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ENERGY ANALYSIS AND ENERGY CONSERVATION OPTION FOR THE WAREHOUSE FACILITY AT THE HUMAN SERVICES CENTER COMPLEX

DRAFT REPORT

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SUMMARY

The energy use of the warehouse facility at the Human Services Center Complex in Austin, Texas was analyzed using the DOE-2.1B building energy simulation program. An analysis was made for each building as specified in the building plans provided by the State Purchasing and General Services Commission.

The table below summarizes the energy use of the warehouse facility. Cooling and electrical energy use were 7.2% and 90% of the total energy use, respectively.

Table 1 - Total Energy Use For the Warehouse Facility

Building	Cooling (MBtu)	Heating (MBtu)	Electrical Energy (MBtu)	Total (MBtu)
Warehouses	0	118.5	3750.0	3868.5
Offices	451.6	52.6	1890.4	2394.6
Complex	451.6	171.1	5640.4	6263.1

The energy consumption of the warehouse facility was compared with the energy consumption of the buildings modified to comply with the ASHRAE standards. As shown in Table 2, the net reduction of 6.7% in energy use was obtained using the ASHRAE standards.

Table 2 - Comparison of Total Energy Use For the Base Facility and Proposed ASHRAE Standards

Type	Cooling (MBtu)	Heating (MBtu)	Electrical Energy (MBtu)	EUI (KBtu/sf-yr)
Base	451.6	171.1	5640.4	59.4
ASHRAE	432.2	105.4	5299.3	55.4
% Reduction	4.3	38.4	6.0	6.7

ABSTRACT

The energy use and peak load requirement of the warehouse facility at the Human Services Center Complex buildings in Austin, Texas were analyzed using the DOE 2.1B building energy simulation program. An analysis was made for each building as specified in schematic designs and primary drawings. The energy consumption of the buildings were compared with the energy consumption of the modified buildings which conformed to the ASHRAE energy standard.

CHAPTER 1

INTRODUCTION

The cost of comfort heating and cooling is typically the largest single component of annual energy costs in commercial buildings. In Texas, 63% of the total energy use in commercial sector is used for heating, ventilation and air-conditioning (HVAC), which is about 8.5% of the total energy consumption of Texas [1].

The Energy System Laboratory at Texas A & M University is working with Texas Public Utility Commission (PUC) and State Purchasing and General Services Commission (SPGSC) to evaluate the energy use of new buildings in Austin. The warehouse facility at the Human Services Center Complex was chosen for the preliminary studies to evaluate possible conservation strategies for reducing the energy use of these buildings.

The warehouse facility at the Human Services Center Complex consist of three buildings. These buildings are Texas Rehabilitation Commission (TRC), Texas Department of Health (TDH) and Texas Blind and Youth Commission (TBC & TYC). The DOE2.1B building energy simulation program [2] was used to analyze the energy consumption of these buildings before the construction of the buildings starts. The proposed ASHRAE Standard [3] has been created to encourage the energy efficient design of new buildings. It provides criteria and minimum standards to reduce energy consumption without constraining the building function or the comfort of the occupants. It also provides methods for determining compliance with the standard.

The standard provides criteria for the design of new buildings for human occupancy. The design of the building envelope is covered as well as the selection of the Heating, Ventilating, and Air Conditioning (HVAC) equipment, water heating system, lighting and auxiliary systems.

CHAPTER 2

DESCRIPTIONS OF THE BUILDINGS

The warehouse facility at the Human Services Center Complex consist of three buildings. The Schematic Design Proposal and Primary drawings by Fouts Gomez Architects were provided by SPGSC and Texas A & M University.

To make estimates of the energy use of the warehouse facility at the Human Services Center Complex using DOE 2.1B computer program, the various operational schedules of the buildings are required. This chapter provides a description of the warehouse facility at the Human Service Center Complex floors, the construction details, schedules and various zones. Because many of the schedules were not known, they were assumed.

