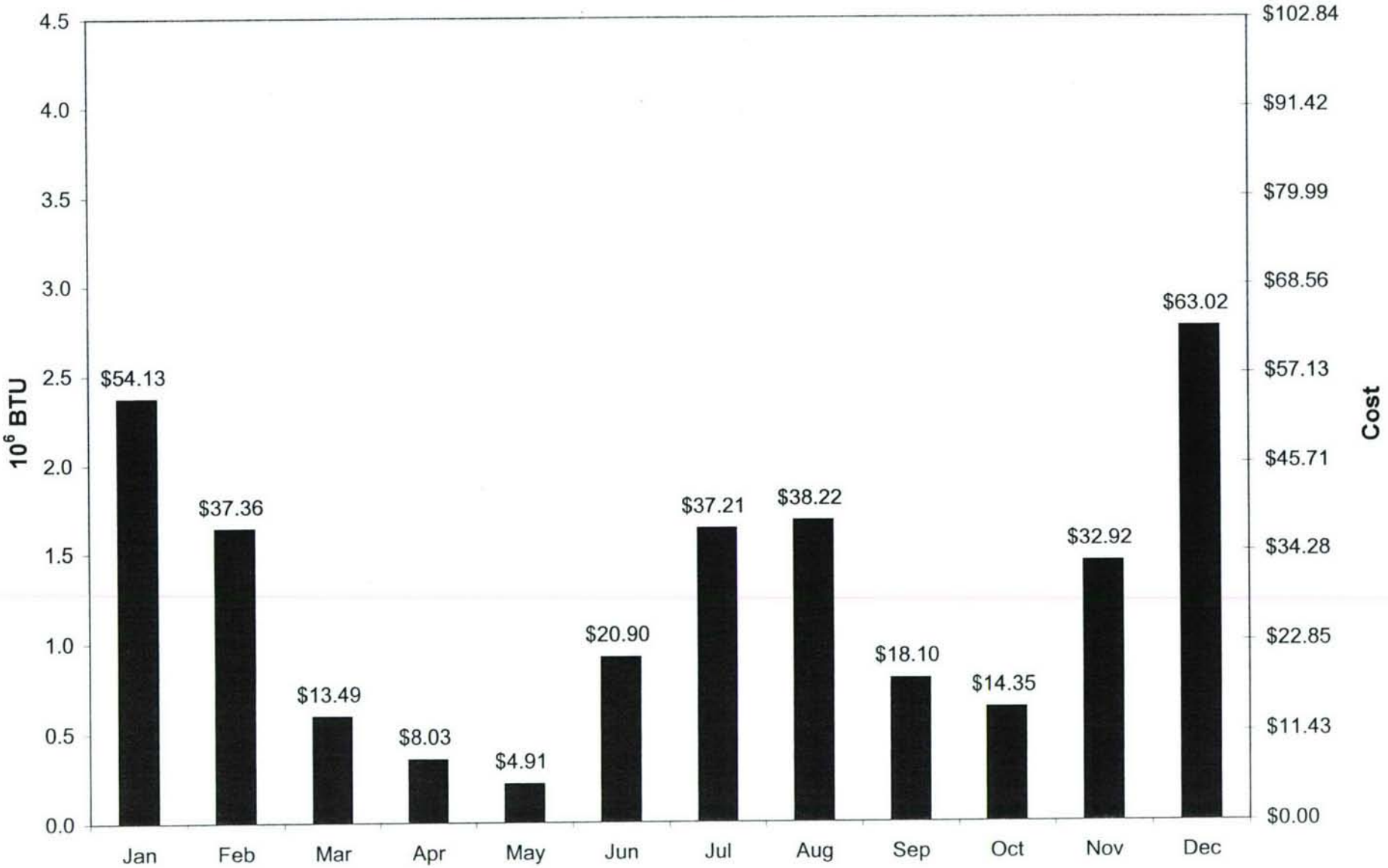
Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

1997 Monthly HVAC Energy Use / Cost

(based on $.078 / kWh or $22.85 / 10^6 BTU)



Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

APPENDIX C

{Annual Climatology Data for Plumblee Home}

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1990)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1990 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	57.9	32.2	45.1	5.9	609	0	70	18	21	13	0	0	17	0	4.63	0.98	1.10	26	0.0	0		8	6	1
2	62.9	33.0	48.0	6.3	473	0	76	17	8	25	0	0	14	0	3.28	-0.33	0.62	19	0.0	0		6	4	0
3	65.5	38.9	52.2	2.8	410	21	89	13	24	8	0	0	8	0	2.57X	M	0.70	29	0.0	0		5	2	0
4	73.1	43.2	58.2	-1.8	239	41	95	27	28	8	3	0	4	0	1.98	-1.34	0.61	3	0.0	0		5	1	0
5	76.6	53.5	65.1	-2.8	73	82	89	17	43	12	0	0	0	0	7.52	3.64	1.15	29	0.0	0		10	8	2
6	88.0	62.4	75.2	0.5	0	310	95	30	53	5	12	0	0	0	0.89	-3.28	0.50	23	0.0	0		3	1	0
7	91.8	68.0	79.9	1.6	0	467	99	11	59	3	21	0	0	0	2.48	-1.91	1.10	11	0.0	0		5	2	1
8	89.5	66.0	77.8	0.4	0	402	98	5	62	31	16	0	0	0	3.85	-0.69	0.95	23	0.0	0		6	4	0
9	82.2	57.3	69.8	-1.2	48	195	99	8	42	25	6	0	0	0	0.16	-3.85	0.12	14	0.0	0		1	0	0
10	74.7	48.0	61.4	1.6	153	50	89	9	32	27	0	0	1	0	7.78	4.61	2.80	11	0.0	0		9	6	3
11	68.4	37.4	52.9	2.8	355	0	80	4	29	30	0	0	7	0	2.21	-0.62	1.40	10	0.0	0		3	2	1
12	57.3	34.0	45.7	4.0	591	0	72	24	19	26	0	0	14	0	3.93	0.53	1.30	4	0.0	0		7	3	1
Annual	74.0	47.8	60.9	1.7	2951	1568	99	Sep	8	Feb	58	0	65	0	41.28X	M	2.80	Oct	0.0	0		68	39	9

Notes

(blank) Not reported.

\+ Occurred on one or more previous dates during the month. The date in the Date field is the last day of occurrence. Used through December 1983 only.

A Accumulated amount. This value is a total that may include data from a previous month or months or year (for annual value).

B Adjusted Total. Monthly value totals based on proportional available data across the entire month.

E An estimated monthly or annual total.

X Monthly means or totals based on incomplete time series. 1 to 9 days are missing. Annual means or totals include one or more months which had 1 to 9 days that were missing.

M Used to indicate data element missing.

T Trace of precipitation, snowfall, or snowdepth. The precipitation data value will = zero.

Elem-> Element Types are included to provide cross-reference for users of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

S Precipitation amount is continuing to be accumulated. Total will be included in a subsequent monthly or yearly value. Example: Days 1-20 had 1.35 inches of precipitation, then a period of accumulation began. The element TPCP would then be 00135S and the total accumulated amount value appears in a subsequent monthly value. If TPCP = "M" there was no precipitation measured during the month. Flag is set to "S" and the total accumulated amount appears in a subsequent monthly value.

Dynamically generated Wed Jun 16 17:18:19 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1991)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1991 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	51.5	27.8	39.7	0.5	777	0	66	17	8	26	0	0	22	0	5.00	1.35	1.50	12	0.0	0		10	5	1
2	57.5	31.4	44.5	2.8	568	0	75	5	10	16	0	0	19	0	1.93	-1.68	0.45	18	0.0	0		5	0	0
3	65.3	39.2	52.3	2.9	398	13	85	23	27	12	0	0	8	0	5.61	1.54	2.00	30	0.0	0		8	4	2
4	73.4	46.9	60.2	0.2	189	50	88	30	29	2	0	0	1	0	2.58X	M	0.69	30	0.0	0		8	1	0
5	83.6	58.1	70.9	3.0	29	218	95	31	42	19	7	0	0	0	2.72	-1.16	1.00	20	0.0	0		6	2	1
6	88.7	63.7	76.2	1.5	0	342	96	30	53	7	19	0	0	0	2.29	-1.88	1.25	19	0.0	0		3	1	1
7	91.8	70.0	80.9	2.6	0	501	99	24	63	19	24	0	0	0	6.32	1.93	3.40	3	0.0	0		7	3	2
8	88.7	66.2	77.5	0.1	0	392	98	5	56	11	15	0	0	0	4.38	-0.16	1.85	15	0.0	0		4	3	2
9	84.6	57.7	71.2	0.2	33	223	96	18	44	30	8	0	0	0	4.68	0.67	2.00	20	0.0	0		3	3	3
10	75.0	45.6	60.3	0.5	173	35	87	5	34	8	0	0	0	0	1.21	-1.96	0.46	3	0.0	0		4	0	0
11	62.1	35.3	48.7	-1.4	481	2	77	17	21	28	0	0	10	0	0.40	-2.43	0.21	23	0.0	0		2	0	0
12	58.7	32.5	45.6	3.9	595	0	76	3	17	20	0	0	17	0	3.03	-0.37	1.16	29	0.0	0		8	1	1
Annual	73.4	47.9	60.7	1.4	3243	1776	99	Jul	8	Jan	73	0	77	0	40.15X	M	3.40	Jul	0.0	0		68	23	13

Notes

(blank) Not reported.

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M Used to indicate data element missing.

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Elem-> Element Types are included to provide cross-reference for users of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

S Precipitation amount is continuing to be accumulated. Total will be included in a subsequent monthly or yearly value. Example: Days 1-20 had 1.35 inches of precipitation, then a period of accumulation began. The element TPCP would then be 00135S and the total accumulated amount value appears in a subsequent monthly value. If TPCP = "M" there was no precipitation measured during the month. Flag is set to "S" and the total accumulated amount appears in a subsequent monthly value.

Dynamically generated Wed Jun 16 17:20:22 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1992)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1992 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	53.8	29.1	41.5	2.3	721	0	65	22	19	17	0	1	22	0	3.70	0.05	2.20	4	0.0	0		5	2	1
2	57.6	32.2	44.9	3.2	575	0	71	22	21	11	0	0	15	0	3.10	-0.51	1.63	26	0.0	0		5	2	1
3	62.2	36.2	49.2	-0.2	484	0	83	4	24	17	0	0	13	0	2.90	-1.17	1.28	7	0.0	0		6	2	1
4	72.5	45.0	58.8	-1.2	239	60	88	25	27	3	0	0	4	0	3.16	-0.16	2.05	22	0.0	0		6	1	1
5	74.8	46.8	60.8	-7.1	152	31	91	25	35	5	2	0	0	0	3.38	-0.50	0.70	30	0.0	0		10	3	0
6	83.0	60.9	72.0	-2.7	5	219	92	9	49	22	3	0	0	0	6.75	2.58	1.40	16	0.0	0		11	5	3
7	91.8	67.7	79.8	1.5	0	464	100	14	62	13	24	0	0	0	2.49	-1.90	0.76	23	0.0	0		7	1	0
8	85.1	62.6	73.9	-3.5	0	280	96	13	55	31	9	0	0	0	3.57	-0.97	1.14	27	0.0	0		7	2	2
9	81.6	57.2	69.4	-1.6	33	172	90	10	43	30	2	0	0	0	1.97	-2.04	0.43	20	0.0	0		7	0	0
10	71.2	40.6	55.9	-3.9	273	0	83	16	28	20	0	0	4	0	5.42	2.25	2.50	5	0.0	0		6	3	3
11	60.6	38.7	49.7	-0.4	458	2	76	4	25	18	0	0	10	0	4.88	2.05	1.40	4	0.0	0		9	3	2
12	51.7	28.9	40.3	-1.4	759	0	66	30	19	7	0	0	23	0	3.01	-0.39	1.10	11	0.0	0		4	2	2
Annual	70.5	45.5	58.0	-1.3	3699	1228	100	Jul	19	Dec	40	1	91	0	44.33	-0.71	2.50	Oct	0.0	0		83	26	16

Notes

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Elem- > Element Types are included to provide cross-reference for users of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

S Precipitation amount is continuing to be accumulated. Total will be included in a subsequent monthly or yearly value. Example: Days 1-20 had 1.35 inches of precipitation, then a period of accumulation began. The element TPCP would then be 00135S and the total accumulated amount value appears in a subsequent monthly value. If TPCP = "M" there was no precipitation measured during the month. Flag is set to "S" and the total accumulated amount appears in a subsequent monthly value.

Dynamically generated Wed Jun 16 17:22:12 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1993)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1993 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	52.8	32.7	42.8	5.3	682	0	69	5	22	28	0	0	19	0	3.89	0.39	1.07	5	0.0	0		7	4	1
2	50.9	28.2	39.6	-1.0	705	0	68	22	16	19	0	0	22	0	3.59	-0.04	0.98	12	0.0T	0T	28	7	3	0
3	59.7	35.6	47.7	-1.8	529	0	75	31	8	15	0	0	11	0	8.50	4.62	3.10	4	0.0X	0		7	3	2
4	73.4	42.5	58.0	-0.6	218	13	85	30	33	7	0	0	0	0	4.59	1.47	1.17	10	0.0	0		7	3	3
5	83.0	57.4	70.2	3.4	19	187	90	12	44	23	2	0	0	0	3.33	-1.00	0.78	31	0.0	0		7	3	0
6	89.3	63.8	76.6	2.0	0	355	99	11	54	6	17	0	0	0	1.60	-2.66	1.21	1	0.0	0		4	1	1
7	95.5	69.3	82.4	4.2	0	545	102	10	60	12	29	0	0	0	7.36	2.76	2.28	20	0.0	0		5	4	4
8	90.0	66.2	78.1	1.1	0	414	98	30	62	27	20	0	0	0	2.93	-1.34	0.74	14	0.0	0		8	4	0
9	85.9	60.2	73.1	2.7	8	256	95	3	45	30	7	0	0	0	3.17	-0.41	2.00	5	0.0	0		3	2	1
10	71.9	44.0	58.0	-1.3	235	25	85	21	33	30	0	0	0	0	1.14	-2.12	0.41	9	0.0	0		3	0	0
11	64.0	35.7	49.9	-0.5	450	6	84	16	24	9	0	0	13	0	3.73	0.66	2.02	28	0.0	0		4	2	2
12	50.5	28.8	39.7	-1.6	777	0	68	4	15	31	0	1	24	0	2.29	-1.17	0.80	21	1.0	0		8	1	0
Annual	72.2	47.0	59.7	1.0	3623	1801	102	Jul	8	Mar	75	1	89	0	46.12	1.16	3.10	Mar	1.0X	0	Feb	70	30	14

Notes

(blank) Not reported.

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Dynamically generated Wed Jun 16 17:23:43 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1994)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1994 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	46.0	22.4	34.2	-3.3	948	0	67	25	-2	20	0	3	26	2	4.77X	M	1.12	28	0.0X	0		7	4	2
2	53.4	28.9	41.2	0.6	662	0	76	21	18	11	0	0	19	0	2.39	-1.24	1.07	24	0.0X	0		3	2	1
3	64.3	37.7	51.0	1.5	428	0	81	9	26	1	0	0	9	0	5.92	2.04	1.86	2	0.0	0		7	5	3
4	77.6	46.9	62.3	3.7	136	62	92	27	34	8	1	0	0	0	2.42	-0.70	1.55	16	0.0	0		6	1	1
5	78.8	49.6	64.2	-2.6	102	83	94	25	40	3	3	0	0	0	1.10X	M	0.86	4	0.0	0		2	1	0
6	89.3	63.6	76.5	1.9	0	351	101	20	50	5	16	0	0	0	1.37X	M	0.47	30	0.0	0		5	0	0
7	92.2	67.7	80.0	1.8	0	473	98	21	62	29	25	0	0	0	6.44	1.84	1.20	29	0.0	0		10	6	2
8	88.5	61.3	74.9	-2.1	0	313	95	11	51	25	17	0	0	0	4.67	0.40	1.60	30	0.0	0		7	4	1
9	81.0	55.8	68.4	-2.0	15	125	92	16	50	21	3	0	0	0	0.80	-2.78	0.30	2	0.0	0		3	0	0
10	71.7	43.5	57.6	-1.7	234	11	85	3	32	28	0	0	1	0	1.17	-2.09	0.37	14	0.0	0		4	0	0
11	66.8	39.9	53.4	3.0	345	2	78	15	29	24	0	0	6	0	1.55	-1.52	0.78	29	0.0	0		3	1	0
12	56.8	35.1	46.0	4.7	587	1	78	8	22	13	0	0	15	0	0.75	-2.71	0.21	23	0.0	0		4	0	0
Annual	72.2	46.0	59.1	0.5	3457	1421	101	Jun	-2	Jan	65	3	76	2	33.35X	M	1.86	Mar	0.0X	0		61	24	10

Notes

(blank) Not reported.

