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ASSESSMENT AND SUGGESTIONS TO IMPROVE THE COMMERCIAL BUILDING MODULE OF EIA-NEMS

Final Report

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ABSTRACT

The National Energy Modeling System (NEMS) is a comprehensive, computer-based, energy-economy modeling system developed and maintained by the Department of Energy's Energy Information Administration (EIA). NEMS forecasts the national production, imports, conversion, consumption, and prices of energy out to 2015, subject to macroeconomic assumptions, world energy markets, resource availability and costs, technological developments, and behavioral and technological choice criteria. NEMS has nine program modules of which the Commercial Sector Demand (CSD) module is one. Currently the CSD module uses a matrix of Energy Use Intensities (EUIs) gleaned from the 1989 CBECS database to model service demand per major fuel type for eight different geographic census divisions and eleven different building types.

Over the last 7 years, the Energy Systems Laboratory (ESL) of Texas A&M University built up an extensive database of monitored hourly energy use data in about 150 institutional, hospital and state and governmental buildings as a part of the LoanSTAR energy monitoring program. Further, the ESL has acquired expertise in commercial buildings simulations as well as in related technology improvements. This study included two tasks.

First, the NEMS CSD-EUI matrix data for the Texas region was compared to those determined from end-use monitored data from the Texas LoanSTAR database. The LoanSTAR end-use monitored data showed much higher values of total, heating, and cooling use than the NEMS data for the health care and large office buildings. The differences were over an **order of magnitude** in space cooling for both types of building. While differences of a factor of one or two were expected in view of the small sample sizes, the order of magnitude difference was a cause for concern. The health care buildings in the sample tended to be large medical facilities, which may account for some of the difference. However, the large office buildings in the sample (consisting of state facilities in Austin as well as large offices at some of the universities) were typical of large common buildings, and no satisfactory explanation could be given for the large differences in EUIs.

Second, the interaction effects between lighting and heating and cooling energy use for seven different building categories in three different geographic locations were characterized using the ASEAM building simulation software. The simulation study indicated that neglecting energy interaction effects can be a major shortcoming, which future modeling refinements of the CSD module should overcome. One possible approach would be to follow the one adopted in this study, namely perform computer simulations for each of the eight geographic census divisions of the United States and for each of the 11 different building types and generate a correction-matrix which can subsequently be used to correct the basic NEMS CSD-EUI matrix whenever required.

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CHAPTER 1

BACKGROUND

The National Energy Modeling System (NEMS) is a comprehensive, computer-based, energy-economy modeling system developed and maintained by the Department of Energy's Energy Information Administration (EIA). NEMS forecasts the national production, imports, conversion, consumption, and prices of energy to the year 2015, subject to macroeconomic assumptions, world energy markets, resource availability and costs, technological developments, and behavioral and technological choice criteria. Because a substantial portion of carbon dioxide and air pollution emissions are associated with energy use in the commercial, transportation, residential and industrial sectors, NEMS provides sophisticated mechanisms for forecasting emissions associated with U.S. energy use in each sector. NEMS is a useful tool for evaluating policy measures taken under the Clean Air Act and the Climate Change Action Plan to control these emissions.

NEMS computer software is made up of nine program modules:

1) Commercial, Transportation, Residential, Industrial and Macroeconomic Activity,
2) Commercial Demand and Macroeconomic Activity,
3) Industrial Demand and Macroeconomic Activity,
4) Residential Demand and Macroeconomic Activity,
5) Transportation Demand and Macroeconomic Activity,
6) Electricity Market and Renewable Fuels,
7) Coal Market,
8) Petroleum Market and International Energy, and
9) Oil and Gas Supply and Natural Gas Transmission and Distribution.

Each module can be run individually or together depending on the particular requirement. A personal computer version of the software is also available.

Each year, EIA organizes building technology forecasting workshops with the purpose of acquiring inputs from technology experts as to areas in which improvements should be made in the residential and commercial modules of NEMS. In regard to the Commercial Sector Demand Module (CSDM) which is the focus of this study, the following six critical NEMS-CSDM refinement issues were identified in FY95:

Task 1) Representing auxiliary or parasitic equipment more explicitly (this includes, fans, blowers, cooling towers, Variable Speed Drives,...),

Task 2) Representing the interactions between various end-uses; for example, lighting and cooling loads, shell and heating loads,...,

Task 3) Representing the operation (or potential improvement of the operation) of buildings,

Task 4) Characterizing the cost and performance of commercial sector end-use technologies and ensuring that all relevant technologies are included and characterized properly,

Task 5) Evaluating whether cost characterizations of retrofit vs new and upgrade vs replacement technology have been done properly,

Task 6) Evaluating whether dual (or triple) function heating/cooling technologies have been characterized properly.

The Energy Systems Laboratory (ESL) of Texas A&M University was approached by EPA to evaluate some of the above issues and recommend improvements to the existing CSD module. During the past 7 years, the ESL has built up an extensive database of monitored hourly energy use data in about 150 institutional, hospital and state and governmental buildings in Texas, as part of the Texas LoanSTAR program. Further, the ESL has acquired expertise in commercial buildings simulations as well as in related technology improvements.

CHAPTER 2

OBECTIVES AND SCOPE

Currently the CSD module uses a matrix of Energy Use Intensities (EUIs) to model service demand per major fuel type for different geographic census divisions and different building types. These data have been gleaned from the Commercial Building Energy Consumption Survey (CBECS) of 1989. Recently, EIA modelers have proposed that more recent CBECS data (from a 1992 survey released in 1995) be used to update the EUI matrix. Though much effort was made in acquiring realistic values of these EUIs, it was felt that such an approach had inherent limitations in capturing varying synergisms between energy end-uses.

The ESL, with consent from the EPA project monitor, proposed to perform the following activities in the framework of the current project:

(a) compare the EUI matrix data against those determined from end-use monitored data from the Texas LoanSTAR database, and

(b) quantify, using engineering simulation models, the importance of the interaction effects (Task 2 listed above) for different building categories in a few locations. This quantification would permit EIA to evaluate whether neglecting the interaction effects in the CSD module (as is done currently) is a major shortcoming or not, and decide on the need to include such effects in future modeling refinements of the CSD module.