BUILDING ENVELOP

A. Exterior Walls

Exterior facing of the warehouse facility is 1.5" flutes fastened to 6" precast concrete tilt-up panel. There are 1/2" air gaps between the concrete and the 1.5" insulation batts. The interior wall finish is 5/8" gypsum wallboard.

B. Exterior Windows and Doors

Six types of windows provided in the drawings. Exterior glass at all the locations would be 1/4" double pane glass. The side lites would be 1/4" tempered glass. There are several types of exterior doors. All the exteriors doors will be 16 gage stock hollow metal variety. Insulated rolling doors and vinyl strip curtains would be used for the loading and unloading zones.

C. Roof Construction and Skylights

The roofing membrane at the warehouse facility is polyester reinforced nitrile butadiene polyblend with 2" Isocynanurate insulation with R-14.4 R-value. Roofing membrane must be placed over the insulation and mechanically fastened with coated fasters and plates. The skylights are double pane glass, exterior lite tinted, interior lite clear. The area of each skylight is 36 sq. ft. The total area of skylights is 2.4% of the total roof area.

SCHEDULES

The warehouse facility at the Human Services Complex consist of several warehouses and offices, so the operating schedules should be the same Monday through Friday. Two schedules were assumed for the warehouse facility: a schedule for Monday through Friday and another for holidays and weekends. Four schedules are discussed below: (1) occupancy, (2) lighting, (3) office equipment, and (4) infiltration.

Occupancy

The number of the people occupying each zone was obtained from the warehouse facility specifications. One person per 100 s.f. in offices, one per 300 s.f. in warehouse areas was used. The occupancy schedules and the occupancy capacities by floors of each building are shown in Tables 2.1 and 2.2, respectively. The maximum number of people in the buildings is estimated to be 406.

Table 2.1 - Occupancy Schedules For the Warehouse Facility*

Time	Monday -Friday	Holidays & Weekends
1am - 8am	0.0	0.0
8am - 12pm	0.9	0.0
12pm - 2pm	0.6	0.0
2pm - 6pm	0.9	0.0
6pm - 12am	0.0	0.0

* 1.0 = 406 people

Table 2.2 - Occupancy Capacities For the Warehouse Facility.

Building	Occupants		
	1st Floor	Mezzanine	Total
TRC	118	46	164
TCB	43	15	58
TYC	10	4	14
TDH	89	81	170

Lighting

The peak lighting levels were estimated to be 2.0 w/sf in office areas. The lighting level in warehouse areas is 1.0 w/sf. The lighting system for the entire building will be the fluorescent 34 watt miser lamps with energy saving ballasts. Office and finished areas with a ceiling will be illuminated using recessed troffer lighting fixtures with acrylic lenses. Warehouse areas will be illuminated using recessed fluorescent-not vented. The lighting schedules are shown in Table 2.3.

Table 2.3 - Assumed Lighting Schedule For The Warehouse Facility *

Time	Monday -Friday	Holidays & Weekends
1am - 6am	0.1	0.2
6am - 5pm	0.9	0.2
5pm - 12pm	0.3	0.2

* Where 1.0 = 2.0 w/sf (Office)
1.0 = 1.0 w/sf (Warehouse)

Office Equipment

The peak equipment wattage for an office was estimated to be 1 w/sf. The office equipment schedules are shown in Table 2.4. Office equipment includes items such as computer terminals, typewriters, desk lamps, etc. During weekends and holidays, no equipment is assumed to be on.

Table 2.4 - Assumed Office Equipment Schedule For The Warehouse Facility *

Time	Monday -Friday	Holidays & Weekends
1am - 6am	0.0	0.0
6am - 12pm	0.9	0.0
12pm - 14pm	0.5	0.0
14pm - 17pm	0.9	0.0
17pm - 24pm	0.0	0.0

* Where 1.0 = 1.0 w/sf (Office)

Infiltration

Infiltration was assumed to be 0.5 air-change/hr for the office and 1.0 air-change/hr for the warehouse areas. Because of the loading and unloading doors with rolling and vinyl strip curtain in warehouse areas, the infiltration through these doors could be large. The infiltration schedules are shown in Table 2.5. During week nights, weekends, and holidays, the infiltration is assumed to be negligible due to the lack of the people moving in and out of the building.