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Dynamically generated Wed Jun 16 17:24:00 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1995)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1995 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	50.7	30.5	40.6	3.1	749	1	73	15	14	6	0	1	20	0	4.94	1.44	2.00	15	0.0T	0T	31	7	2	2
2	50.9	27.6	39.3	-1.3	712	0	74	27	11	7	0	1	20	0	3.21	-0.42	1.50	17	0.0	0		5	2	2
3	67.4	39.1	53.3	3.8	356	2	83	23	22	5	0	0	6	0	3.57	-0.31	1.20	9	0.0	0		8	1	1
4	74.7	43.9	59.3	0.7	204	40	91	21	30	3	2	0	2	0	0.70	-2.42	0.50	13	0.0	0		2	1	0
5	79.4	55.5	67.5	0.7	55	139	92	19	38	4	1	0	0	0	3.52	-0.81	0.90	3	0.0	0		10	2	0
6	85.6	61.8	73.7	-0.9	1	271	96	10	54	24	6	0	0	0	12.00	7.74	4.40	29	0.0	0		16	5	5
7	92.9	68.5	80.7	2.5	0	492	99	25	61	9	23	0	0	0	4.97	0.37	1.17	31	0.0	0		9	4	1
8	90.5	68.8	79.7	2.7	0	461	100	17	64	29	20	0	0	0	5.06	0.79	4.67	28	0.0	0		2	1	1
9	81.0	57.5	69.3	-1.1	32	165	94	2	43	29	2	0	0	0	1.67	-1.91	0.74	23	0.0	0		4	1	0
10	75.0	48.4	61.7	2.4	143	47	87	4	37	31	0	0	0	0	6.84	3.58	2.50	21	0.0	0		5	3	3
11	57.8	33.6	45.7	-4.7	573	0	73	29	25	16	0	0	18	0	4.03	0.96	0.90	8	0.0	0		10	3	0
12	48.8	25.4	37.1	-4.2	860	0	73	16	8	25	0	0	27	0	0.94	-2.52	0.80	9	0.0	0		1	1	0
Annual	71.2	46.7	59.0	0.3	3685	1618	100	Aug	8	Dec	54	2	93	0	51.45	6.49	4.67	Aug	0.0	0	Jan	79	26	15

Notes

(blank) Not reported.

\+ Occurred on one or more previous dates during the month. The date in the Date field is the last day of occurrence. Used through December 1983 only.

A Accumulated amount. This value is a total that may include data from a previous month or months or year (for annual value).

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Dynamically generated Wed Jun 16 17:24:34 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1996)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1996 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	48.0	25.4	36.7	-0.8	867	0	68	20	17	23	0	3	26	0	2.63X	M	1.04	27	12.0X	6	7	4	3	1
2	51.7	26.7	39.2	-1.4	741	0	79	28	4	5	0	5	19	0	1.86X	M	M		0.0X	0		2	0	0
3	55.1	31.9	43.5	-6.0	662	0	77	15	13	10	0	0	15	0	5.32	1.44	M		0.0	0		6	3	2
4	70.6	42.0	56.3	-2.3	270	14	85	29	28	9	0	0	6	0	2.18X	M	0.50	2	0.0	0		6	1	0
5	81.5	54.4	68.0	1.2	64	162	98	22	37	1	9	0	0	0	5.79	1.46	1.20	1	0.0	0		8	6	2
6	89.5	62.4	76.0	1.4	4	340	100	25	43	2	15	0	0	0	1.43	-2.83	0.60	10	0.0	0		5	1	0
7	90.2	65.5	77.9	-0.3	0	407	98	20	53	5	21	0	0	0	2.94	-1.66	0.97	9	0.0	0		6	2	0
8	86.2	63.7	75.0	-2.0	0	316	94	8	58	1	7	0	0	0	7.19	2.92	3.00	28	0.0	0		6	5	2
9	80.7	56.3	68.5	-1.9	16	128	91	10	38	15	3	0	0	0	11.73	8.15	5.15	6	0.0	0		11	7	2
10	70.9	44.2	57.6	-1.7	225	0	82	17	35	13	0	0	0	0	4.25	0.99	1.51	2	0.0	0		5	3	3
11	60.1	30.8	45.5	-4.9	582	3	84	1	21	12	0	0	20	0	3.06	-0.01	0.85	9	0.0	0		6	3	0
12	59.0	28.6	43.8	2.5	647	0	78	13	12	22	0	0	19	0	3.84	0.38	0.91	1	0.0	0		8	3	0
Annual	70.3	44.3	57.3	-1.4	4078	1370	100	Jun	4	Feb	55	8	105	0	52.22X	M	M	Sep	12.0X	6	Jan	73	37	12

Notes

(blank) Not reported.

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X Monthly means or totals based on incomplete time series. 1 to 9 days are missing. Annual means or totals include one or more months which had 1 to 9 days that were missing.

M Used to indicate data element missing.

T Trace of precipitation, snowfall, or snowdepth. The precipitation data value will = zero.

Elem- > Element Types are included to provide cross-reference for users of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

S Precipitation amount is continuing to be accumulated. Total will be included in a subsequent monthly or yearly value. Example: Days 1-20 had 1.35 inches of precipitation, then a period of accumulation began. The element TPCP would then be 00135S and the total accumulated amount value appears in a subsequent monthly value. If TPCP = "M" there was no precipitation measured during the month. Flag is set to "S" and the total accumulated amount appears in a subsequent monthly value.

Dynamically generated Wed Jun 16 17:25:13 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1997)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1997 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	51.9	25.7	38.8	1.3	803	0	84	4	10	19	0	3	23	0	2.84X	M	0.70	9	0.0X	0		5	4	0
2	55.5	34.0	44.8	4.2	559	0	76	28	25	17	0	0	16	0	2.62	-1.01	0.85	15	0.0	0		7	2	0
3	66.9	40.2	53.6	4.1	347	0	80	30	30	18	0	0	4	0	3.14	-0.74	0.63	14	0.0	0		10	2	0
4	66.2	42.6	54.4	-4.2	320	10	83	5	29	10	0	0	1	0	5.77	2.65	1.45	29	0.0	0		7	5	2
5	77.1	48.3	62.7	-4.1	114	50	90	20	39	12	1	0	0	0	1.46	-2.87	0.45	27	0.0	0		4	0	0
6	81.3	61.3	71.3	-3.3	46	242	95	27	47	5	7	0	0	0	5.15	0.89	1.61	3	0.0	0		7	2	1
7	88.9	67.9	78.4	0.2	2	424	98	29	58	31	16	0	0	0	5.02	0.42	2.13	23	0.0	0		8	3	2
8	88.0	64.7	76.4	-0.6	0	360	98	18	56	25	11	0	0	0	1.35	-2.92	1.16	21	0.0	0		2	1	1
9	81.5	59.3	70.4	0.0	18	189	93	3	48	7	4	0	0	0	4.22	0.64	1.89	10	0.0	0		4	3	2
10	71.9	47.0	59.5	0.2	218	51	88	10	32	23	0	0	1	0	2.07X	M	0.68	27	0.0	0		4	2	0
11	57.4	34.8	46.1	-4.3	559	0	71	3	22	26	0	0	9	0	3.26	0.19	1.25	22	0.0	0		6	3	1
12	50.5	30.6	40.6	-0.7	750	0	65	21	20	16	0	0	19	0	2.97X	M	M		0.0X	3	30	6	0	0
Annual	69.8	46.4	58.1	-0.6	3736	1326	98	Aug	10	Jan	39	3	73	0	39.87X	M	M	Jul	0.0X	3	Dec	70	27	9

Notes

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Elem-> Element Types are included to provide cross-reference for users of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

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Dynamically generated Wed Jun 16 17:25:21 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

ANNUAL CLIMATOLOGICAL SUMMARY
(1998)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **311239/99999, BURLINGTON FIRE STN #5, North Carolina** Elev. 660 ft. above sea level Lat. 36°04'N, Lon. 79°27'W

Date	Temperature (° F)														Precipitation (inches)									
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
											Number of Days						Greatest Observed		Snow, Sleet			Number of Days		
1998 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Max >=90°	Max <=32°	Min <=32°	Min <=0°	Total	Depart. from Normal	Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	52.5	33.7	43.1	5.6	671	1	72	6	17	2	0	0	17	0	6.23	2.73	1.12	16	0.0X	0		12	5	2
2	55.2	33.4	44.3	3.7	574	0	71	19	23	2	0	0	12	0	5.63	2.00	2.25	17	0.0	0		7	3	2
3	59.8	38.2	49.0	-0.5	511	23	85	31	20	14	0	0	9	0	6.52	2.64	2.33	19	0.0	0		7	5	2
4	70.4	46.4	58.4	-0.2	209	19	85	1	36	6	0	0	0	0	4.82	1.70	1.71	17	0.0	0		7	4	2
5	79.5	57.8	68.7	1.9	31	153	92	17	47	6	3	0	0	0	4.57	0.24	1.13	26	0.0	0		7	5	1
6	87.8	65.1	76.5	1.9	8	359	99	28	47	8	15	0	0	0	2.23	-2.03	0.54	30	0.0	0		7	1	0
7	91.4	69.7	80.6	2.4	0	487	99	23	65	14	20	0	0	0	0.80	-3.80	0.63	28	0.0	0		2	1	0
8	89.2	67.3	78.3	1.3	0	419	100	30	56	21	12	0	0	0	0.36	-3.91	0.26	17	0.0	0		2	0	0
9	86.4	62.9	74.7	4.3	5	301	95	8	51	24	11	0	0	0	4.38	0.80	3.00	4	0.0	0		3	2	2
10	74.3	48.3	61.3	2.0	135	29	87	2	33	24	0	0	0	0	1.50	-1.76	1.16	9	0.0	M		2	1	1
11	63.6	39.9	51.8	1.4	389	0	79	1	27	7	0	0	4	0	1.31	-1.76	0.36	15	0.0	0		6	0	0
12	56.4	35.5	46.0	4.7	586	4	79	8	23	27	0	3	15	0	4.90	1.44	1.20	13	0.0X	0		6	5	3
Annual	72.2	49.8	61.1	2.4	3119	1795	100	Aug	17	Jan	61	3	57	0	43.25	-1.71	3.00	Sep	0.0X	M		68	32	15

Notes

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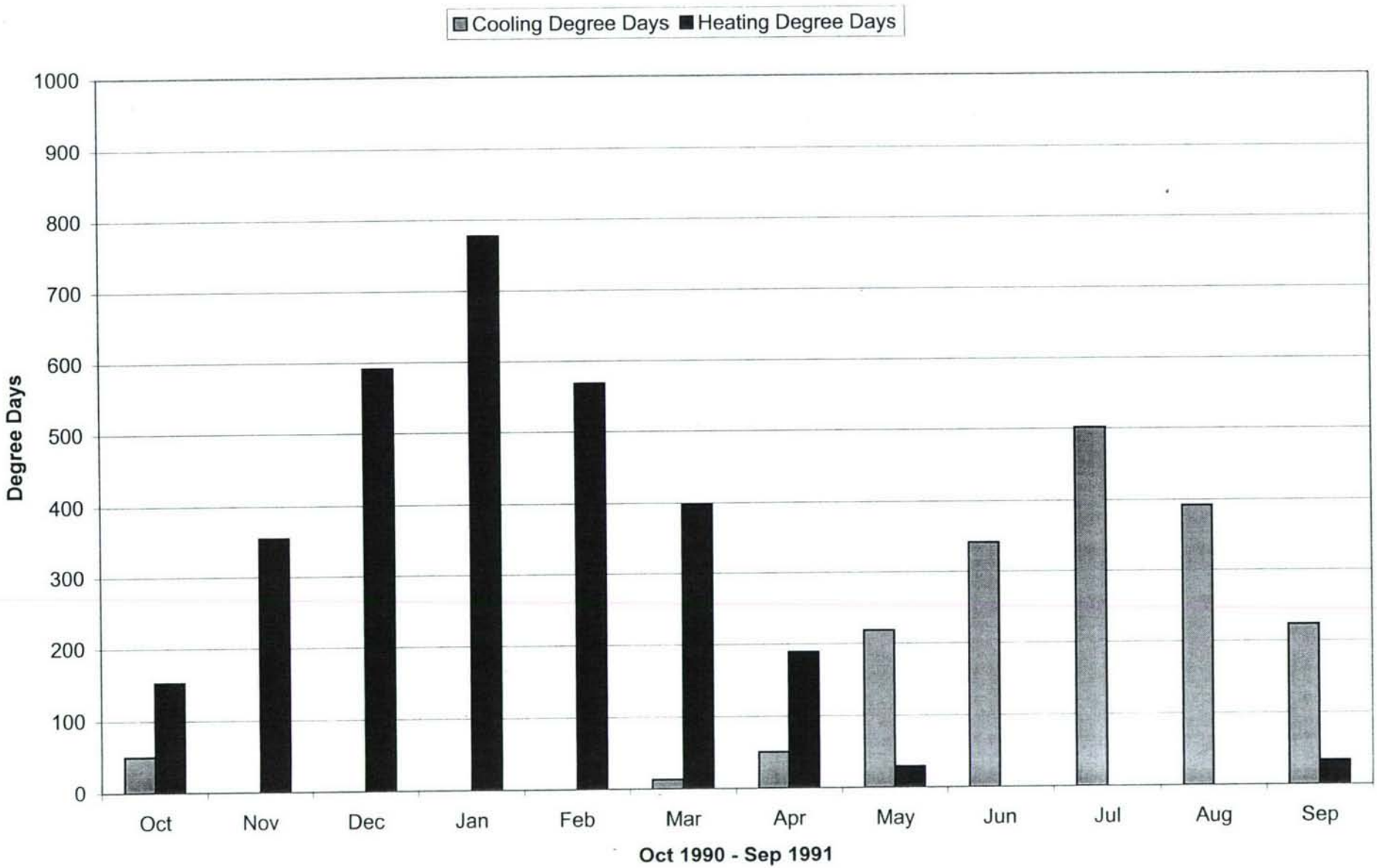
Dynamically generated Mon Jun 21 16:24:44 EDT 2004 via http://cdo.ncdc.noaa.gov/ancsum/ACS
Data provided from the NCDC CDO System
Additional documentation can be found at http://www5.ncdc.noaa.gov/cdo/3220doc.txt