CHAPTER 3
EUI COMPARISON AGAINST LOANSTAR DATABASE

3.1 Description of CSDM EUI Matrix

The EUI matrix used by NEMS consists of 10 different end uses and 11 building types for each of the geographic census divisions of the United States. The state of Texas falls in census division seven. Table 1 shows the EUIs currently used by CSDM. Note that the EUIs are in units of (MBtu/sq.ft./year), and apply to source energy.

EIA has recognized the need to revise these numbers using the 1992 CBECS data. Because this revision is yet to be done, we have limited ourselves to comparing LoanSTAR results against the 1989 CBECS EUI numbers assembled in Table 1.

3.2 Description of LoanSTAR database

In 1988, the Texas Governor's Energy Management Center (GEMC) of Texas received approval from the U.S. Department of Energy to establish a $98.6 million statewide retrofit demonstration revolving loan program. The program was given the name LoanSTAR (Loans to Save Taxes and Resources) (Claridge et al., 1991). The LoanSTAR program uses a revolving loan financing mechanism to fund energy-conserving retrofits in state, public school, and local government buildings. Retrofit projects are identified by energy audits conducted by engineering teams under contract to the Governor's Energy Office-GEO (in 1990, the GEMC was renamed the GEO). Each retrofit competes for funds on the basis of the estimated payback period, ability to repay the loan through energy savings, engineering assessment of the viability of the retrofit, and the feasibility of metering the project effectively.

The projects funded by LoanSTAR primarily include retrofits to lighting, HVAC systems, building shell modifications, electric motors, energy management and control systems, boilers, and thermal storage systems. The length of the loan can be up to 4 years. Loan proceeds can be used to pay for the retrofit, engineering and design, and the installation expenses.

A unique feature of the LoanSTAR program was the Monitoring and Analysis Program (MAP) that was established to measure and report the energy savings from the retrofits. The MAP was a quality assurance measure to ensure that agencies purchasing retrofits receive real savings for their investment. For each site, a monitoring plan was developed to verify estimated savings.

Table 1. Energy Use Indices (EUI) Matrix for Geographical Region 7 (West-South-Central) for the Commercial Sector Demand Module of NEMS. Units are in MBtu/sq.ft./year.

Building Type	Space Heating	Space Cooling	Water Heating	Ventilation	Cooking	Lighting	Refrigeration	Office Equipment (pc)	Office Equipment (non-pc)	Other uses	
Assembly	0.79	4.97	0.09	3.35	0.16	10.34	2.54	1.01	1.01	5.89	E
	7.62	0.03	1.53	0.00	4.70	0.00	0.00	0.00	0.00	0.89	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O
Education	1.29	5.16	0.22	4.18	0.10	12.96	1.60	1.31	1.31	4.12	E
	28.79	0.00	2.50	0.00	0.62	0.00	0.00	0.00	0.00	1.28	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O
Food Sales	0.14	20.23	1.68	5.88	11.23	23.94	57.70	1.30	1.30	8.35	E
	4.23	0.00	1.35	0.00	19.33	0.00	0.00	0.00	0.00	0.53	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O
Food Services	3.39	35.73	3.88	17.31	19.41	28.38	18.61	2.01	2.01	16.73	E
	33.86	0.00	51.15	0.00	44.35	0.00	0.00	0.00	0.00	13.84	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O
Health Care	1.54	17.38	1.11	9.37	2.45	35.88	2.94	1.45	1.45	5.41	E
	18.56	0.00	16.52	0.00	9.25	0.00	0.00	0.00	0.00	2.18	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	O
Lodging	1.35	7.86	0.61	7.33	3.12	11.18	3.56	0.37	0.37	1.76	E
	16.20	0.00	27.27	0.00	1.78	0.00	0.00	0.00	0.00	1.04	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	O
Large Office	1.48	8.96	0.36	19.46	0.22	23.14	2.66	14.17	14.17	6.96	E
	5.33	0.00	3.95	0.00	0.79	0.00	0.00	0.00	0.00	0.21	NG
	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	O
Small Office	2.04	14.32	0.58	5.68	0.28	26.20	3.49	13.92	13.92	2.73	E
	14.70	0.56	2.46	0.00	0.02	0.00	0.00	0.00	0.00	1.22	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	O
Mercantile & Service	0.71	6.19	0.37	2.31	0.33	16.75	1.00	7.62	7.62	10.82	E
	9.66	0.01	2.01	0.00	1.19	0.00	0.00	0.00	0.00	5.19	NG
	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O
Warehouse	0.80	0.79	0.13	0.46	0.09	7.27	1.57	3.14	3.14	2.15	E
	8.08	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.95	NG
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	O
Other	0.20	6.15	0.15	1.44	0.19	23.47	2.59	2.60	2.60	15.47	E
	9.69	0.00	0.53	0.00	0.35	0.00	0.00	0.00	0.00	14.43	NG
	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	O

E = Electricity NG = Natural Gas O = Other

This was usually done by metering consumption before and after the retrofit and then analyzing the data to account for weather and changes in building operation. The metering was typically installed at least 6 months (preferably one year wherever possible) prior to the retrofit and remained in place for the life of the equipment and/or the retrofit.

Table 2 presents a list of the building types (this classification is different from that of the NEMS program) monitored by the LoanSTAR program as of 1993 (Phillips, 1993). A list of the individual buildings is given in Table 3. Since NEMS used source EUIs while the energy use from the LoanSTAR end-use monitoring was in site EUIs, the latter had to be converted to source values. The conversion factors used are given in Table 4.

3.3 Comparison

The LoanSTAR buildings used in the comparison to the NEMS building types had at least one year's worth of monitored data. The LoanSTAR buildings were divided into three categories (consistent with NEMS nomenclature and categorization): education, health care and large offices. The sample size from the LoanSTAR buildings was relatively small. Thus, it was possible that the total sample in a given category may not be large enough to provide a typical representation of buildings in that category.