Table 2.5 - Assumed Infiltration Schedule For The Warehouse Facility

Time	Monday -Friday	Holidays & Weekends
1am - 6am	0.0	0.0
6am - 17pm	1.0	0.0
17pm - 24pm	0.2	0.0

ZONES

Each floor and the mezzanine in each building are treated as single zones. Figure 2.1 shows a typical floor plan of The warehouse facility. The complex was divided into two zones. The office areas were treated differently from the warehouse areas. The gross area of each building is shown in Table 2.6. The total gross office area is 26,465 square feet. The gross area of the warehouse facility at the Human Services Center Complex is 105,368 square feet.

Table 2.6 - Floor Areas For the Warehouse Facility

Building	1st Floor sf	Mezzanine sf	Total sf
TRC	35406	13739	49145
TCB	12870	4505	17375
TYC	3024	1058	4082
TDH	23169	11597	34766

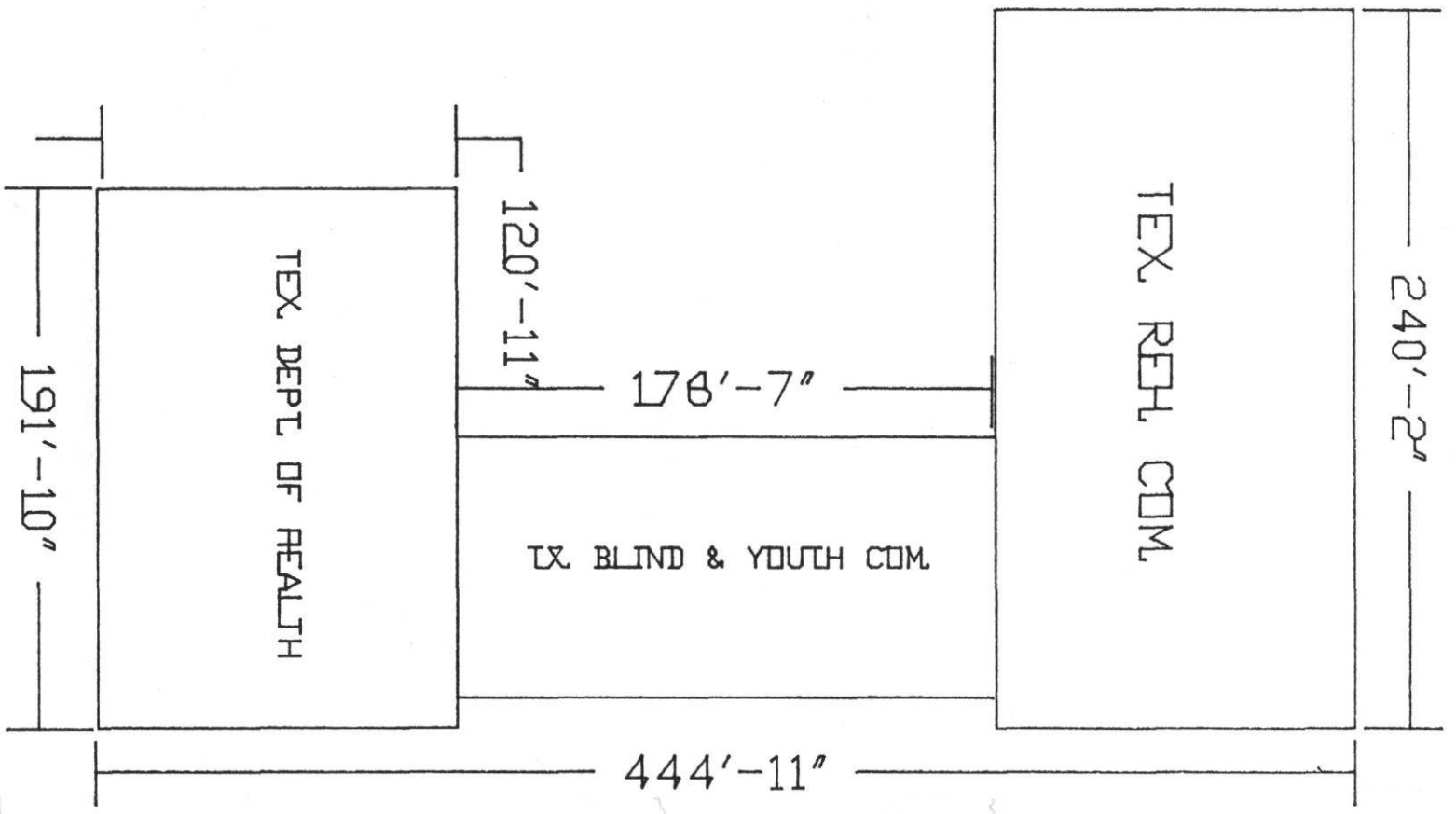

Figure 2.1 The Warehouse Facility Layout

CHAPTER 3

SYSTEM DESCRIPTION

The heating and ventilating system in warehouse areas is a constant volume system without cooling capability or humidity control. In its most basic configuration, the system provides forced air heating from an air handling unit that contains a heating coil provided by gas fired radiant panels and a supply fan. The amount of heat added by the zone coil is controlled from a thermostat that senses zone temperature. The areas will be ventilated by air fans and relief vents.

The office areas will be heated by indirect gas fired and cooled with roof mounted, packaged HVAC equipment utilizing Direct Expansion (DX) cooling and indirect gas fired heating. The Packaged Single Zone Air Conditioner with Heating (PSZ) was used for the office areas. In its most basic configuration, the PSZ system consists of a compressor, an air-cooled condenser, an evaporator with a fan supplying cooled air to the indoors and a thermostat.