Monthly Heating & Cooling Degree Days

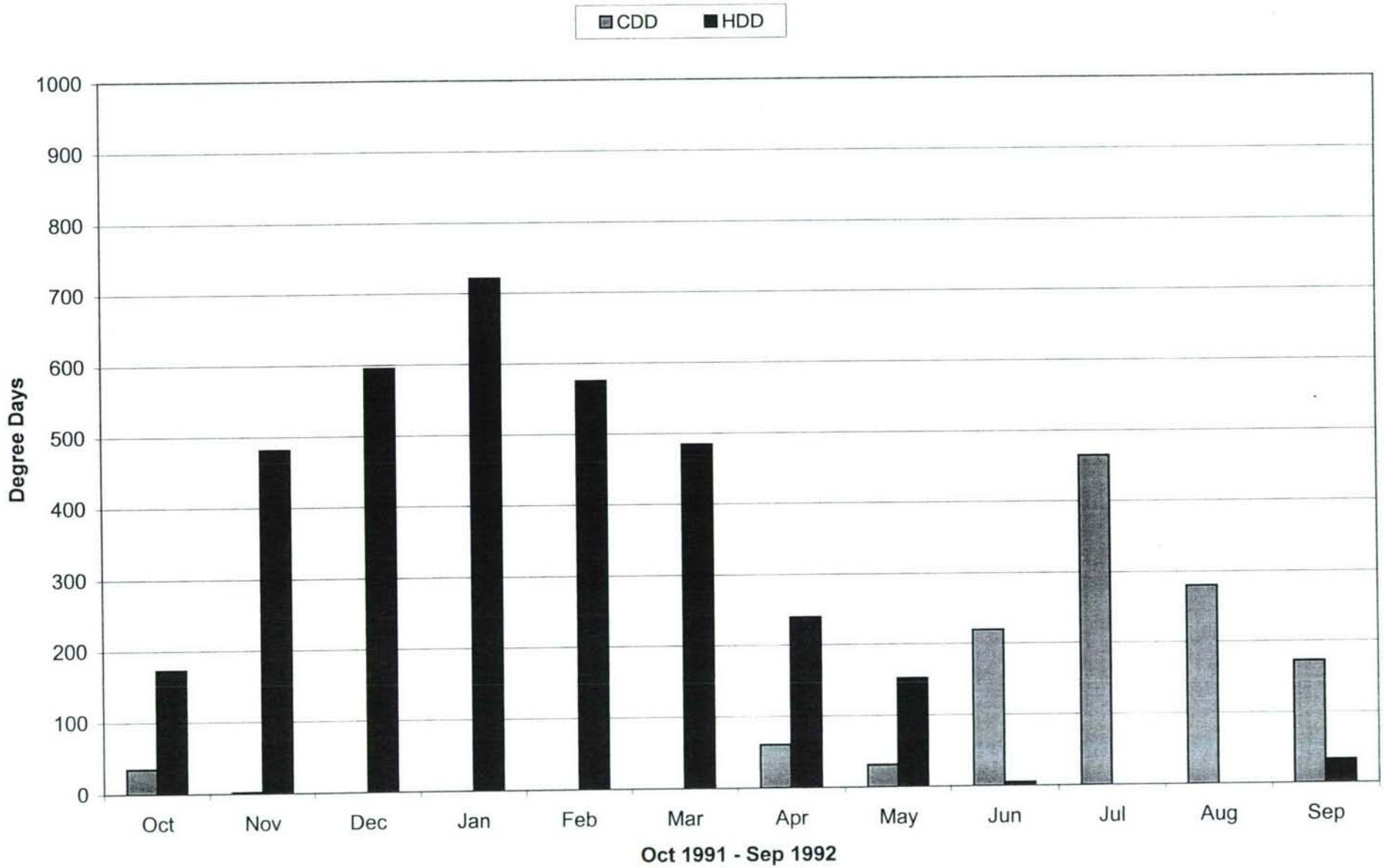


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days

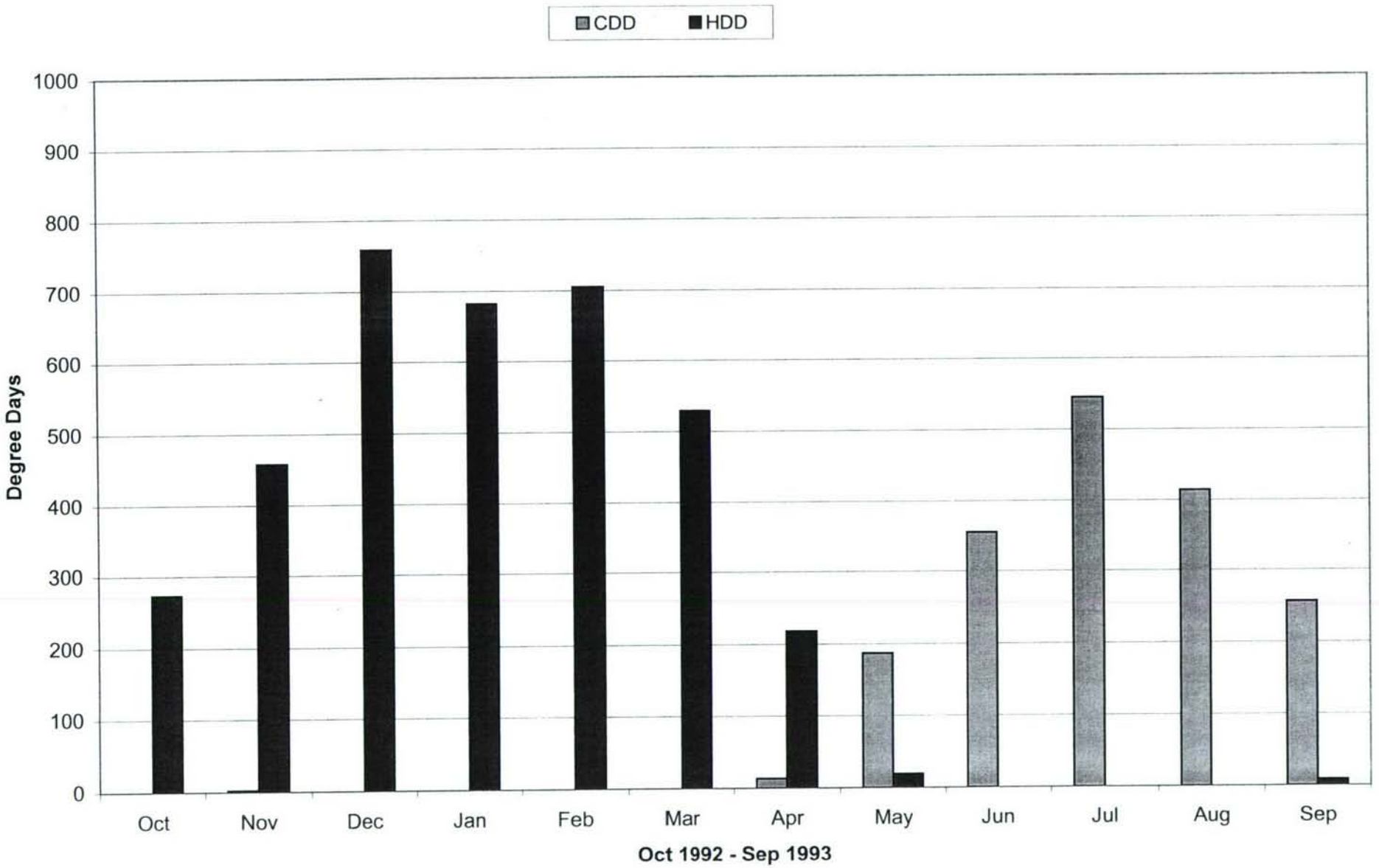


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days

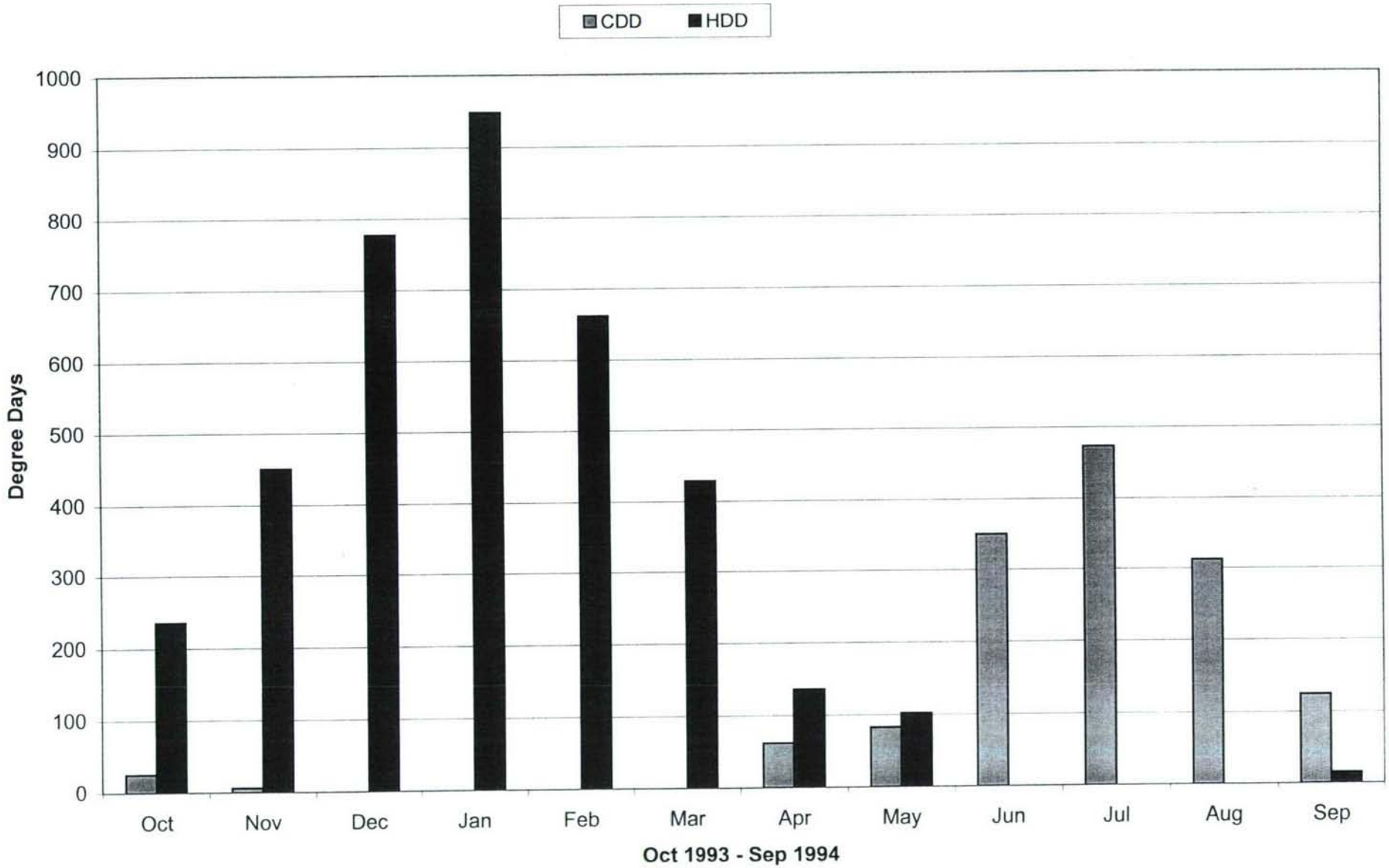


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days

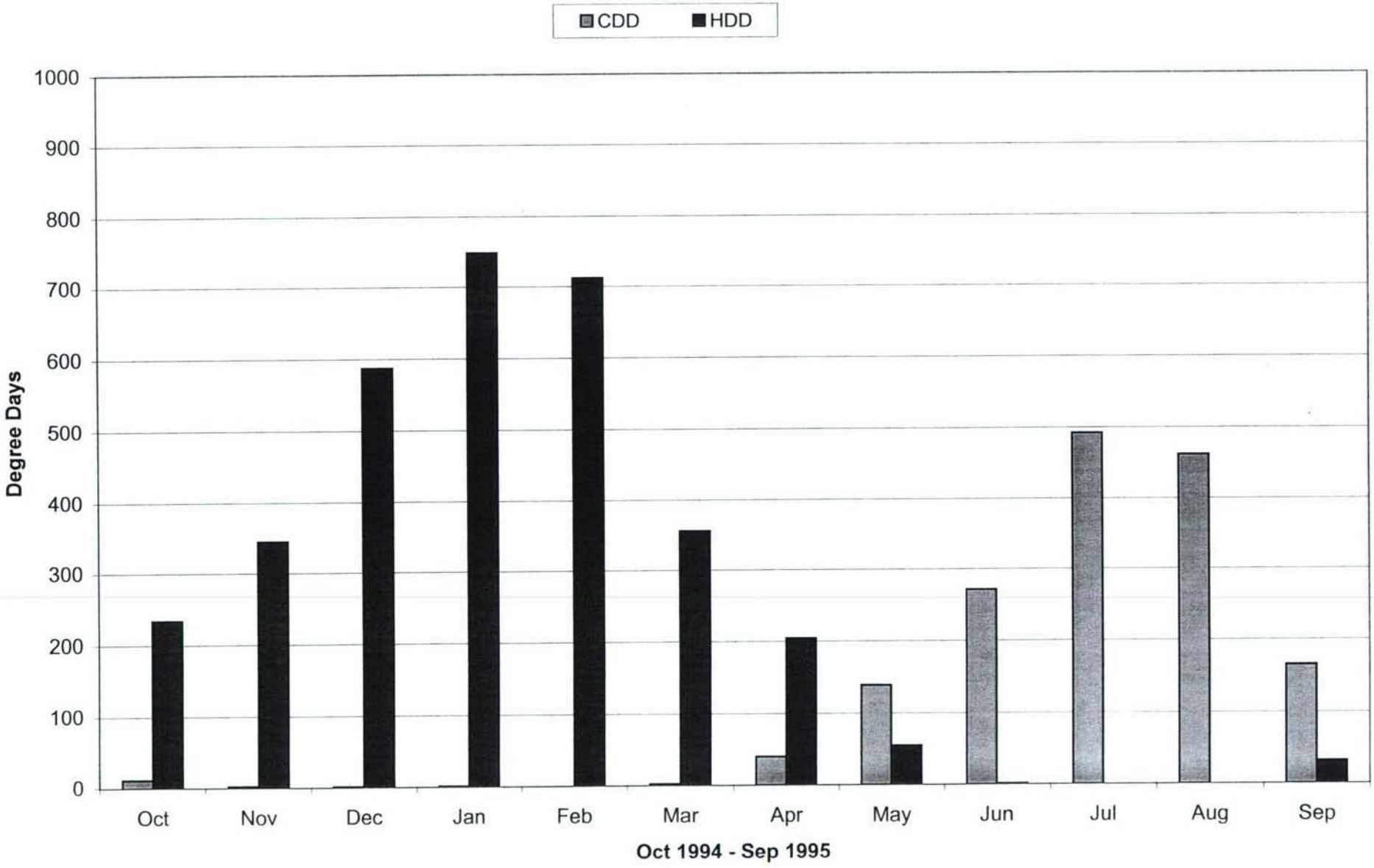


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days

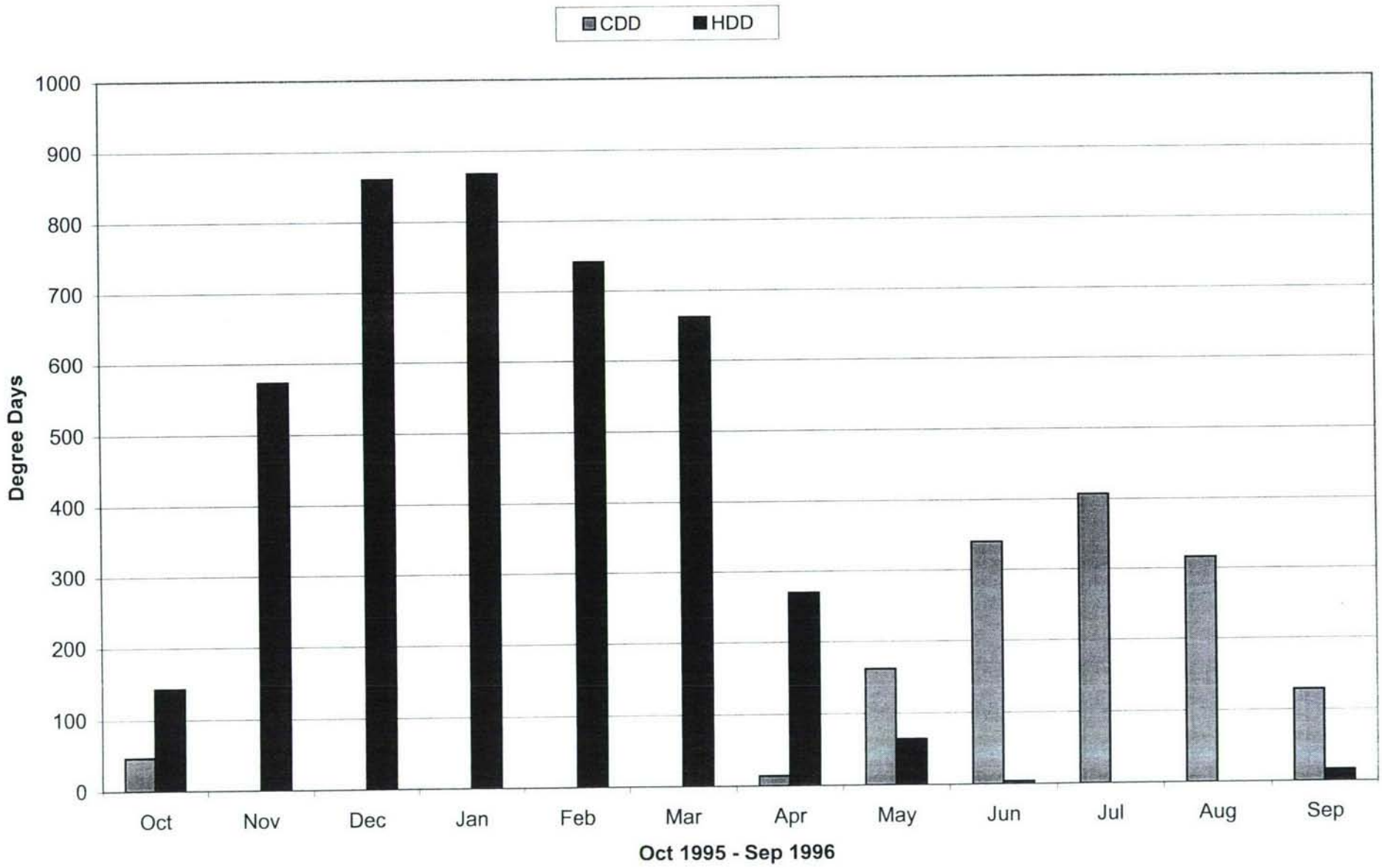


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days

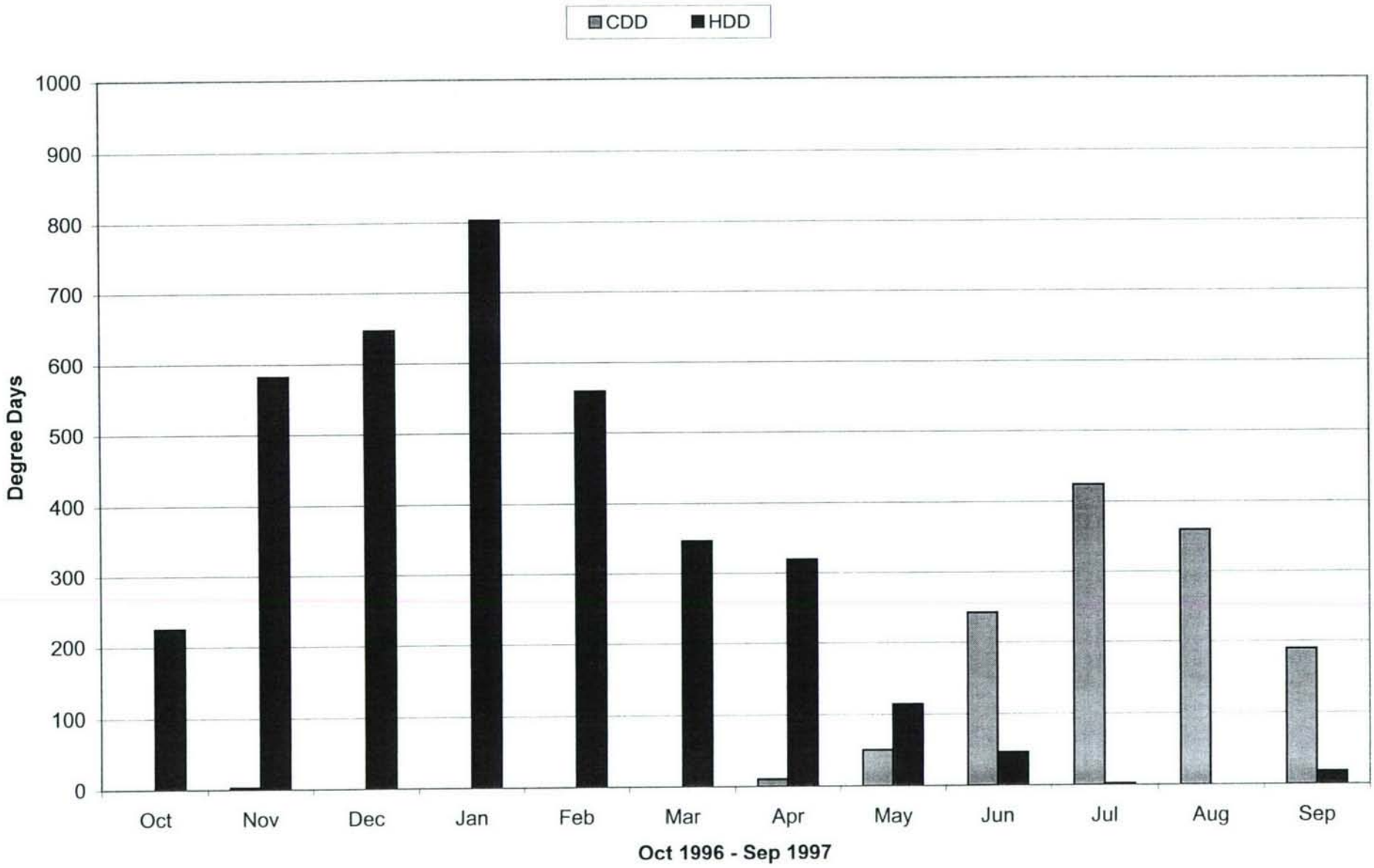


Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

Monthly Heating & Cooling Degree Days



Plumblee Residence

2160 sf Passive Solar-Heated Home

Alamance County, NC

APPENDIX D

{Energy-10: Thermal Performance Simulations}

Energy-10 Summary Page Jul 23, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Energy Efficient Case	
Scheme Number:	8 / Saved	none
Library Name:	PLUMBLEELIB / Saved	-
Simulation status, Thermal/DL	valid/NA	-
Comments:	EES by Harry Boody, PE	
Weather file:	Grnsboro.etl	-
Floor Area, ft²	2160.0	-
Surface Area, ft²	5856.5	-
Volume, ft³	18653.0	-
Total Conduction UA, Btu/h-F	362.4	-
Average U-value, Btu/hr-ft²-F	0.062	-
Wall Construction	2 x 4 cypress, R=14.5,etc	-
Roof Construction	shingle, attic, r-30, R=30.5	-
Floor type, insulation	Crawl Space, Reff=162.7,etc	-
Window Construction	2058 double, wood, U=0.48,etc	-
Window Shading	36 deg lat plumblee,etc	-
Wall total gross area, ft²	1536	-
Roof total gross area, ft²	2160	-
Ground total gross area, ft²	2160	-
Window total gross area, ft²	427	-
Windows (N/E/S/W:Roof)	5/7/13/4:0	-
Glazing name	double, U=0.49	-

Operating parameters for zone 1

HVAC system	Air Source Heat Pump/ER Backup	-
Rated Output (Heat/SCool/TCool),kBtu/h	39/25/34	-
Rated Air Flow/MOOA,cfm	1320/0	-
Heating thermostat	68.0 °F, no setback	-
Cooling thermostat	77.0 °F, no setup	-
Heat/cool performance	COP=3.0,EER=10.1	-
Economizer?/type	no/NA	-
Duct leaks/conduction losses, total %	11/10	-
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	-
Added mass?	none	-
Daylighting?	no	-
Infiltration, in²	ACH=0.2	-

Results:

		-)
Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW		
Simulation dates	01-Jan to 31-Dec	00-Jan to 00-Jan
Energy use, kBtu	52783	NA
Energy cost, $	1067	NA
Saved by daylighting, kWh	-	NA
Total Electric, kWh	15469	NA
Internal/External lights, kWh	915/0	NA
Heating/Cooling/Fan, kWh	4059/2718/429	NC
Elec. Res./Heat Pump, kWh	3083/976	NA
Hot water/Other, kWh	6559/788	NC