Table 5 provides a summary of the LoanSTAR buildings. Fourteen buildings qualify for the Large Office category. The site and source EUIs for whole building electricity use (WB Electric), whole-building heating (WB Heating) and whole-building cooling (WB Cooling) are shown in Table 5a. The size of the buildings, the location, the type of retrofits performed (the key to the retrofit code can be found in Table 5d), and the retrofit energy percentage savings are given in the table for each building. The area-weighted values are also shown. We note from Table 5a that the average pre-retrofit whole building (WB) source Electric EUI was 230.06 MBtu/yr/sq.ft and that the retrofits reduced the EUI by 14.77%.

Table 2. Types of buildings being monitored by the Texas LoanSTAR program as of end 1993.

Building Type	Building Description	Building Areas By Type
1	Classrooms/Offices	2,392,903
2	Classrooms/ Offices/Labs	4,918,781
3	Classrooms/Offices/Theaters	332,000
4	Libraries	1,381,515
5	Medical Institutions	7,395,363
6	Offices	1,582,729
7	Offices/Computer Facilities	4,100,626
8	School Districts	2,065,767
9	Thermal Energy Plants	3,716,800

Table 3. List of buildings being monitored by the Texas LoanSTAR program as of end 1993.

Name of Building	Code	Site #	Area	No. of Bldgs	Bldg Type
Battle Hall	BAT	181	47,166	1	1
W. C. Hogg Hall	WCH	117	48,905	1	1
Garrison Hall	GAR	118	54,069	1	1
Bates Hall	BTH	182	56,190	1	1
Steindham Hall	STD	115	56,800	1	1
Gearing Hall	GEA	119	61,000	1	1
Reed McDonald Building	RMD	498	80,218	1	1
Taylor Hall	TAY	179	100,773	1	1
Davis Hall	DVS	169	101,580	1	1
Heldenfels Hall	HLD	499	104,950	1	1
University Hall	UNV	111	123,450	1	1
Painter Hall	PAI	116	128,409	1	1
Graduate School of Business	GSB	166	146,763	1	1
Business Building	BUS	112	149,900	1	1
University Teaching Center	UTC	101	152,690	1	1
Jester Hall	JST	178	157,2701	1	1
College of Business Administration	CBA	165	242,857	2	1
Education Building	EDB	100	251,161	1	1
Main Building	MNB	167	328,752	1	1
Waggener Hall	WAG	105	57,600	1	2
Teague Building	TGB	497	60,000	1	2
Langford Architecture Bldg. A	LAA	494	69,950	1	2
Nursing Building	NUR	108	94,815	1	2
Bio Sciences West	BSW	496	96,038	1	2
Langford Architecture Bldg. B	LAB	495	102,105	1	2
El Paso CC. Rio Grande	ECR	326	102,422	1	2

Table 3. Continued

Burdine Hall	BUR	107	103,441	1	2
Geology Building	GEO	177	127,000	1	2
TSTC Harlingen	TST	150	139,193	6	2
El Paso CC. Trans Mountain	ECT	327	154,000	2	2
Nursing Hall	NUH	170	155,004	1	2
Life Science Building	LSB	171	213,672	1	2
Engineering II	ENG	168	246,102	1	2
Texas Woman's University	TWU	315	253,175	3	2
Zachry Engineering Center	ZEC	1	324,000	1	2
College of Mainland	CMC	320-321	339,167	1	2
Texas A&M University Galveston	TAG	139	382,232	9	2
El Paso CC, Valle Verde	ECV	325	406,805	10	2
Welch Hall	WEL	106	439,540	1	2
University of Texas, Dallas	UTD	137	481,549	3	2
University of Houston - Clear Lake	UHC	322	570,971	4	2
Winship Hall	WIN	114	109,000	1	3
Fine Arts Building	FNA	113	223,000	1	3
Moody Memorial	MLB	403	67,380	1	4
Archive Building	ARC	208	120,000	1	4
Library	LIB	172	201,040	1	4
Perry Castaneda Library	PCL	102	483,895	1	4
Evans Library Complex	EVL	491-493	509,200	3	4
Ward Memorial Hospital	WMH	145	37,000	1	5
John Sealy North	JSN	400	54,494	1	5
MHMR Waco	MHW	251	124,033	28	5
Clinical Sciences	CSB	401	124,870	1	5
Basic Sciences	BSB	402	137,856	1	5
School of Public Health	SPH	300	233,738	1	5
Texas Dept. of Health	TDH	130	284,000	5	5
John Sealy South	JSS	404	373,085	1	5
Dental School	SAD	141	484,019	1	5
MHMR Wichita Falls	MHF	244-245	495,802	30	5
Texas College of Ostp. Medicine	COM	138	496,000	3	5
Medical School	SAM	142	606,097	1	5
MHMR Terrel	MHT	246-249	689,554	22	5
MHMR Austin	MHR	151	845,435	50	5
Medical School Building	MSB	124	887,187	1	5
U.T. M.D. Anderson Cancer Center	MDA	136	1,522,193	8	5
Anson Jones Building	AJB	227	49,413	1	6
Insurance Annex	INX	207	62,000	1	6
Tom C. Clark Building	TCB	229	79,912	1	6
Midland County Courthouse	MCC	144	90,100	1	6
Central Services Building	CSV	226	97,030	1	6
Insurance Building	INS	206	102,000	1	6
Price Daniels Building	PDB	228	151,620	1	6
Treasury Building	TRB	220	203,672	1	6
Brown Heatly Building	BHB	236	262,905	1	6
W.P. Clements Building	WPC	237	484,077	1	6
Police Station	POL	240		1	6
Municipal Court Building	MUN	241		1	6