The temperature in office areas for cooling was set at 75 F during the day and allowed to float to 85 during the week nights, weekends, and holidays. The temperature for heating was set at 75 F during the day and 65 F during week nights, weekends, and holidays. The maximum humidity was set at 60% and minimum at 40%. Each zone in office areas was assigned a separate HVAC system. The fresh air requirements per person was assumed to be 7 cfm/person. The fan schedules are shown in Table 3.1.

Table 3.1 - Fan Schedules For the Warehouse Facility

Time of Operation	Monday -Friday	Holidays & Weekends
1am - 10am	off	off
10am - 15pm	on	off
15pm - 24pm	off	off

CHAPTER 4

BASE CASE ANALYSIS

The energy consumption of the warehouse facility at the Human Services Center Complex was analyzed using the DOE2.1b building energy simulation program [5]. DOE2.1b is a public domain computer program which can be used to evaluate the energy consumption and hourly loads of buildings and their associated HVAC systems. It calculates hourly performance and response of a building or a zone whose description has been provided by the user. In addition, DOE2.1b can simulate the peak loads of a building and is capable of producing an economic analysis of the energy use and the costs and benefits of making alterations in design.

The total cooling peak load of each building consists of peak loads on walls, roofs, glass, occupants, lights, equipments, and infiltration. Appendix A provides the cooling and heating peak load components of each building as well as system monthly loads for each floor. The total cooling and heating peak loads occur on August 11 at 4 pm and January 18 at 10 am, respectively. Figure 4.1 shows the distribution of the total cooling loads for the warehouse facility. The infiltration, the heat gain due to the walls and roof conduction, and lighting loads constitutes 35%, 20%, and 20% of the total cooling peak load, respectively.