Peak Electric, kW	15.6	NA
Fuel, hw/heat/total, kBtu	0/0/0	NC
Emissions, CO2/SO2/NOx, lbs	20790/122/63	NA
Construction Costs	197913	0
Life-Cycle Cost	282963	248386

Energy-10 Summary Page Jul 23, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Energy Efficient Case	Gas Furnace Case
Scheme Number:	8 / Saved	9 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

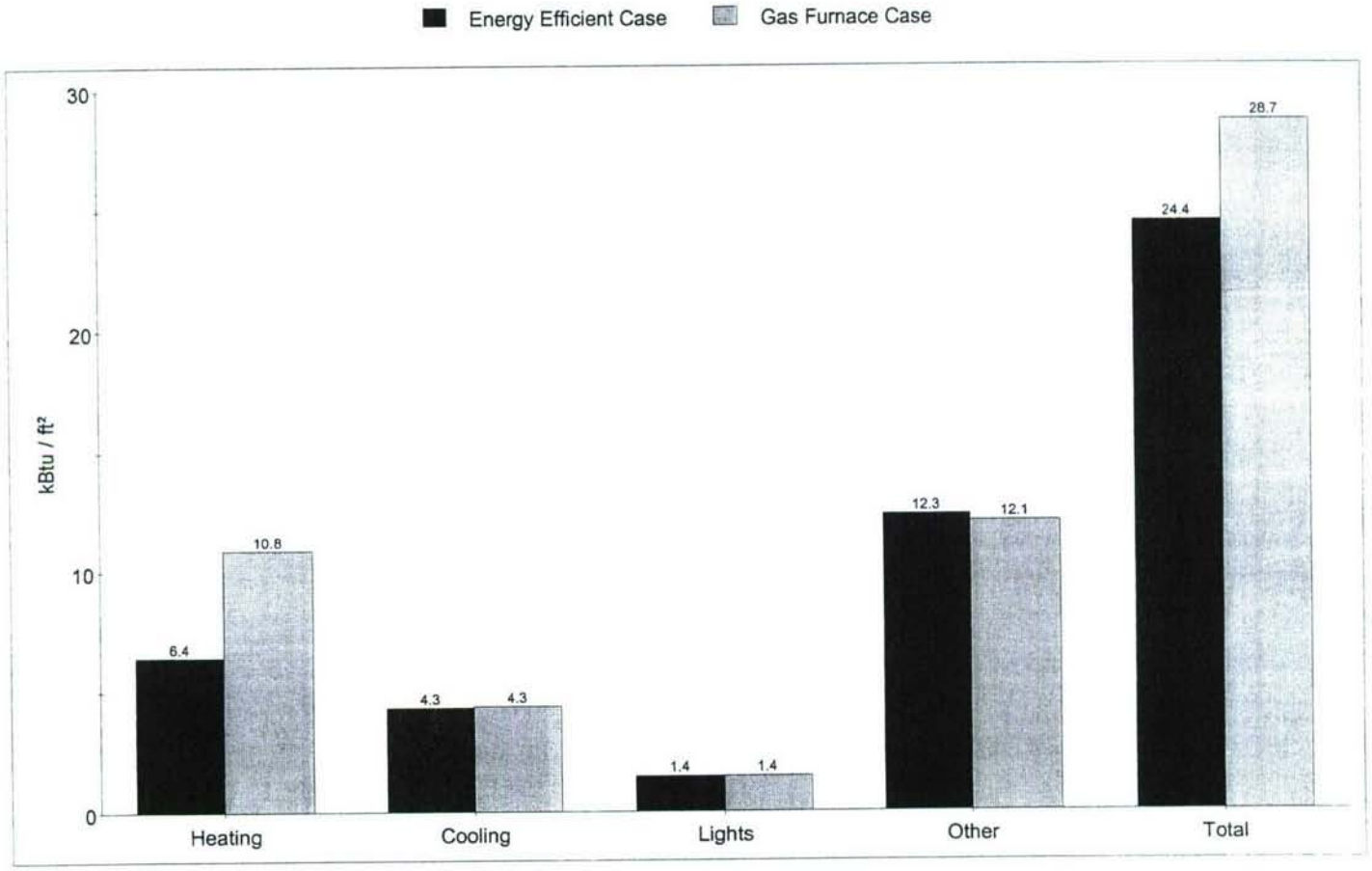
Operating parameters for zone 1

HVAC system	Air Source Heat Pump/ER Backup	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	39/25/34	38/25/33
Rated Air Flow/MOOA,cfm	1320/0	1210/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	COP=3.0,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	52783	61933
Energy cost, $	1067	1251
Saved by daylighting, kWh	-	NA
Total Electric, kWh	15469	4727
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	4059/2718/429	0/2744/280
Elec. Res./Heat Pump, kWh	3083/976	0/0
Hot water/Other, kWh	6559/788	0/788
Peak Electric, kW	15.6	3.7
Fuel, hw/heat/total, kBtu	0/0/0	22383/23420/45803
Emissions, CO2/SO2/NOx, lbs	20790/122/63	11763/42/25
Construction Costs	197913	200474
Life-Cycle Cost	250873	257916

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Orientation 15 East Case
Scheme Number:	9 / Saved	28 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

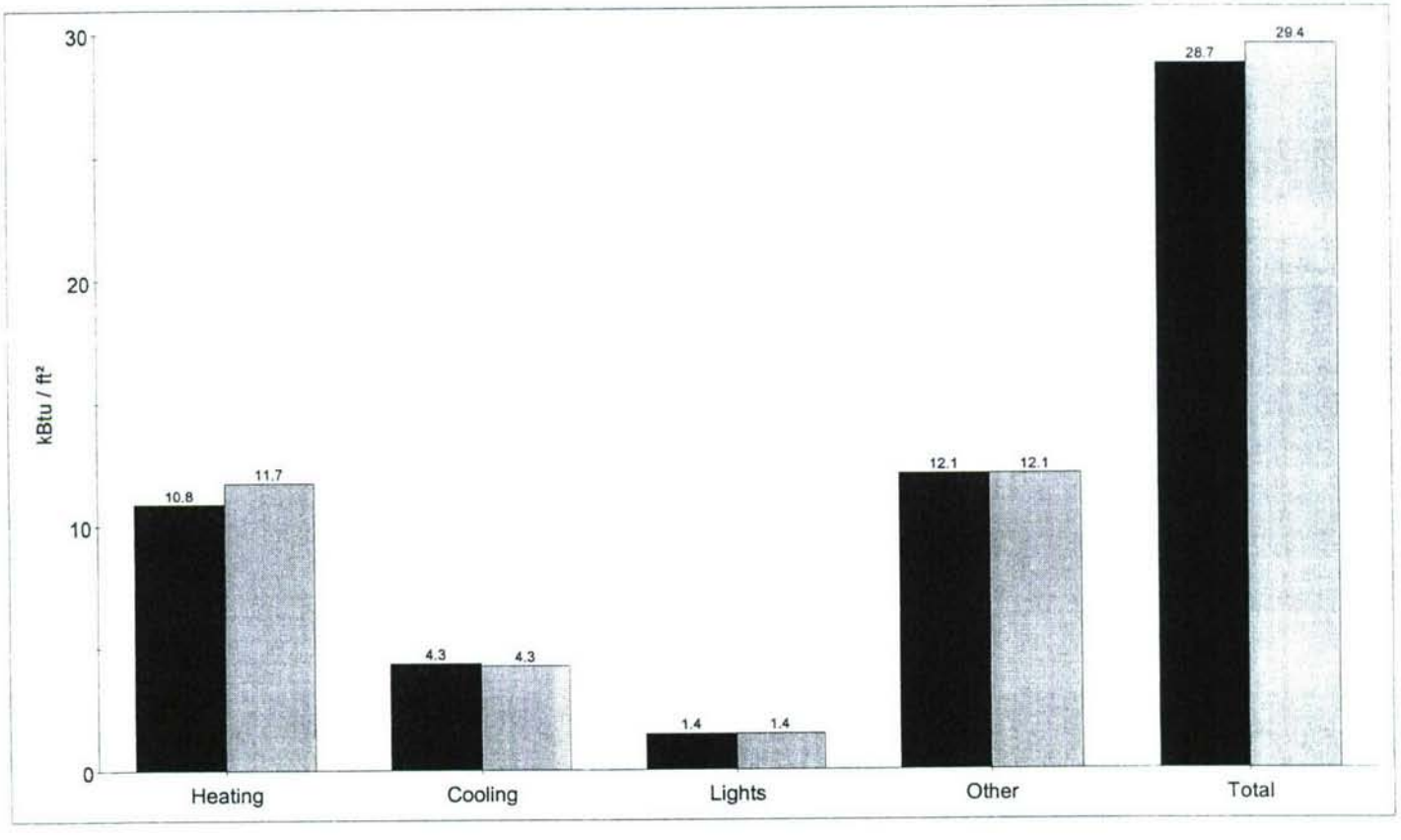
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	38/25/34
Rated Air Flow/MOOA,cfm	1210/0	1232/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	63611
Energy cost, $	1251	1285
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4678
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2692/283
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/25264/47647
Emissions, CO2/SO2/NOx, lbs	11763/42/25	11915/42/25
Construction Costs	203458	200622
Life-Cycle Cost	257916	259123

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Orientation 30 East Case
Scheme Number:	9 / Saved	12 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

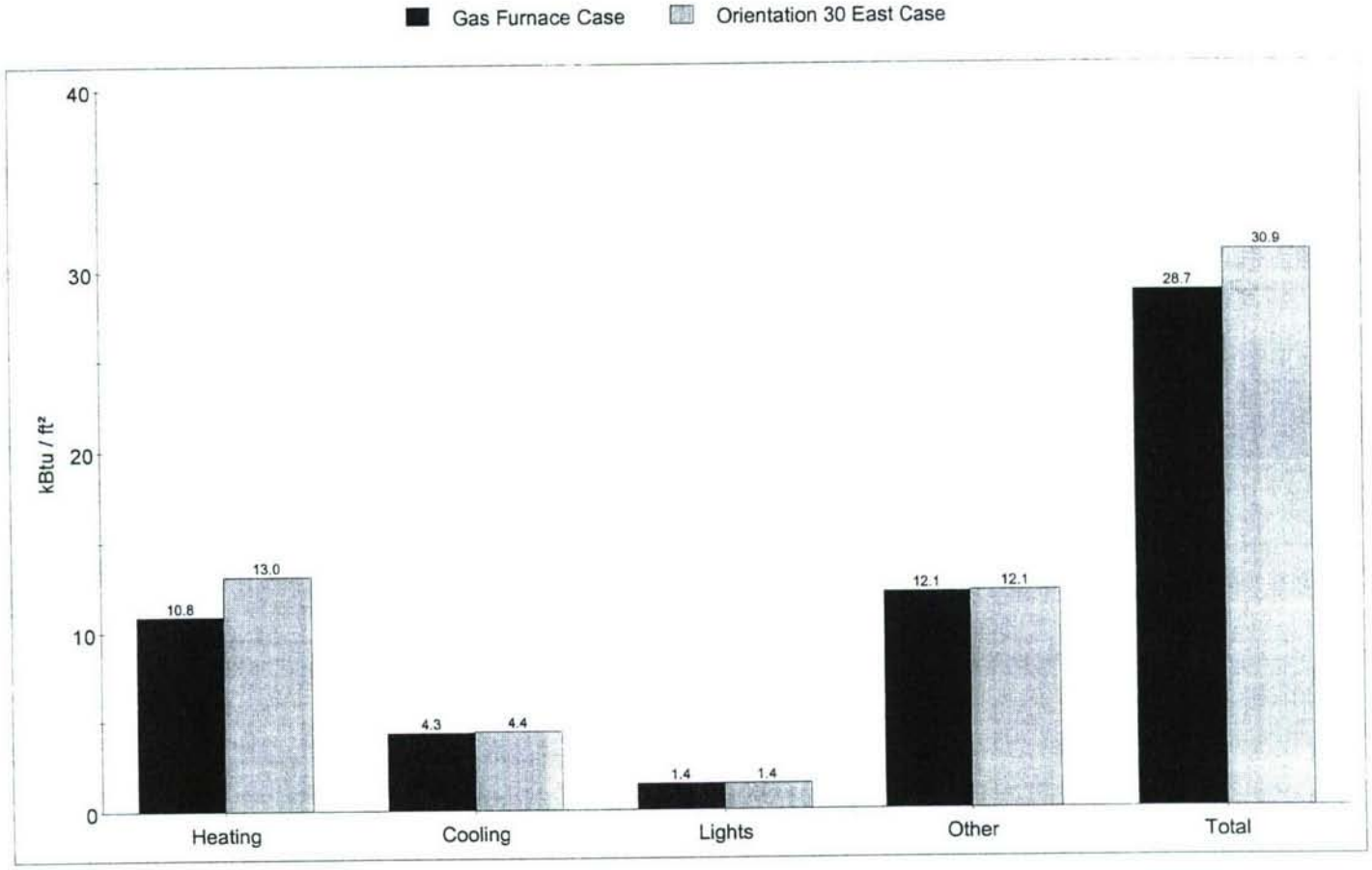
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	38/25/34
Rated Air Flow/MOOA,cfm	1210/0	1249/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	66806
Energy cost, $	1251	1350
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4777
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2773/301
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/28124/50507
Emissions, CO2/SO2/NOx, lbs	11763/42/25	12385/43/26
Construction Costs	203458	200711
Life-Cycle Cost	257916	261133