Table 3. Continued

John Henry Faulk Building	JHF	242		1	6
James E. Rudder	JER	205	80,000	1	7
John H. Reagan	JHR	203	169,756	1	7
Sam Houston Building	SHB	201	182,961	1	7
Capitol Building	CPB	200	282,499	1	7
Lyndon B. Johnson	LBJ	210	308,080	1	7
Stephen F. Austin Building	SFA	202	470,000	1	7
Dallas County Gvmt. Center	DCG	146	473,800	1	7
Willaim B. Travis	WBT	209	491,000	1	7
J. H. Winter's Complex	JHW	211	503,000	3	7
William B. Hobby	WPH	221-224	546,749	3	7
Capitol Extention	CPX	212	592,781	1	7
Sims Elementary School	SIM	128	62,400	1	8
GISD/Rosengerg Elementary School	RES	164	63,044	1	8
GISD/Morgan Elementary School	MES	163	76,798	1	8
GISD/Oppe Elementary School	OES	160	80,400	1	8
GISD/Weis Middle School	WMS	161	80,769	1	8
GISD/Parker Elementary School	PES	162	81,742	1	8
Dunbar Middle School	DMS	129	92,884	1	8
Dobie Middle School	DHS	252	128.693	1	8
NISD/Chamberlain Middle School	CMS	153	132,443	1	8
NISD/Nacogdoches High School	NHS	152	202,615	1	8
Stroman High School	SHS	126	210,474	9	8
Victoria High School	VHS	127	257,014	3	8
Lanier High School	LHS	253	283,843	1	8
Crocket High School	CHS	254	312,648	1	8
Thermal Energy Plant	TEP	173-175	31,555	1	9
Del Mar College	DMC	143	636,702	18	9
South West Texas State University	SWT	149	637,223	11	9
University of Texas Panam	UTP	125	909,462	14	9
Texas Southern University	TSU	310-312	1,501,858	3	9
Waste Water Facility	WWT	243		1	9
			27,886,484		

Table 4. Conversion factors used to convert site energy use to source energy use.

Whole Building electricity, lighting
1 kWhr/ft^{2}yr = 11.6 MBtu/ft^{2}yr
Hot Water
1 MBtu/ft^{2}yr = 1/0.8 MBtu/ft^{2}yr (0.8 for efficiency of boiler)
Chilled Water
-Using vapor compression chillers (COP = 3.5) $1\ \text{MBtu/ft}^2\text{yr} = \frac{11.6\text{MBtu / kWhr}}{3.5\text{x}3.412\text{MBtu / kWhr}} = 0.972\ \text{MBtu/ft}^2\text{yr}$ -Using absorption chillers (COP = 1) 1 MBtu/ft^{2}yr = 1 MBtu/ft^{2}yr
Chiller Electric (vapor compression chiller)
1 kWhr/ft^{2}yr = 11.6 MBtu/ft^{2}yr
Mbtu = 10^3 Btu

Table 5b and 5c provide similar information for the Education and Health Care building types based on monitored data from four schools and eight hospitals, respectively.

Energy retrofits (all of them with payback periods of less than 4 years) reduced energy use by 14.8%, 26.7% and 29% for WB Electric, WB Heating and WB Cooling, respectively, for the large offices. These numbers were 28.2%, 18.9% and 6.4% for health care buildings. For education buildings, WB Electric and WB Heating savings due to energy retrofits were 9.4% and 29.3% respectively.

A summary of the comparison between the area-weighted average EUIs determined from the LoanSTAR database and those used by NEMS for Region 7 are shown in Table 6.

Table 5a. Location, size and energy use of Office Buildings in LoanSTAR database

NUMBER OF LOCATIONS: 14

SITE

			WB ELECTRIC (KW hr/yr/ft^2)			WB HEATING (MBtu/yr/ft^2)			WB COOLING (MBtu/yr/ft^2)			
NAME	LOCATION	AREA (ft^2)	PRE	POST	%Savings	PRE	POST	%Savings	PRE	POST	%Savings	RETROFIT
Burdine Hall	Austin	103441	10.51	8.23	21.68%	65.70	36.20	44.89%	87.60	58.40	33.33%	A,F
Business Building	Arlington	149900	17.96	16.13	10.16%	31.54	31.03	1.59%	*	89.46		A,C
Dallas County Government	Dallas	473800	21.90	22.65	-3.42%	50.81	50.37	0.86%	86.72	81.20	6.37%	E,G,H,J
Education Building	Austin	251161	16.21	7.73	52.28%	56.94	30.68	46.13%	98.11	61.07	37.71%	A,F,G
Fine Arts Building	Arlington	223000	17.52	15.73	10.20%	42.92	42.32	1.41%	*	107.96		A,C,E
Midland County Courthouse	Midland	90100	20.15	16.90	16.12%	*	*		*	*		C,H,J,P
Nursing Building	Austin	94815	16.64	12.67	23.86%	87.60	55.63	36.50%	83.22	62.28	25.16%	A,F
Painter Hall	Austin	128409	*	18.57		70.08	44.14	37.01%	*	136.97		A,E
Steinham Hall	Austin	56849	*	4.77		37.23	22.69	39.05%	*	69.35		A,S
University Hall	Arlington	123450	16.64	12.17	26.90%	*	35.19		68.33	46.53	31.90%	A,C,E
W.C. Hogg Hall	Austin	48905	8.76	8.57	2.21%	98.11	56.55	42.37%	115.63	75.77	34.47%	A,F,V
Waggener Hall	Austin	57598	21.90	18.70	14.61%	45.99	19.14	58.37%	358.37	74.72	79.15%	A
Winship Hall	Austin	109064	14.45	13.17	8.91%	131.40	85.74	34.75%	188.34	90.87	51.755	A,F
Zachry Engineering Center	College Station	324400	30.22	26.23	13.20%	*	*		162.06	106.51	34.28%	A,J,W
AREA WEIGHTED		2234892	19.83	16.90	14.77%	59.32	43.51	26.66%	120.08	85.32	28.95%	