Figure 4.2 shows the breakup of the peak heating energy for the warehouse facility at the Human Services Center Complex. The infiltration loads, in case of heating, are much more significant than cooling, because the indoor-outdoor temperature difference is much greater in winter than in summer. The infiltration and heat losses through external walls and roof contribute 75% and 22%, respectively to the peak load.

Table 4.1 shows the total annual energy use for the warehouse facility at the Human Service Center Complex. As shown in Table 4.1, the cooling load is zero for the warehouse areas because, they are ventilated with outside air by roof mounted forced air fans. The Energy Efficiency Ratio (EER) of the office packaged HVAC equipments is assumed to be 10. The Energy Usage Index (EUI), which is the annual energy use of the building divided by its gross floor area, was calculated and is shown in Table 4.2. Because the warehouse is not air conditioned, its EUI is substantially less than the offices. The weighted average (combined) EUI for the warehouse and office spaces is 59.4 Btu/sq yr.

Table 4.1 - Total Energy Use For the Warehouse Facility
Base Case

Building	Cooling (MBtu)	Heating (MBtu)	Electrical Energy (MBtu)	Total (MBtu)
Warehouses	0	118.5	3750.0	3868.5
Offices	451.6	52.6	1890.4	2394.6
Complex	451.6	171.1	5640.4	6263.1

Table 4.2 - Energy Usage Index For
Base Case

Building	EUI (KBtu/SF Yr)
Warehouses	53.3
Offices	73.1
Combined	59.4

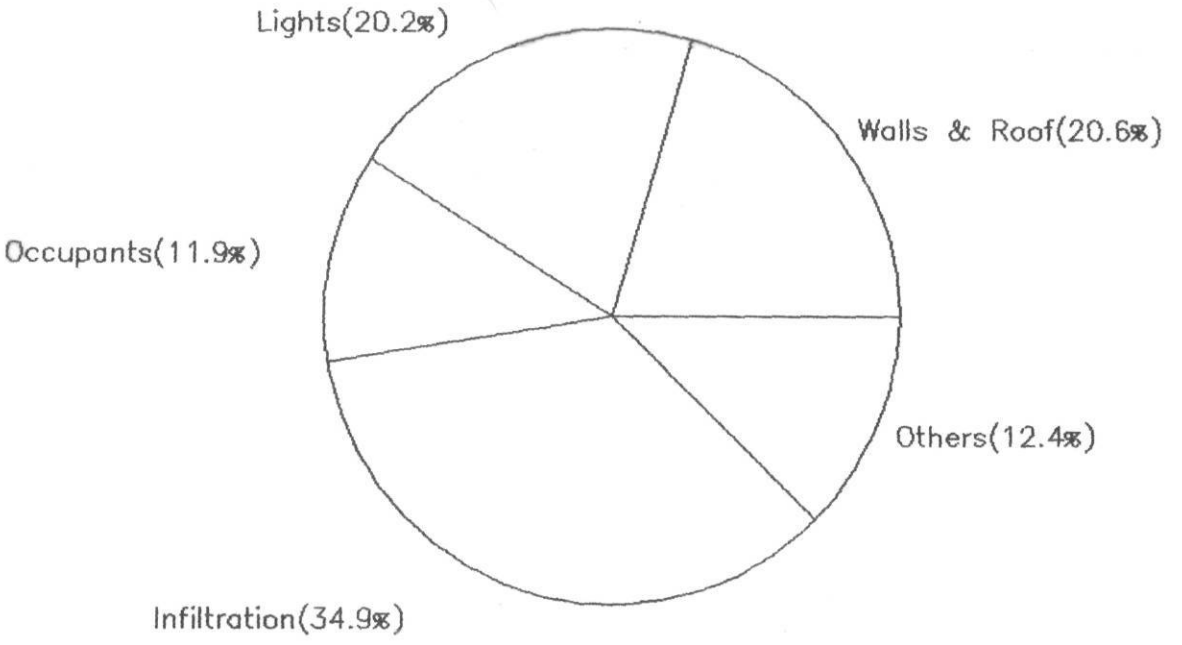

Figure 4.1 Distribution of Peak Cooling Load the Base Warehouse Facility (Total Loads = 1713 Kbtu/br)