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 27, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Orientation 45 East Case
Scheme Number:	9 / Saved	14 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

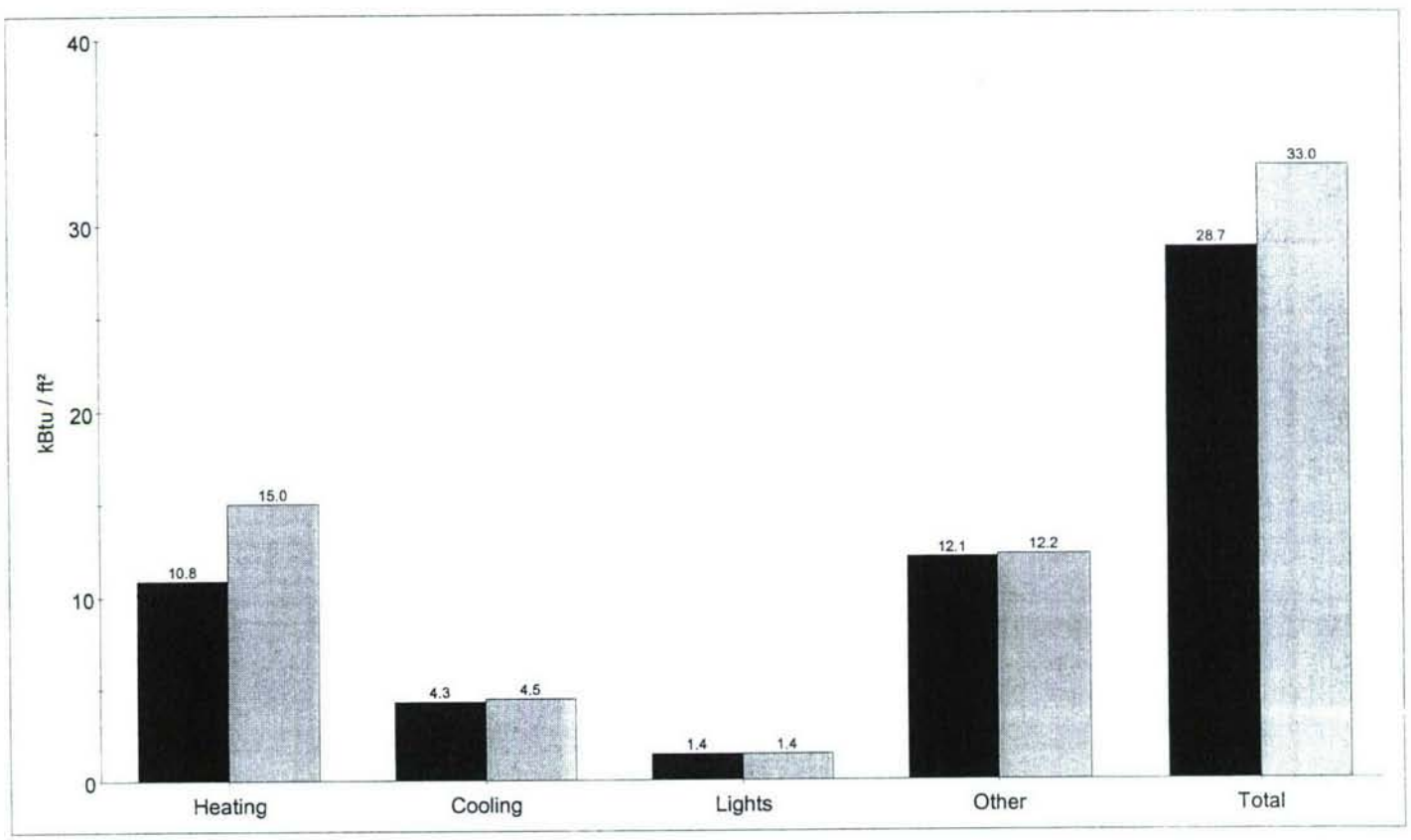
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	40/30/40
Rated Air Flow/MOOA,cfm	1210/0	1614/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	71326
Energy cost, $	1251	1441
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4880
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2823/354
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/32292/54675
Emissions, CO2/SO2/NOx, lbs	11763/42/25	13015/45/27
Construction Costs	203458	202620
Life-Cycle Cost	259123	261133

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	South-Facing low-e Case
Scheme Number:	9 / Saved	30 / Saved
Library Name:	PLUMBLEELIB / Saved	modified / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	306.8
Average U-value, Btu/hr-ft²-F	0.062	0.052
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.28,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double low-e, U=0.26

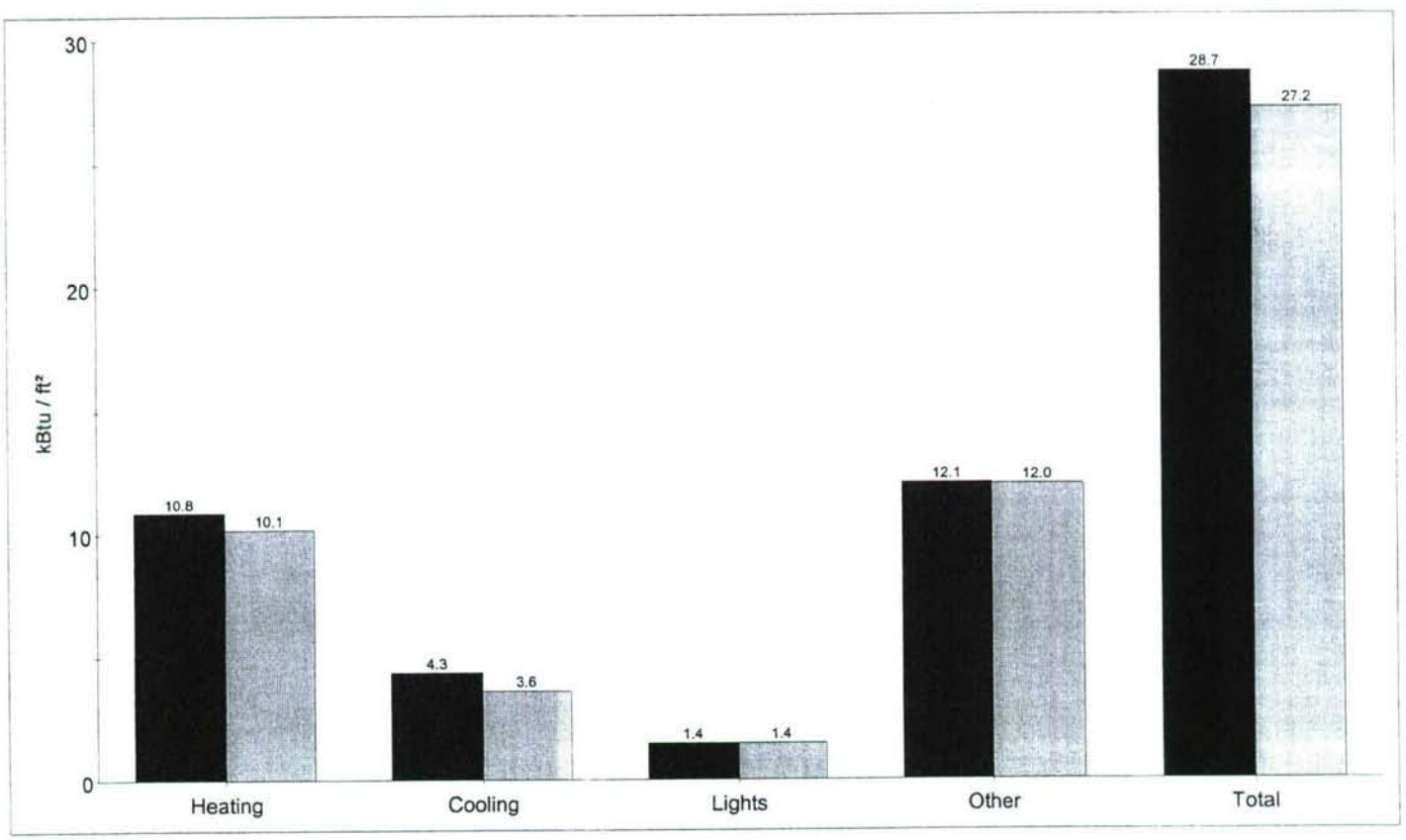
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	34/23/31
Rated Air Flow/MOOA,cfm	1210/0	1119/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	58727
Energy cost, $	1251	1187
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4232
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2288/240
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.4
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/21905/44288
Emissions, CO2/SO2/NOx, lbs	11763/42/25	10918/38/23
Construction Costs	203458	199623
Life-Cycle Cost	257916	254460

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 27, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	8 South-Facing low-e Case
Scheme Number:	9 / Saved	31 / Saved
Library Name:	PLUMBLEELIB / Saved	PLBLELOWELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	281.0
Average U-value, Btu/hr-ft²-F	0.062	0.048
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.28,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	299
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/9/4:0
Glazing name	double, U=0.49	double low-e, U=0.26

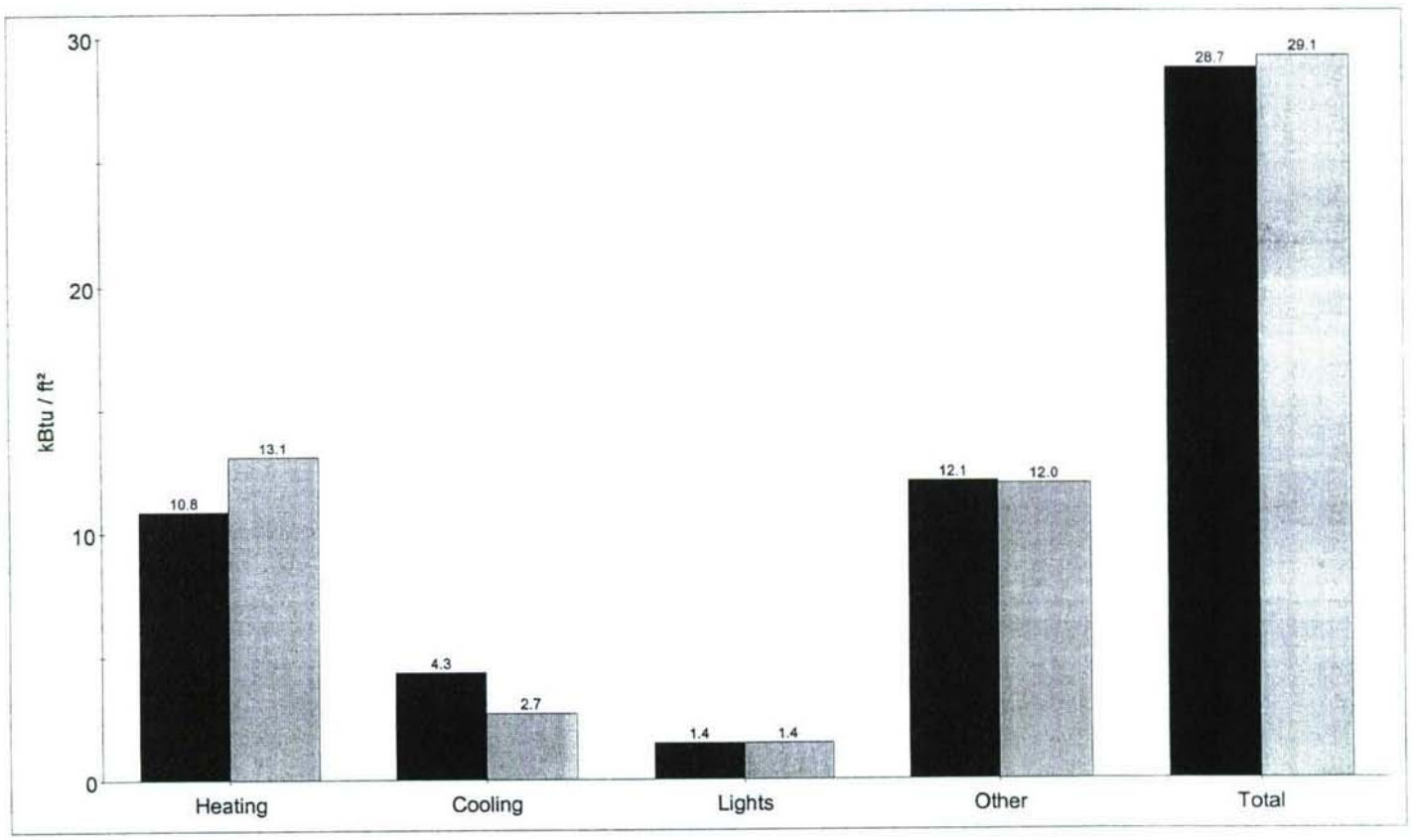
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	32/22/29
Rated Air Flow/MOOA,cfm	1210/0	1030/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	62957
Energy cost, $	1251	1272
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	3612
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/1693/217
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.1
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/28247/50630
Emissions, CO2/SO2/NOx, lbs	11763/42/25	10834/34/21
Construction Costs	203458	198945
Life-Cycle Cost	257916	255458

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 27, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	6 South-Facing low-e Case
Scheme Number:	9 / Saved	32 / Saved
Library Name:	PLUMBLEELIB / Saved	PLBLELOWELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	274.9
Average U-value, Btu/hr-ft²-F	0.062	0.047
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.28,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	270
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/7/4:0
Glazing name	double, U=0.49	double low-e, U=0.26

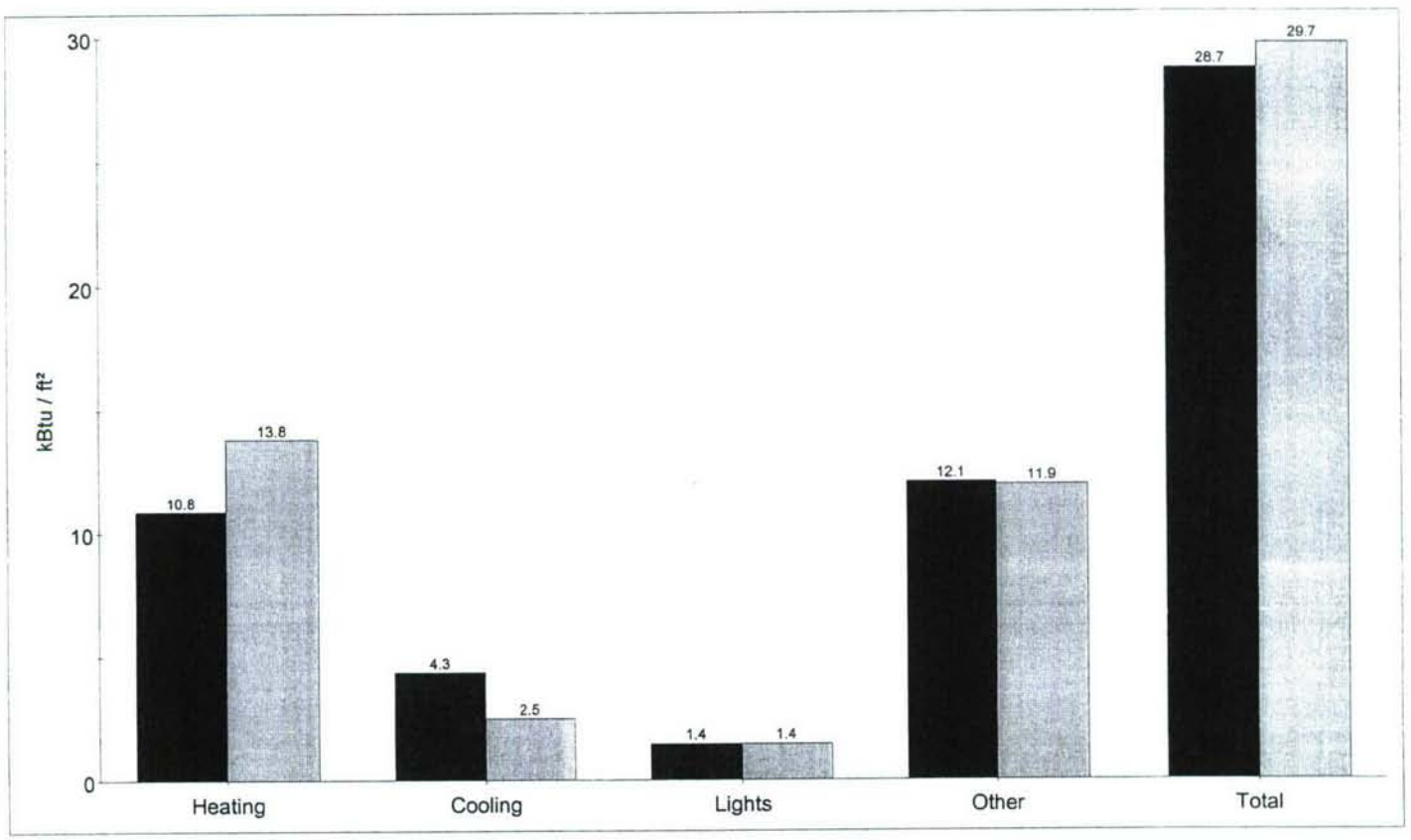
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	31/21/28
Rated Air Flow/MOOA,cfm	1210/0	1010/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	64148
Energy cost, $	1251	1296
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	3499
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/1582/214
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.0
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/29825/52208
Emissions, CO2/SO2/NOx, lbs	11763/42/25	10868/33/21
Construction Costs	203458	198785
Life-Cycle Cost	257916	255811