SOURCE

			WB ELECTRIC (MBtu/yr/ft^2)			WB HEATING (MBtu/yr/ft^2)			WB COOLING (MBtu/yr/ft^2)			TOTAL WB ENERGY (MBtu/yr/ft^2)	
NAME	LOCATION	AREA (ft^2)	PRE	POST	%Savings	PRE	POST	%Savings	PRE	POST	%Savings	PRE	POST
Burdine Hall	Austin	103441	121.94	95.51	21.68%	82.13	45.26	44.89%	85.09	56.73	33.33%	289.16	197.49
Business Building	Arlington	149900	208.31	187.15	10.16%	39.42	38.79	1.59%	*	86.90		208.31	312.84
Dallas County Government	Dallas	473800	254.04	262.74	-3.42%	63.51	62.97	0.86%	84.24	78.87	6.37%	401.79	404.58
Education Building	Austin	251161	187.99	89.70	52.28%	71.18	38.34	46.13%	95.30	59.32	37.71%	354.47	187.37
Fine Arts Building	Arlington	223000	203.23	182.51	10.20%	53.66	52.90	1.41%	*	104.87		256.89	340.27
Midland County Courthouse	Midland	90100	233.72	196.04	16.12%	*	*		*	*		233.72	196.04
Nursing Building	Austin	94815	193.02	146.97	23.86%	109.50	69.53	36.50%	80.84	60.50	25.16%	383.36	277.01
Painter Hall	Austin	128409	*	215.41		87.60	55.18	37.01%	*	133.05		87.60	403.64
Steindham Hall	Austin	56849	*	55.33		46.54	28.36	39.05%	*	67.36		46.54	151.06
University Hall	Arlington	123450	193.07	141.13	26.90%	*	43.99		66.37	45.20	31.90%	259.44	230.32
W.C. Hogg Hall	Austin	48905	101.62	99.37	2.21%	122.64	70.68	42.37%	112.32	73.60	34.47%	336.58	243.66
Waggner Hall	Austin	57598	254.04	216.92	14.61%	57.49	23.93	58.37%	348.11	72.58	79.15%	659.64	313.43
Winship Hall	Austin	109064	167.67	152.73	8.91%	164.25	107.17	34.75%	182.95	88.27	51.75%	514.86	348.17
Zachry Engineering Center	College Station	324400	350.58	304.31	13.20%	*	*		157.42	103.46	34.28%	350.58	304.31
AREA WEIGHTED		2234892	230.06	196.07	14.77%	57.62	42.26	26.66%	116.64	82.87	28.95%	404.33	321.21

Table 5b. Location, size and energy use of educational buildings in the LoanSTAR database.

NUMBER OF LOCATIONS: 4

SITE

			WB ELECTRIC (KW hr/yr/ft^2)			WB HEATING (MBtu/yr/ft^2)			WB COOLING (MBtu/yr/ft^2)	
NAME	LOCATION	AREA(ft^2)	PRE	POST	%Savings	PRE	POST	%Savings	PRE	RETROFIT
Dunbar Middle School	Fort Worth	92886	18.40	16.57	7.05%	28.47	21.59	24.18%	*	G
Sims Elementary School	Fort Worth	62400	15.77	11.40	27.70%	14.89	13.37	10.25%	*	G
Stroman High School	Victoria	210500	7.45	7.20	1.51%	16.64	13.14	21.03%	10.80	J,T
Victoria High School	Victoria	257000	8.76	8.30	3.73%	*	11.32		14.02	J,T
AREA WEIGHTED		622786	10.46	9.47	9.41%	19.35	13.67	29.33%	12.57	

SOURCE

			WB ELECTRIC (MBtu/yr/ft^2)			WB HEATING (MBtu/yr/ft^2)			WB COOLING (MBtu/yr/ft^2)	TOTAL WB ENERGY (MBtu/yr/ft^2)	
NAME	LOCATION	AREA(ft^2)	PRE	POST	%Savings	PRE	POST	%Savings	PRE	PRE	POST
Dunbar Middle School	Fort Worth	92886	213.39	192.17	7.05%	35.59	26.98	24.18%	*	248.98	219.16
Sims Elementary School	Fort Worth	62400	182.91	132.24	27.70%	18.62	16.71	10.25%	*	201.52	148.95
Stroman High School	Victoria	210500	86.37	83.52	1.51%	20.81	16.43	21.03%	10.49	117.67	99.95
Victoria High School	Victoria	257000	101.62	96.28	3.73%	*	14.15		13.61	115.23	110.43
AREA WEIGHTED		622786	121.28	109.87	9.41%	24.19	17.09	29.33%	12.21	144.65	126.96

* Unreliable/missing data

Table 5c. Location, size and energy use of Health Care facilities in the LoanSTAR database.

NUMBER OF LOCATIONS: 8

SITE

NAME	LOCATION	AREA (ft^2)	WB ELECTRIC (KWhr/yr/ft^2) PRE	WB ELECTRIC (KWhr/yr/ft^2) POST	%Savings	WB HEATING (MBtu/yr/ft^2) PRE	WB HEATING (MBtu/yr/ft^2) POST	%Savings	WB COOLING (MBtu/yr/ft^2) PRE	WB COOLING (MBtu/yr/ft^2) POST	%Savings	RETROFIT
Basic Sciences Building	Galveston	137856	30.66	28.30	7.70%	*	195.29		306.60	285.10	7.01	C,D,E,J
Clinical Sciences Building	Galveston	124871	35.60	36.20	-1.69%	*	119.19		206.86	188.81	8.73	C,E,M
John Sealy North	Galveston	54494	66.49	61.35	7.73%	324.12	240.82	25.70%	558.45	423.17	24.22	C,E,J
John Sealy South	Galveston	373085	24.09	23.55	2.24%	*	81.69		275.94	243.29	11.83	C,E,J
School of Public Health	Houston	233738	20.59	19.20	6.73%	220.23	81.86	62.83%	210.24	146.18	30.47	A,J
Texas Department of Health	Austin	284000	24.97	22.65	9.28%	62.20	61.84	0.57%	148.92	91.36	38.65	J
UTHSC Medical School	Houston	887187	36.80	33.90	7.88%	124.09	117.37	5.42%	327.68	351.12	-7.15	C,F
UTHSC Medical School	San Antonio	606097	*	9.64		*	*		87.60	78.92	9.91	A,D,F
AREA WEIGHTED		2701328	31.42	22.56	28.18%	122.81	99.59	18.90%	235.71	220.69	6.37	