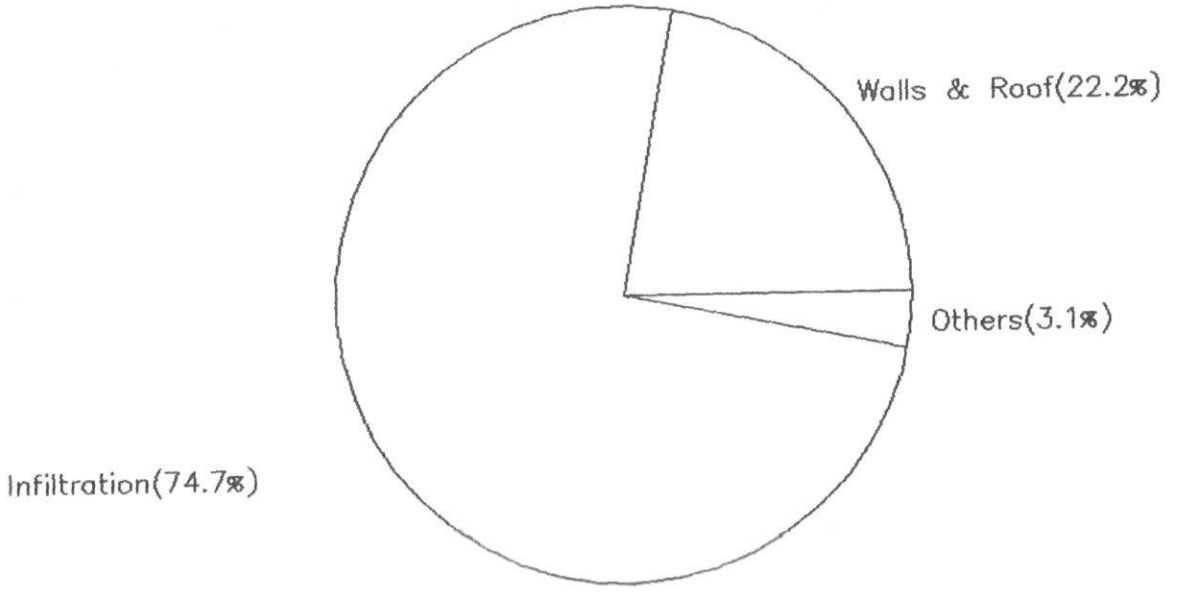

Figure 4.2 Distribution of Peak Heating Load For the Base Warehouse Facility (Total Loads = 1075 Kbtu/hr)

CHAPTER 5

RESULTS & ANALYSIS

A conservation strategy was considered for the warehouse facility at the Human Services Center Complex. The strategy includes redesigns of the buildings to the proposed ASHRAE standard 90.1p.

ASHRAE STANDARDS

ASHRAE has recently proposed a major update to the previously published studies on the non-residential buildings [2]. The update affects several major areas : (1) lighting levels and its controls, (2) control of equipment loads, and (3) HVAC systems.

Lighting and its Control

The major difference between the base buildings and those required with the proposed ASHRAE standards was in the lighting level. The base buildings had 2.0 w/sf, whereas ASHRAE standards recommend 1.8 w/sf. The standards also call for automatic controls including occupancy sensors,light level sensors, etc. These reduce the lighting level during unoccupied hours to those level needed for safety and security. These also adjust the lighting levels when adequate daylight is present. These controls would be useful in the perimeter zones of the the buildings where there is abundant indirect solar insolation.

Control of Equipment Loads

The proposed standards specify that major heat generating equipment should, where practical, be located where it can balance other heat losses. For example, computer centers, mechanical rooms or kitchen areas could be located in the north or northwest perimeter areas of a building depending on the climate and the prevailing wind directions.