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 27, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	4 South-Facing low-e Case
Scheme Number:	9 / Saved	36 / Saved
Library Name:	PLUMBLEELIB / Saved	PLBLELOWELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	269.2
Average U-value, Btu/hr-ft²-F	0.062	0.046
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2028 double low-e, wood, U=0.30,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	244
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/5/4:0
Glazing name	double, U=0.49	double low-e, U=0.26

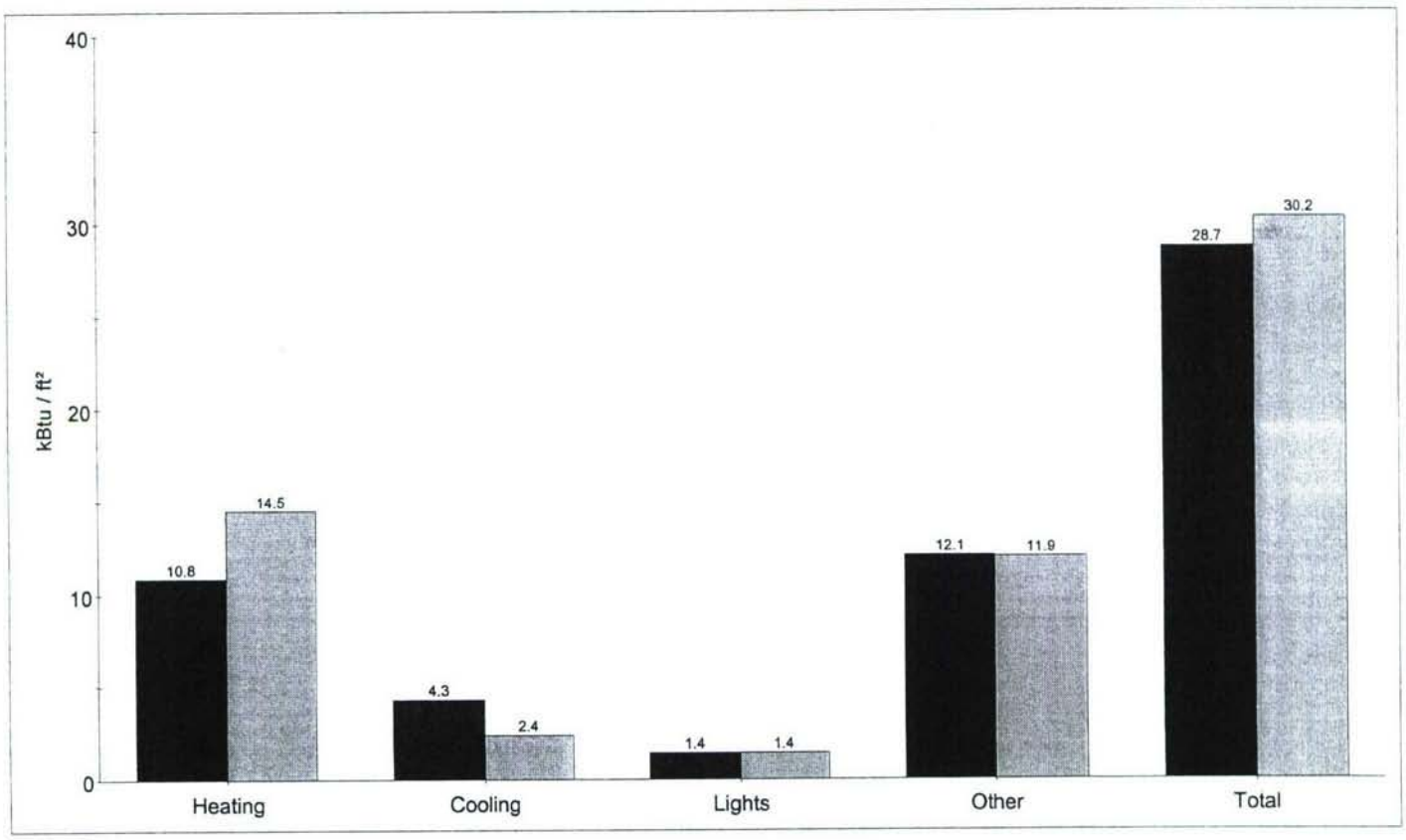
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	31/21/28
Rated Air Flow/MOOA,cfm	1210/0	992/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	65331
Energy cost, $	1251	1320
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	3402
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/1488/212
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	2.9
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/31338/53721
Emissions, CO2/SO2/NOx, lbs	11763/42/25	10917/33/21
Construction Costs	203458	198653
Life-Cycle Cost	250494	256222

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Minimal Glazing Case
Scheme Number:	9 / Saved	35 / Saved
Library Name:	PLUMBLEELIB / Saved	obsolete / Not Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	337.0
Average U-value, Btu/hr-ft²-F	0.062	0.058
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	325
Windows (N/E/S/W:Roof)	5/7/13/4:0	2/4/13/2:0
Glazing name	double, U=0.49	double, U=0.49

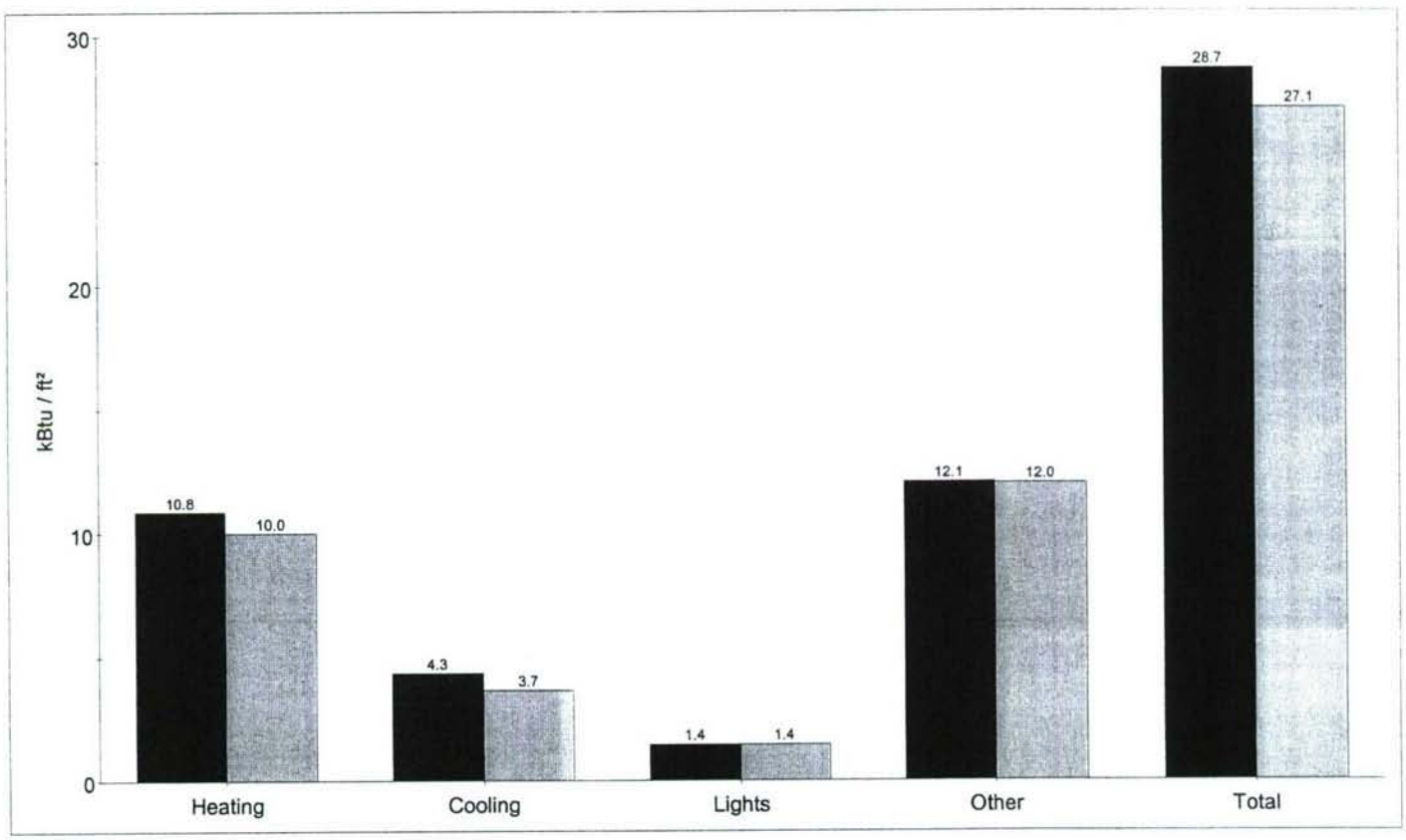
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	35/22/29
Rated Air Flow/MOOA,cfm	1210/0	1054/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	58564
Energy cost, $	1251	1183
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4267
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2328/236
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.3
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/21619/44002
Emissions, CO2/SO2/NOx, lbs	11763/42/25	10932/39/23
Construction Costs	203458	199404
Life-Cycle Cost	257916	253958

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	12 inch Overhang Case
Scheme Number:	9 / Saved	16 / Saved
Library Name:	PLUMBLEELIB / Saved	PLBLEVARIEDLIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	12 inch overhang,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

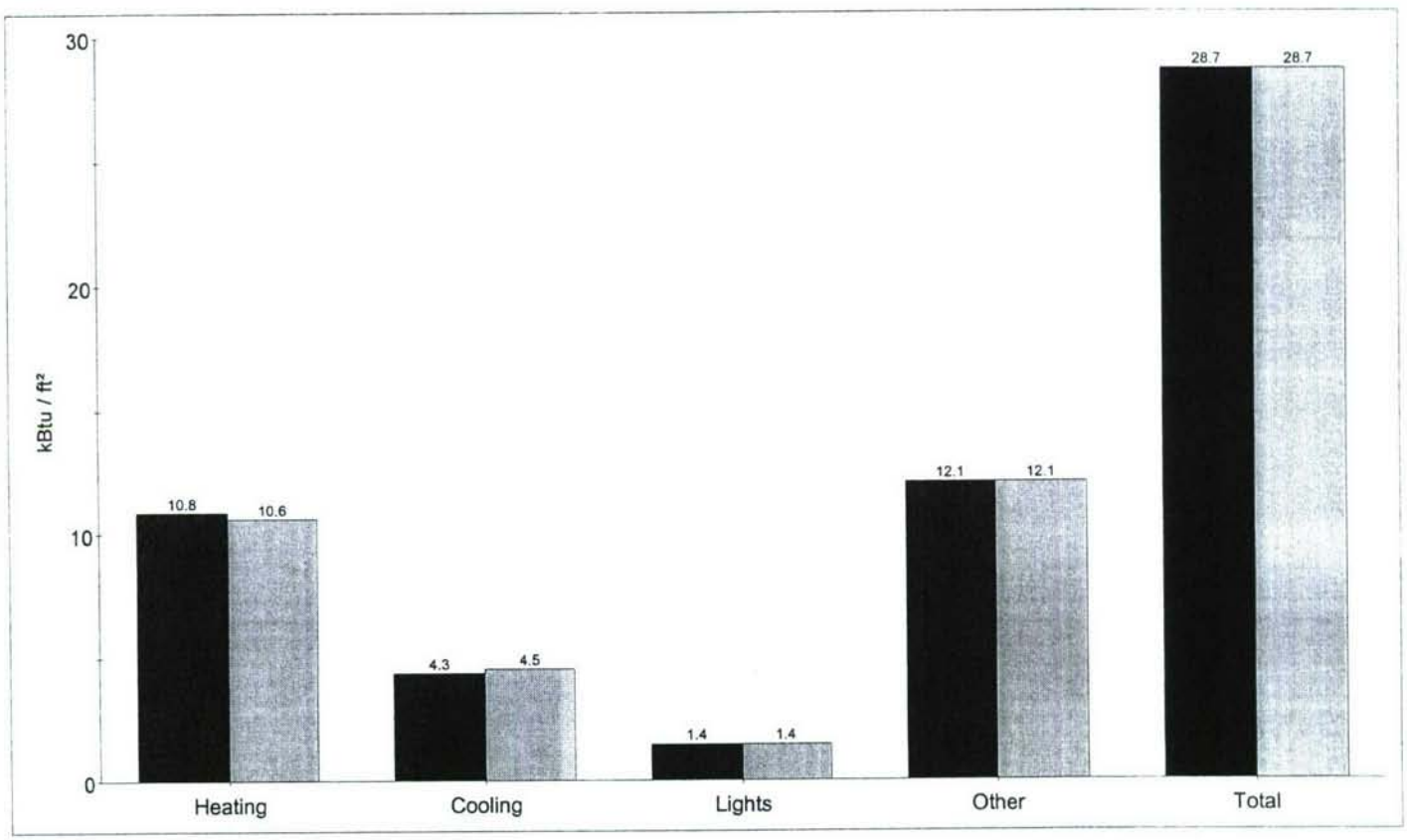
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	38/25/33
Rated Air Flow/MOOA,cfm	1210/0	1218/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW	
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	61889
Energy cost, $	1251	1250
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4863
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2870/289
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/22914/45297
Emissions, CO2/SO2/NOx, lbs	11763/42/25	11885/43/26
Construction Costs	203458	200517
Life-Cycle Cost	257916	257998

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	24 inch Overhang Case
Scheme Number:	9 / Saved	17 / Saved
Library Name:	PLUMBLEELIB / Saved	PLBLEVARIEDLIB / Not Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	24 inch overhang,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

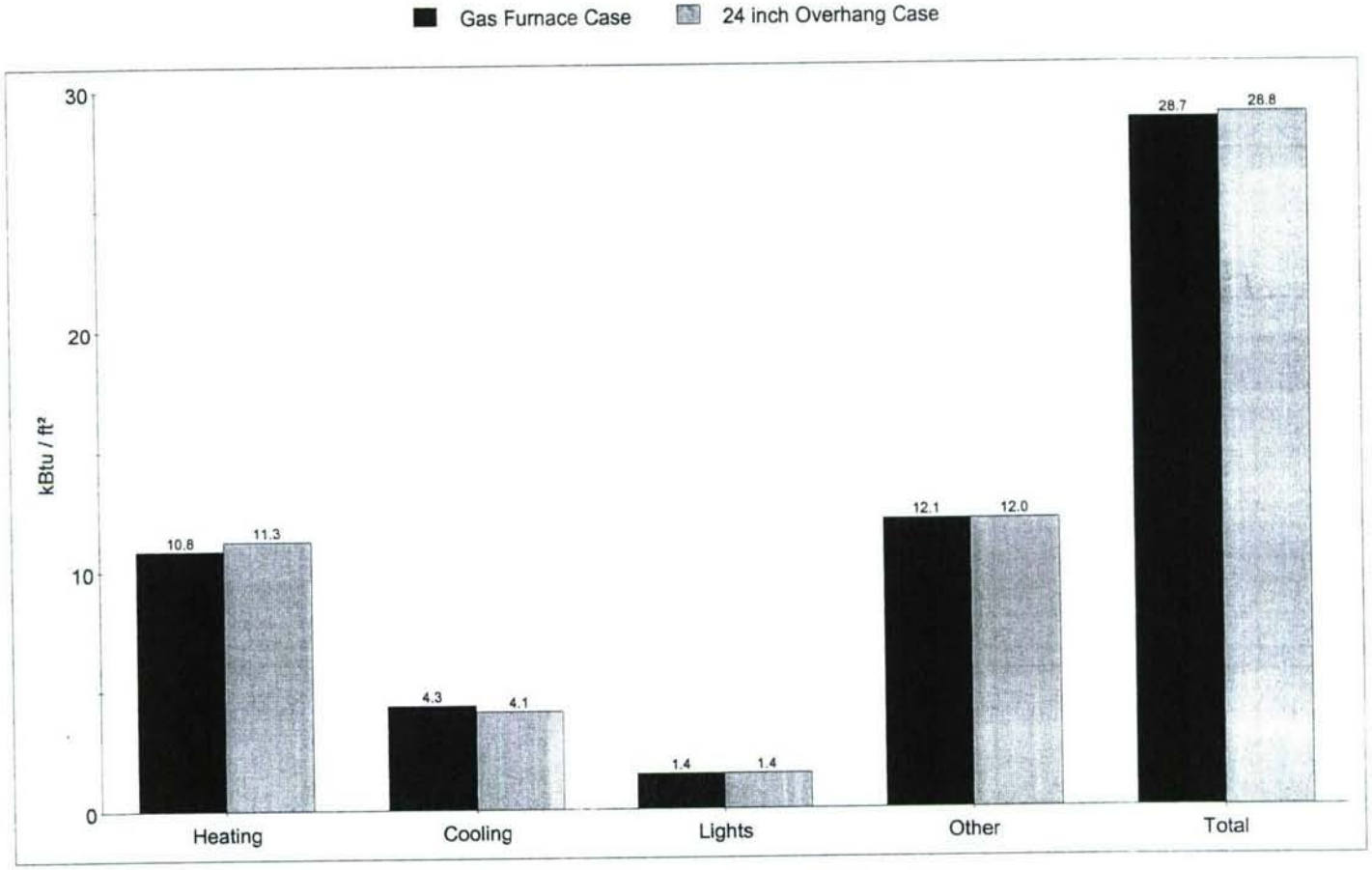
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	38/25/33
Rated Air Flow/MOOA,cfm	1210/0	1208/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	62306
Energy cost, $	1251	1259
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4573
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2599/272
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/24318/46701
Emissions, CO2/SO2/NOx, lbs	11763/42/25	11662/41/25
Construction Costs	203458	200465
Life-Cycle Cost	257916	258054