SOURCE

NAME	LOCATION	AREA (ft^2)	WB ELECTRIC (MBtu/yr/ft^2) PRE	WB ELECTRIC (MBtu/yr/ft^2) POST	%Savings	WB HEATING (MBtu/yr/ft^2) PRE	WB HEATING (MBtu/yr/ft^2) POST	%Savings	WB COOLING (MBtu/yr/ft^2) PRE	WB COOLING (MBtu/yr/ft^2) POST	%Savings	TOTAL WB ENERGY (MBtu/yr/ft^2) PRE	TOTAL WB ENERGY (MBtu/yr/ft^2) POST
Basic Sciences Building	Galveston	137856	355.66	328.28	7.70%	*	244.11		297.82	276.94	7.01%	653.48	849.33
Clinical Sciences Building	Galveston	124871	401.36	409.32	-1.98%	*	148.74		200.94	183.40	108.77%	602.30	741.46
John Sealy North	Galveston	54494	771.27	711.66	7.73%	405.15	301.02	25.70	542.46	411.05	24.22%	1,718.87	1,423.73
John Sealy South	Galveston	373085	279.44	273.18	2.24%	*	102.11		268.04	236.32	11.83%	547.48	611.61
School of Public Health	Houston	233738	238.80	222.72	6.73%	275.28	102.33	62.83	204.22	141.99	30.47%	718.30	467.04
Texas Department of Health	Austin	284000	289.61	262.74	9.28%	77.75	77.30	0.57	144.66	88.74	38.65%	512.01	428.79
UTHSC Medical School	Houston	887187	426.88	393.24	7.88%	155.11	146.71	5.42	318.29	341.07	-7.15%	900.28	881.01
UTHSC Medical School	San Antonio	606097	*	111.78		*	*		85.09	76.66	9.91%	85.09	188.44
AREA WEIGHTED		2701328	363.79	261.29	28.18%	153.51	124.48	18.91	228.95	214.37	6.37%	548.40	562.93

*Unreliable/missing data.

Table 5d. Key to retrofit measures listed in Tables 5a through 5c.

	RETROFIT
A	Variable Air Volume HVAC System installed
B	Reduced Lighting Levels
C	Lighting Modifications
D	Solar Screens
E	Chilled Water Pumps Speed Controls
F	Variable Speed Pumps installed
G	Replace Lighting
H	Motion Sensors
I	Capacitors for PF Improvement
J	Energy Management System Upgrade
K	Domestic HW pump shut down
L	Night set back for AHU
M	Hot Water Pump Speed Control
N	Thermal Energy Storage/Industrial Water Source Heat Pump
O	Reduce HW Pump Speed
P	Electronic Balasts
Q	Two Speed Fans on Cooling Towers, Economizer Cycles
R	Reduce HW Pump Speed
S	Hot/Cold Deck Reset, Resheave AHU's
T	Replace Absorption Chiller
U	Programmable Timers
V	Replace Economizer

Table 6. Comparison of NEMS-CSDM and Texas LoanSTAR EUIs.

		NEMS	Texas LoanSTAR Program		
		Federal Region 7		Pre-retrofit	Post-Retrofit
	Building Type	MBtu/ft^2/yr	No. of Buildings	MBtu/ft^2/yr	MBtu/ft^2/yr
SPACE HEATING	Education	28.79	4	24.19	17.09
	Health Care	18.56	8	153.51	124.48
	Large Offices	5.33	14	57.62	42.26
SPACE COOLING	Education	5.16	4	12.21	*
	Health Care	17.38	8	228.95	214.37
	Large Offices	8.96	14	116.64	82.87
TOTAL (Gas & Electric)	Education	65.44	4	144.65	126.96
	Health Care	125.49	8	548.40	562.93
	Large Offices	101.86	14	404.33	321.21

Note: 1) The Texas LoanSTAR Program EUIs are based on not less than one year of monitored data.

2) 1 Mbtu = 10^3 Btu

3) * Unreliable/missing data

In Table 6, the LoanSTAR data showed much higher values of total, heating and cooling energy use than the NEMS data for the health care and large office buildings. The differences were over an **order of magnitude** in space cooling for both types of building. While differences of a factor of one or two may be expected in view of the small sample sizes, the order of magnitude difference was a cause for concern. The health care buildings in the sample tended to be large medical facilities, which may account for some of the difference. However, the large office buildings in the sample (consisting of state facilities in Austin as well as large offices at some of the universities) are typical of large common buildings, and no satisfactory explanation could be given. The data may indicate that the cooling and heating energy use allocation scheme used by NEMS could be severely under-representing the amount of heating and cooling use in these two building types. In conclusion, significant differences were found between the EUIs computed from the Texas LoanSTAR database and those currently used by NEMS.

CHAPTER 4

IMPORTANCE OF INTERACTION EFFECTS

4.1 Engineering model selected

In the framework of the energy end-use interaction study, the first step was to identify an appropriate engineering model/software capable of evaluating the effect on cooling and heating energy when lighting or equipment intensities are reduced. The public domain building energy analysis software ASEAM (A Simplified Energy Analysis Method) was used in this study to evaluate the importance of interaction effects. ASEAM uses the modified bin method for computing energy consumption of residential and simple commercial buildings based on the general simplified energy analysis methodology described in ASHRAE. Though ASEAM was not as detailed as some other programs such as DOE-2 or BLAST, it was used here because of its ease-of-use and its ability to model the interactions. Because ASEAM is a bin method, it could not adequately capture dynamic building effects such as thermal storage. However, ASEAM provided the needed flexibility and accuracy while it maintained an acceptable level of simplicity.

4.2 Types of buildings and locations selected

Seven different buildings, as described in Table 7, were simulated in three locations: Minneapolis, MN, Washington D.C., and Dallas, TX. These cities were representative of northern, moderate and southern climates, respectively. These building types were selected to be consistent with the NEMS categories. Some important inputs such as building size, number of zones and their sizes and lighting densities, as well as the type of HVAC system are also given in Table 7. To provide the reader with an idea as to the type of inputs required to run ASEAM (Version 3.0), a sample building description file (that of the large office building) is given in Appendix A. The evaluation involves running the simulation, for each building type at each location, with the base case lighting densities shown in Table 7 as well as reducing the lighting densities by 15%, 30% and 45% from the base case values and performing three additional simulation runs. Hence, eighty four simulations were performed.