HVAC Systems

The standards call for VAV systems in office buildings which are more than four stories high. Systems serving areas with large internal loads (lighting, equipment, and people), especially interior zones with little or no exposure to weather, should be designed to take advantage of mild or cool weather conditions to

reduce cooling energy. Economizer controls should be integrated with the mechanical cooling controls so that mechanical cooling is only operated when necessary, and the supply air is not over cooled to a temperature below the desired supply temperature. The system and controls should be designed so that the economizer operation does not increase the heating energy use. The supply air quantity should vary with the sensible (i.e, VAV system). The recommended temperature controls during occupancy are 70 F heating and 75 F for cooling.

Table 4.1 shows the total peak cooling and heating loads for the base buildings and the buildings modified with ASHRAE standards. There is a 0.7% reduction in peak cooling load for the facility. The reduction compared to the base is from the heat gain from lighting. The lighting level was reduced by 0.2 w/sf in the office areas. The peak heating load increased by 1.1% with the proposed ASHRAE standards. The total energy consumption by the facility is given in Table 4.2. The reduction in total energy consumption by the facility with ASHRAE standards compared to the base building is given in Table 4.3. The major reductions in total energy use is on heating energy use (38.4%). This reduction is caused by a heating temperature reduction from 75 to 70 F. Electrical energy and cooling energy were decreased by 6% and 4.3%, respectively due to the lower lighting level in the office areas. The total energy use was reduced by 6.7% for the warehouse and office areas. Appendix B provides the cooling and heating peak load components of each building as well as system monthly loads for each floor.

Table 5.1 - Peak Cooling and Heating Loads For the Warehouse Facility (KBtu/hr)

Type	Cooling	Heating
Base	1713	1075
ASHRAE Stand.	1701	1086
% Reduction	0.7	-1.1

Table 5.2 - Total Energy Use For the Warehouse Facility
ASHRAE Standards

Building	Cooling (MBtu)	Heating (MBtu)	Electrical Energy (MBtu)	Total (MBtu)
Warehouses	0	92.1	3590.8	3682.9
Offices	432.2	13.3	1708.5	2154.0
Complex	432.2	105.4	5299.3	5836.9

Table 5.3 - Comparison of Total Energy Use For the
Base Facility and Proposed ASHRAE Standards

Type	Cooling (MBtu)	Heating (MBtu)	Electrical Energy (MBtu)	EUI (KBtu/sf-yr)
Base	451.6	171.1	5640.4	59.4
ASHRAE	432.2	105.4	5299.3	55.4
% Reduction	4.3	38.4	6.0	6.7

CHAPTER 6

CONCLUSIONS & RECOMMENDATIONS

The current proposal of the warehouse facility at the Human Services Center Complex reflects improvements in energy use over buildings built several years ago. Some of the options for reducing the warehouse facility energy use include: reducing the lighting levels, and reducing the heating temperature setting. These options will not only reduce the peak loads but also reduce the total energy use. Because of the lacking cooling in the warehouse storage areas, the EUI's of this facility are substantially below those of other facilities currently proposed or under construction by the state.

REFERENCES

[1] "Energy Conservation Procedures for HVAC," By Walter & Associates Consulting Engineers, Public Utilities Commission of Texas, Austin, TX, 1984.

[2] "Energy Efficient Design of New Non-Residential Buildings and New High-Rise Residential Buildings", ANSI/ASHRAE/IES 90.1P, public review draft June 10, 1985, The American Society of Heating, Refrigerating, and Air-Conditioning Inc. (ASHRAE), 1791 Tullie Circle NE, Atlanta, GA 30329.

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[4] DOE-2, Reference Manual, Version 2.1B, Lawrence Berkeley Laboratory, University of California, Berkeley, CA. 94720, January 1983.

[5] Handbook of Systems, ASHRAE 1791 Tullie Circle, N.E., Atlanta, GA. 30329.