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	No Brick Pavers Case
Scheme Number:	9 / Saved	33 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.8
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=132.4
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

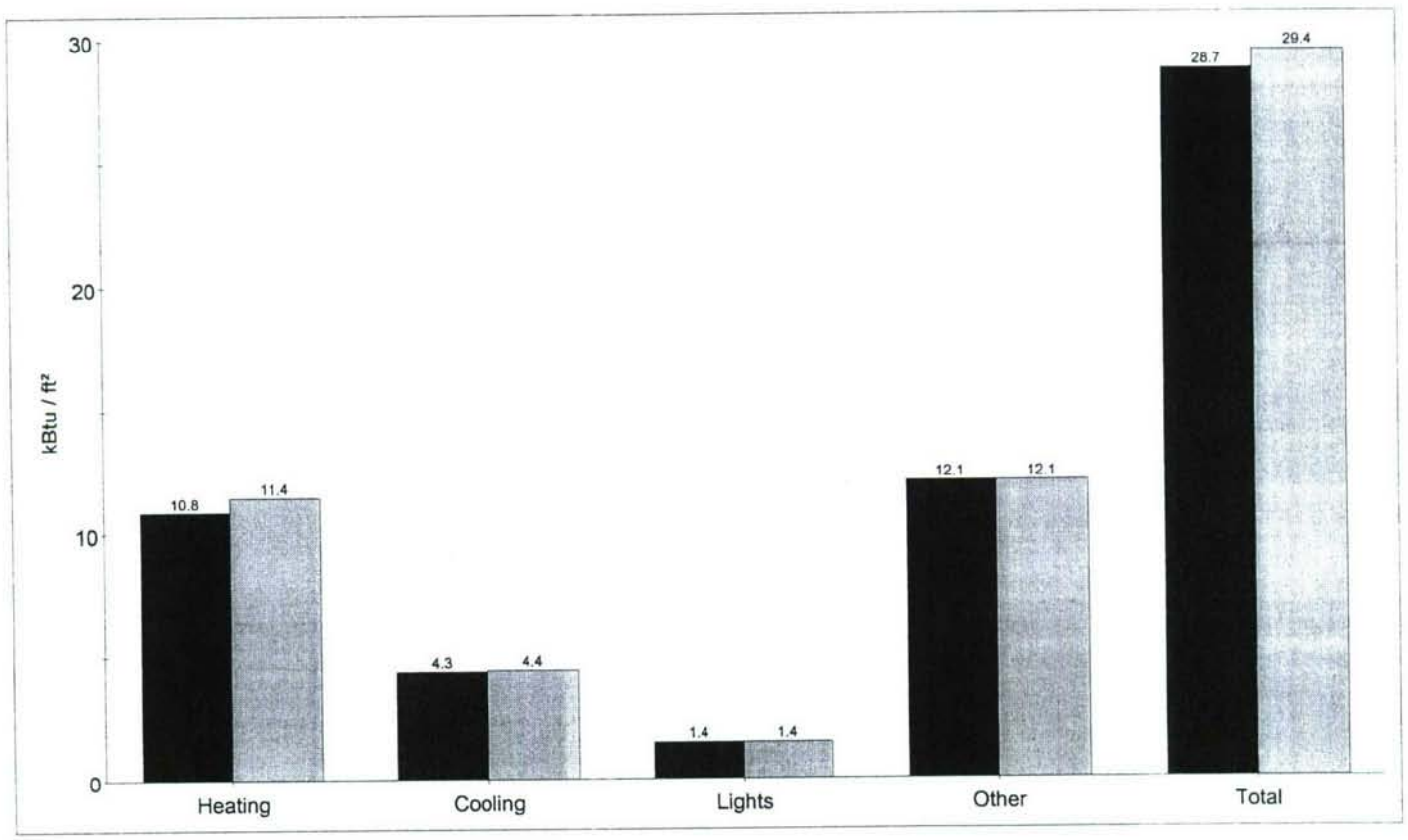
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	38/25/33
Rated Air Flow/MOOA,cfm	1210/0	1221/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	63481
Energy cost, $	1251	1283
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4801
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2807/292
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/24715/47098
Emissions, CO2/SO2/NOx, lbs	11763/42/25	12015/43/26
Construction Costs	203458	200547
Life-Cycle Cost	257916	258932

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Exterior Walls 2x6 Case
Scheme Number:	9 / Saved	34 / Saved
Library Name:	obsolete / Not Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	339.3
Average U-value, Btu/hr-ft²-F	0.062	0.058
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 6 cypress, R=19.8,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

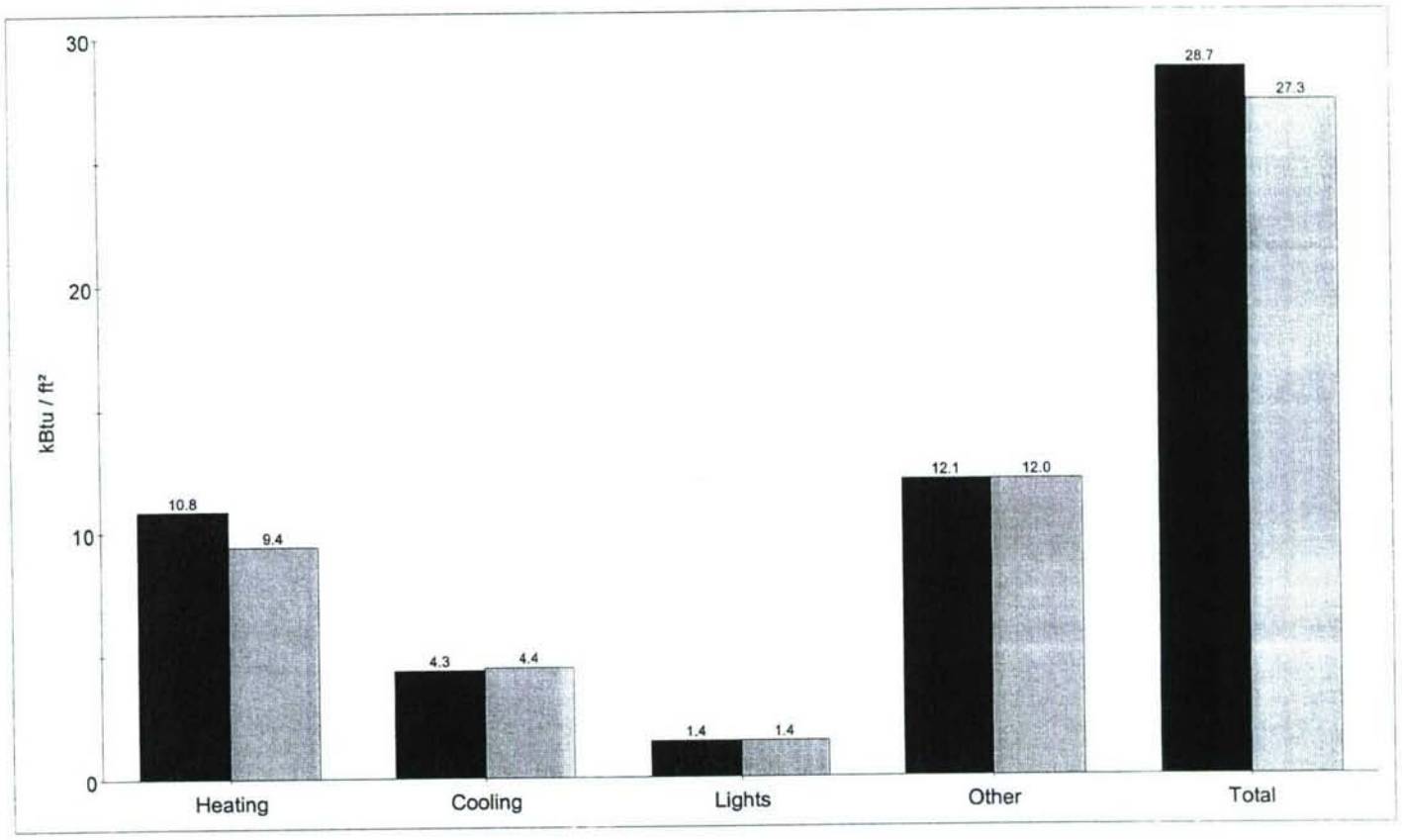
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	36/24/32
Rated Air Flow/MOOA,cfm	1210/0	1187/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	59019
Energy cost, $	1251	1192
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4796
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2816/277
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	3.7
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/20270/42653
Emissions, CO2/SO2/NOx, lbs	11763/42/25	11483/43/25
Construction Costs	203458	200187
Life-Cycle Cost	257916	255790

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Infiltration 0.5 ACH Case
Scheme Number:	9 / Saved	20 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

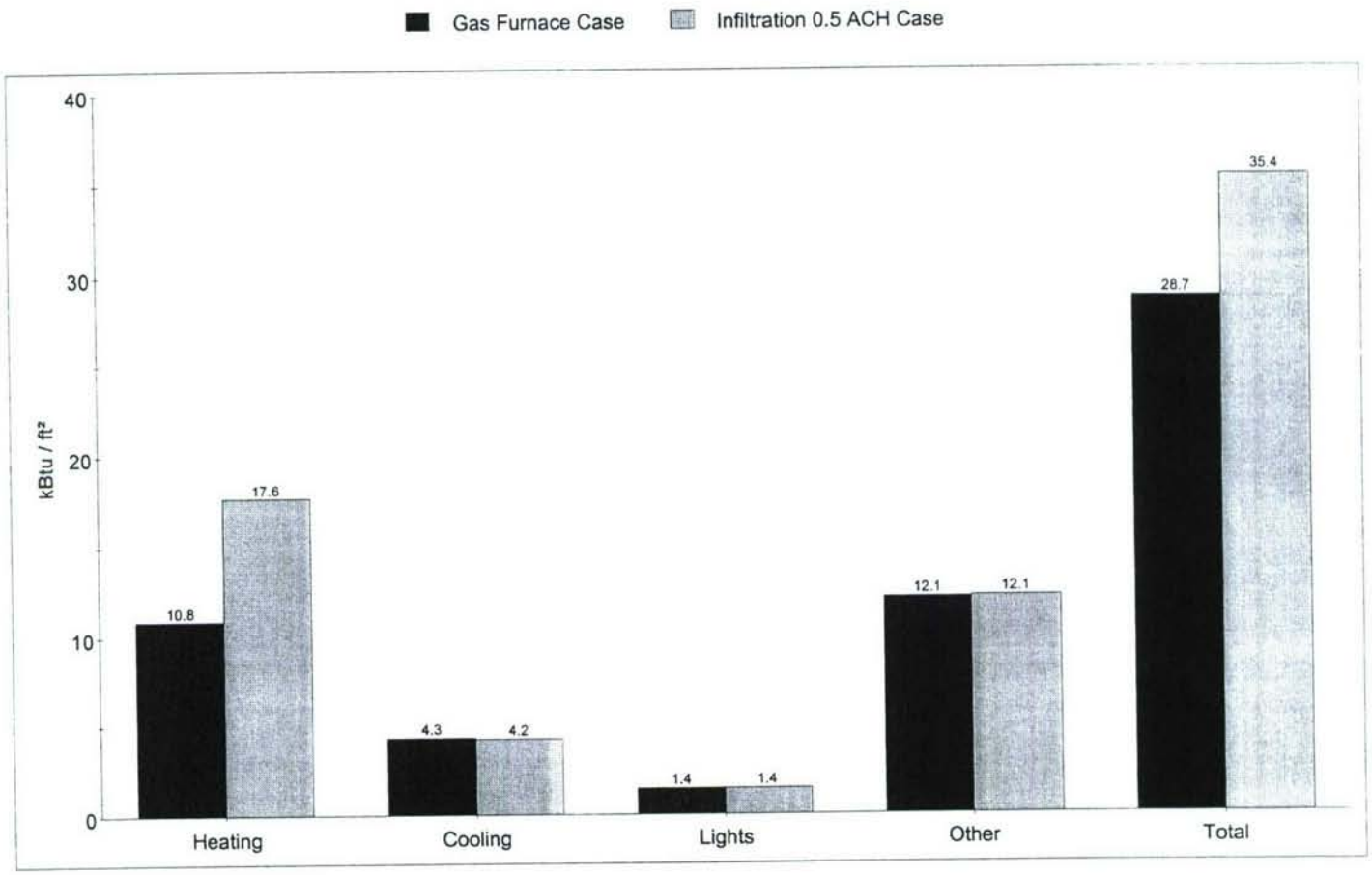
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	46/28/37
Rated Air Flow/MOOA,cfm	1210/0	1287/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.5

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW	
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	76381
Energy cost, $	1251	1543
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4666
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2664/299
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	4.2
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/38078/60461
Emissions, CO2/SO2/NOx, lbs	11763/42/25	13411/44/27
Construction Costs	203458	201844
Life-Cycle Cost	257916	268556

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Infiltration 1.0 ACH Case
Scheme Number:	9 / Saved	21 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

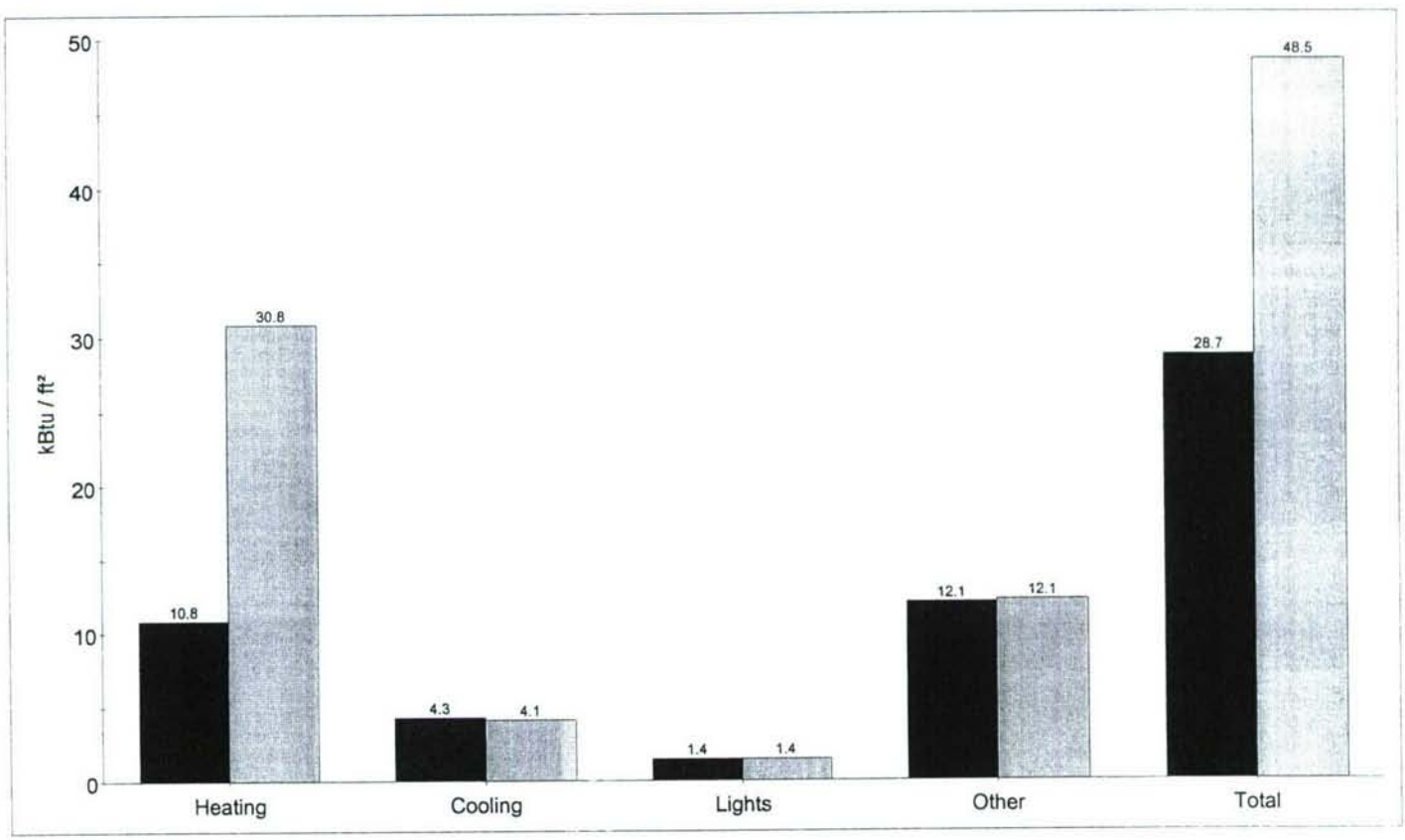
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	59/32/43
Rated Air Flow/MOOA,cfm	1210/0	1417/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=1.0