4.3 Simulation results

The effect of reducing lighting levels on the annual heating and cooling energy use of the large office building is shown in Figure 1 for all three locations. As expected, reducing lighting

levels, increased heating energy use and decreased cooling energy use. This change in cooling and heating energy use was location dependent. It was more pronounced for Dallas (a hot location) and less for Minneapolis. For example, reducing lighting levels in Dallas by 30% from the base case, increased heating by about 4% and reduced cooling by about 5%. The same change in Minneapolis, affected heating and cooling by 1.4% and 3.8%, respectively. Figures 2-7 present similar plots for the other building types. The interaction effects are much more pronounced for other building types. Currently NEMS has no representation for such interaction effects. Thus, forecasts of some EPA and DOE programs which affect lighting levels may not accurately reflect the total energy saved by the programs.

Table 7. Various building types simulated by ASEAM along with some pertinent input data

Bldg Type	Total floor area (sq.ft)	Zones	Floor area (sq.ft)	HVAC type	Base case lighting (W/sq.ft)
Large Office	408,000	1.First floor lobby	13,000	VAV+electric heat	2.0
		2.Interior core	215,600	"	"
		3.Outer zone-west	33,000	"	"
		4.First floor-west perimeter	2,000	"	"
		5.Perimeter-east	33,000	"	"
		6.First floor-east perimeter	2,000	"	"
		7.Perimeter-south	46,200	"	"
		8.Perimeter-north	46,200	"	"
		9.Top floor	221,000	"	"
Small Office	4,880	1.Lobby	480	Packaged single zone (DX+electric heat)	2.0
		2.Lower east	740	"	"
		3.Lower west	1,220	"	"
		4.Upper west	1,220	Packaged single zone (DX+electric heat)	"
		5.Upper west	1,220	"	"
School	67,784	1-4.Classrooms	7,812	Heating and ventilating unit	2.0
		6. Playroom	4,745	"	"
		7.Cafeteria	6,778	"	"
		8.Auditorium	8,134	"	"
		5.Office/Library	16,946	Single zone reheat	"
Large Hotel	277,200	1.Lobby	24,500	VAV reheat	1.0
		2.Conference room	22,200	"	2.0
		5.Mechanical Rooms	17,100	"	1.0
		3.Laundry zone	2,700	VAV reheat	2.0
		4.Kitchen	5,500	"	"
		6.North Guest Perimeter	22,800	VAV reheat	2.29
		7.South " "	22,800	"	"
		8.West " "	53,200	"	"
		9.East " "	53,200	"	"
		10.Tower Lobby zone	53,200	"	1.0
Motel	35,000	1.Lobby	4,000	Packaged Roof unit (DX+electric heat)	2.1
		2.Rooms	31,000	Window A/C+unit heater	1.5
Large Retail	120,000	1.First floor sales	42,000	Single zone reheat (DX+electric heat)	2.79
		2.Second floor sales	60,000	"	"
		3.First floor storage	18,000	"	1.0
Small Retail	13,124	1.Sales zone	11,156	Packaged single zone (DX+electric heat)	2.2
		2.Storage	1,969	Unit electric heater	1.5

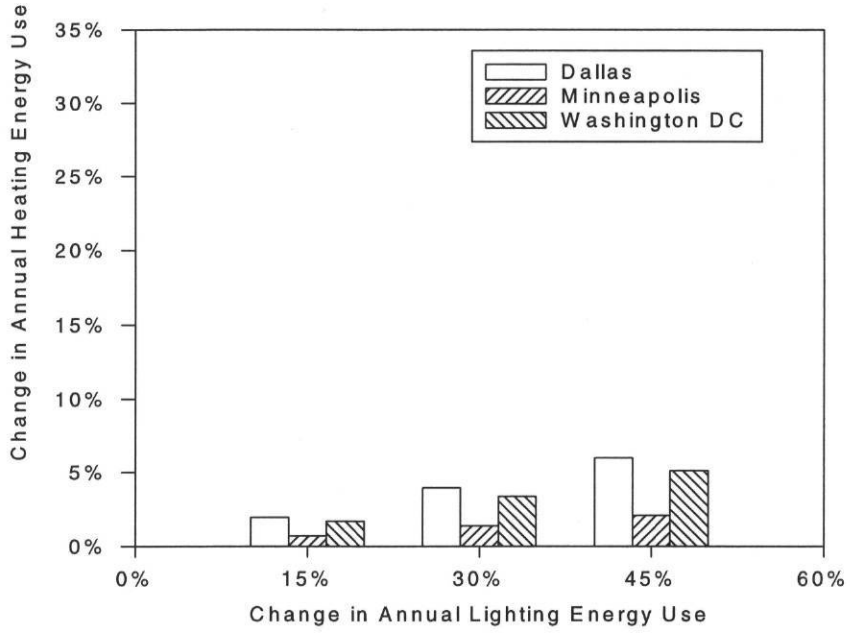

FIGURE 1a. - Impact of lighting energy reduction on heating energy use in the large office building

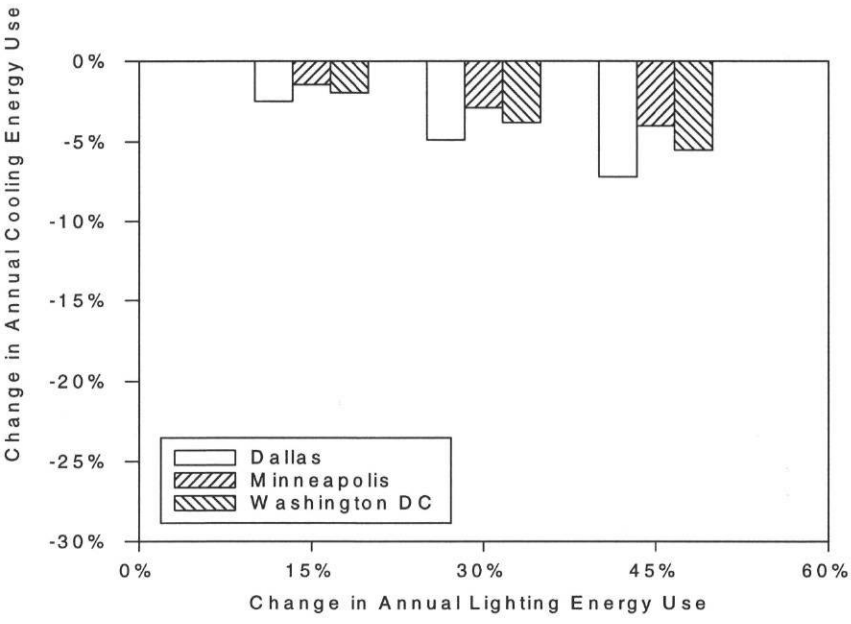

FIGURE 1b -Impact of lighting energy reduction on cooling energy use in the large office building