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	104793
Energy cost, $	1251	2117
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4653
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2610/340
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	4.9
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/66534/88916
Emissions, CO2/SO2/NOx, lbs	11763/42/25	16754/47/31
Construction Costs	203458	204221
Life-Cycle Cost	257916	288936

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004

Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Infiltration 1.5 ACH Case
Scheme Number:	9 / Saved	22 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

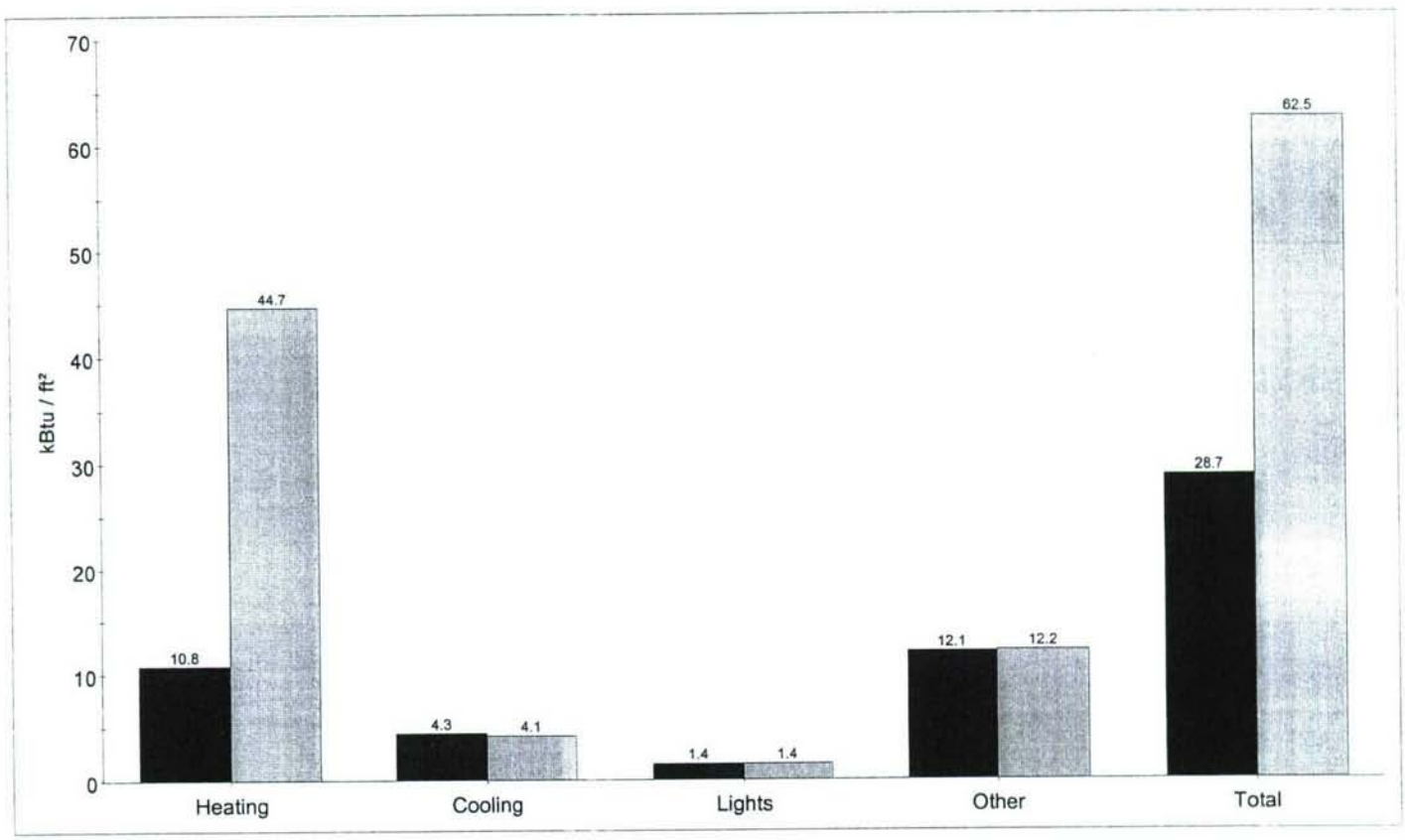
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	73/37/49
Rated Air Flow/MOOA,cfm	1210/0	1560/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=1.5

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW	
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	135009
Energy cost, $	1251	2727
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4702
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2613/386
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	5.6
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/96583/118965
Emissions, CO2/SO2/NOx, lbs	11763/42/25	20369/50/35
Construction Costs	203458	206580
Life-Cycle Cost	257916	310302

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	Infiltration 2.0 ACH Case
Scheme Number:	9 / Saved	23 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.et1	Grnsboro.et1
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

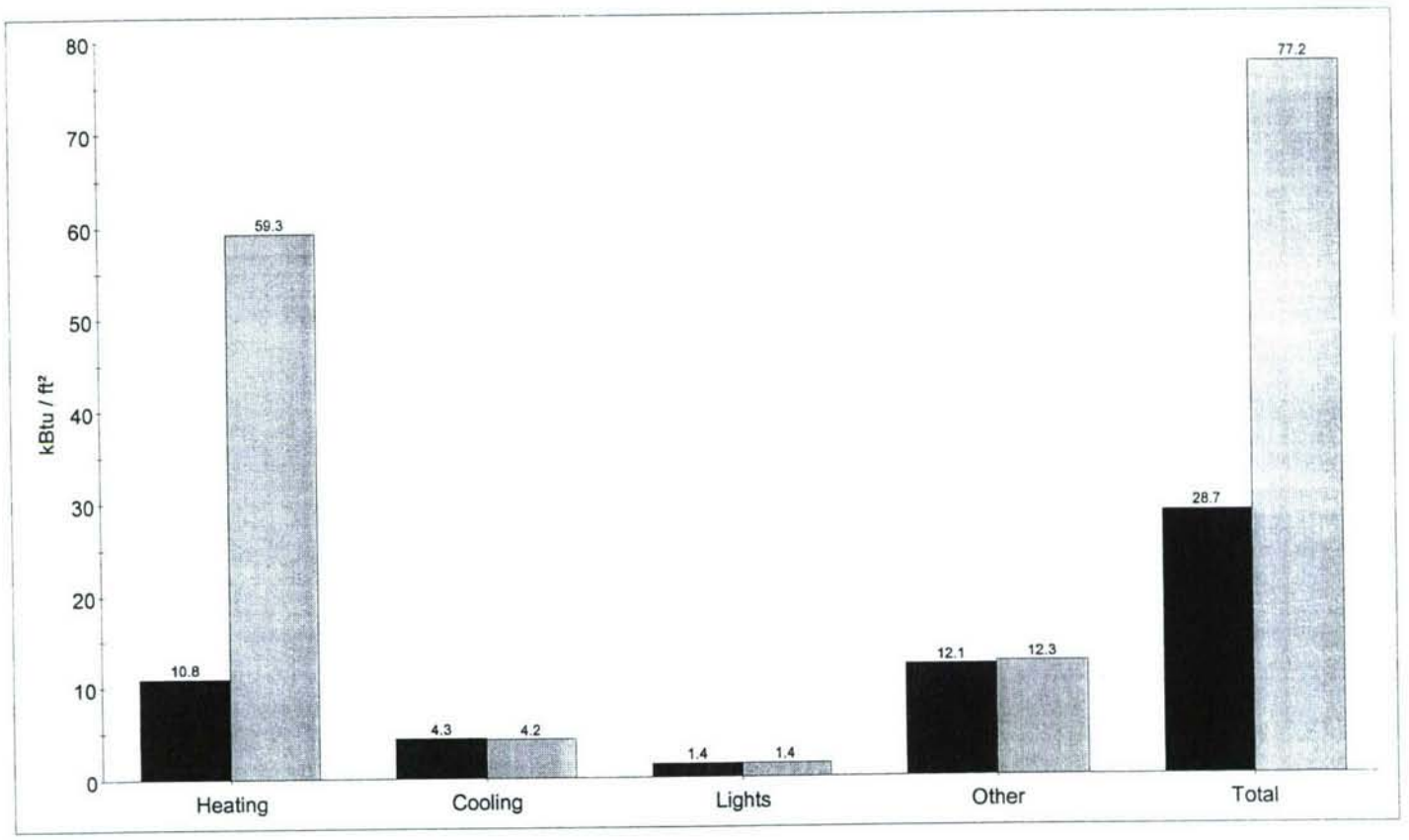
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	88/41/55
Rated Air Flow/MOOA,cfm	1210/0	1778/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	77.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=2.0

Results:

Energy cost 2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	166753
Energy cost, $	1251	3369
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	4793
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/2636/454
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	6.2
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/128014/150397
Emissions, CO2/SO2/NOx, lbs	11763/42/25	24204/54/39
Construction Costs	203458	209245
Life-Cycle Cost	257916	333136

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 26, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	70F Winter & 75F Summer Case
Scheme Number:	9 / Saved	24 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

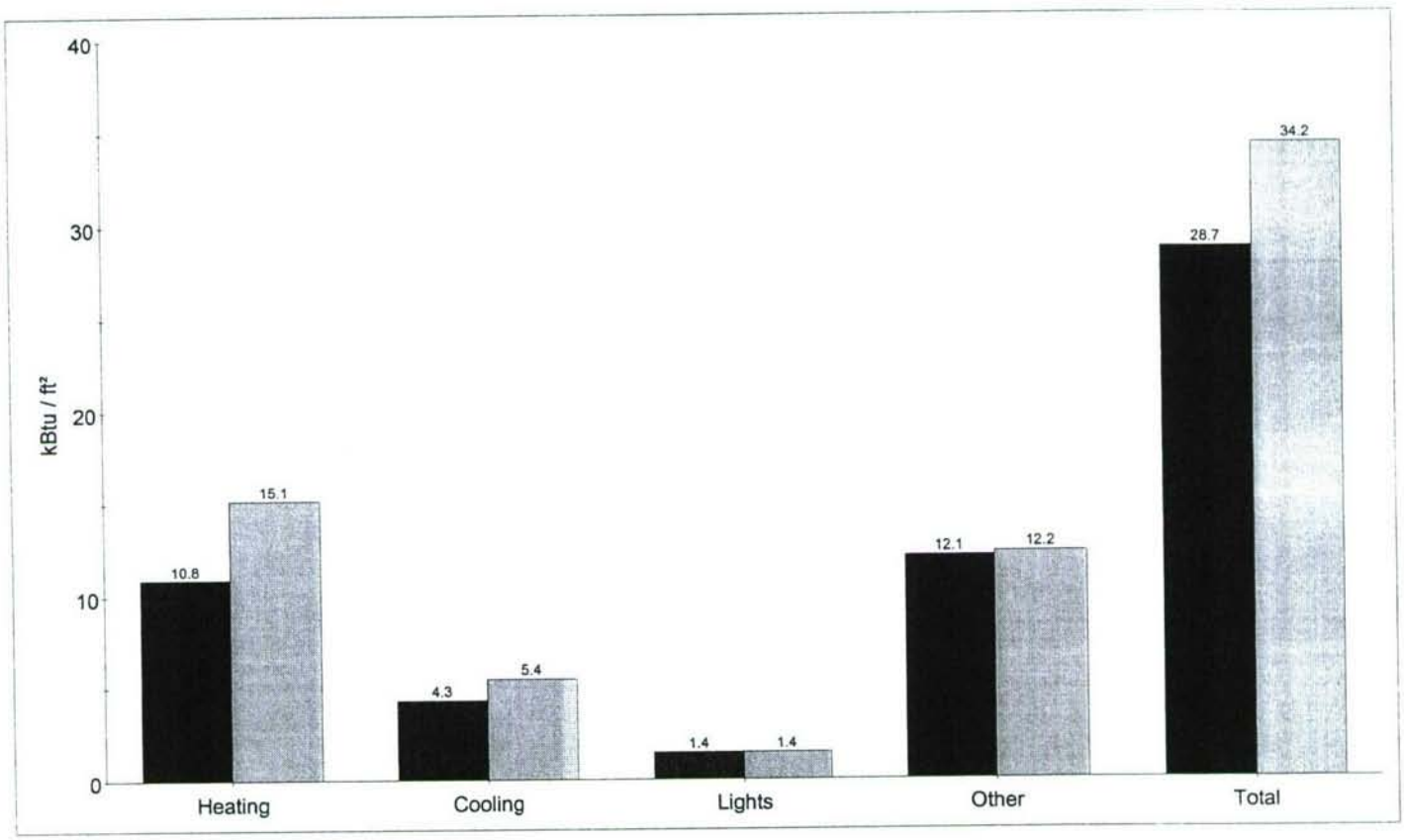
Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	41/26/35
Rated Air Flow/MOOA,cfm	1210/0	1416/0
Heating thermostat	68.0 °F, no setback	70.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	75.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	73980
Energy cost, $	1251	1495
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	5546
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/3438/405
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	4.0
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/32673/55056
Emissions, CO2/SO2/NOx, lbs	11763/42/25	13956/50/30
Construction Costs	203458	201592
Life-Cycle Cost	257916	266986

PROJ2 - ANNUAL ENERGY USE



Energy-10 Summary Page Jul 27, 2004
Project: PROJ2 **Project Directory:** C:\Program Files\Energy10v1_5\PROJ1

Description:	Gas Furnace Case	72F Winter & 73F Summer Case
Scheme Number:	9 / Saved	29 / Saved
Library Name:	PLUMBLEELIB / Saved	PLUMBLEELIB / Saved
Simulation status, Thermal/DL	valid/NA	valid/NA
Comments:	EES by Harry Boody, PE	EES by Harry Boody, PE
Weather file:	Grnsboro.etl	Grnsboro.etl
Floor Area, ft²	2160.0	2160.0
Surface Area, ft²	5856.5	5856.5
Volume, ft³	18653.0	18653.0
Total Conduction UA, Btu/h-F	362.4	362.4
Average U-value, Btu/hr-ft²-F	0.062	0.062
Wall Construction	2 x 4 cypress, R=14.5,etc	2 x 4 cypress, R=14.5,etc
Roof Construction	shingle, attic, r-30, R=30.5	shingle, attic, r-30, R=30.5
Floor type, insulation	Crawl Space, Reff=162.7,etc	Crawl Space, Reff=162.7,etc
Window Construction	2058 double, wood, U=0.48,etc	2058 double, wood, U=0.48,etc
Window Shading	36 deg lat plumblee,etc	36 deg lat plumblee,etc
Wall total gross area, ft²	1536	1536
Roof total gross area, ft²	2160	2160
Ground total gross area, ft²	2160	2160
Window total gross area, ft²	427	427
Windows (N/E/S/W:Roof)	5/7/13/4:0	5/7/13/4:0
Glazing name	double, U=0.49	double, U=0.49

Operating parameters for zone 1

HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtu/h	38/25/33	44/28/37
Rated Air Flow/MOOA,cfm	1210/0	1674/0
Heating thermostat	68.0 °F, no setback	72.0 °F, no setback
Cooling thermostat	77.0 °F, no setup	73.0 °F, no setup
Heat/cool performance	eff=80,EER=10.1	eff=80,EER=10.1
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	11/10	11/10
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/2.08/0.25	0.20/0.04/2.08/0.25
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.2

Results:

Energy cost	2.020$/Therm,0.069$/kWh,0.000$/kW	2.020$/Therm,0.069$/kWh,0.000$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	61933	96174
Energy cost, $	1251	1943
Saved by daylighting, kWh	-	NA
Total Electric, kWh	4727	6815
Internal/External lights, kWh	915/0	915/0
Heating/Cooling/Fan, kWh	0/2744/280	0/4482/630
Hot water/Other, kWh	0/788	0/788
Peak Electric, kW	3.7	4.2
Fuel, hw/heat/total, kBtu	22383/23420/45803	22383/50536/72919
Emissions, CO2/SO2/NOx, lbs	11763/42/25	17771/62/37
Construction Costs	203458	202916
Life-Cycle Cost	257916	282253

PROJ2 - ANNUAL ENERGY USE