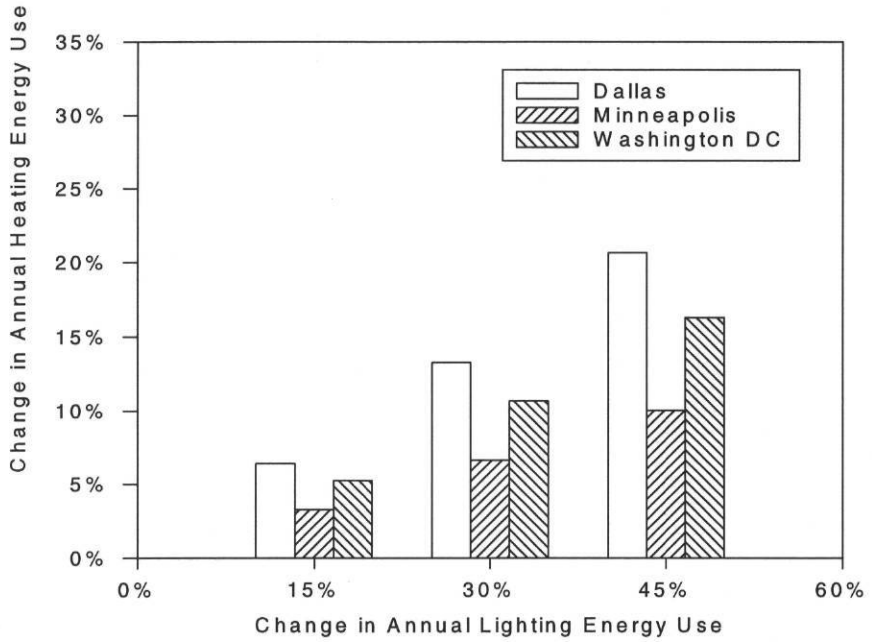

FIGURE 2a - Impact of lighting energy reduction on heating energy use in the small office building

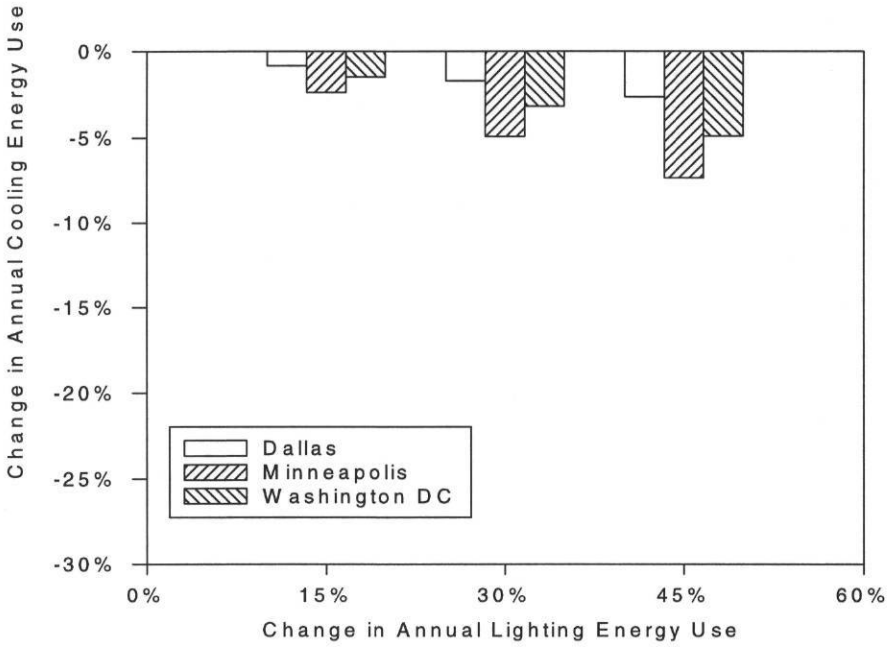

FIGURE 2b - Impact of lighting energy reduction on cooling energy use in the small office building

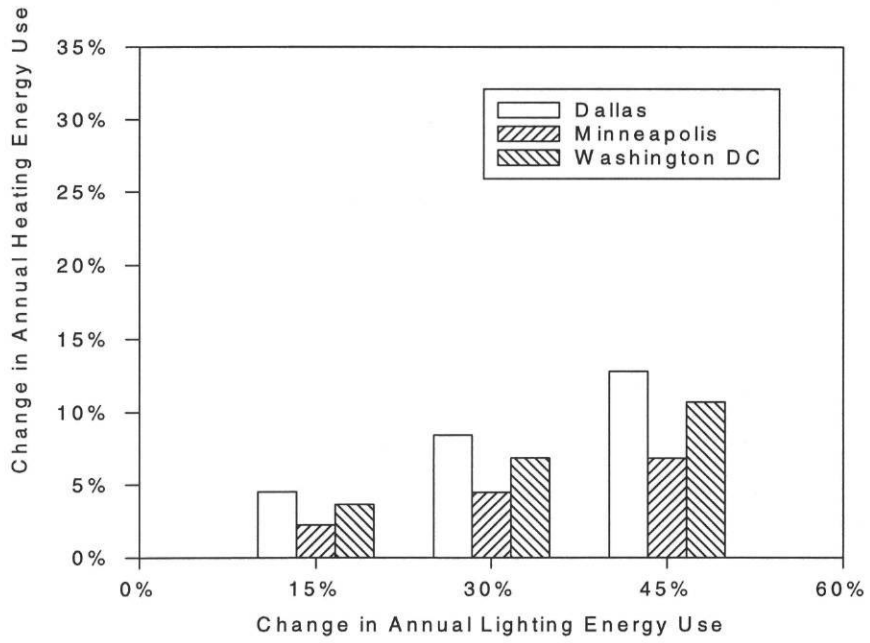

FIGURE 3a - Impact of lighting energy reduction on heating energy use in the school

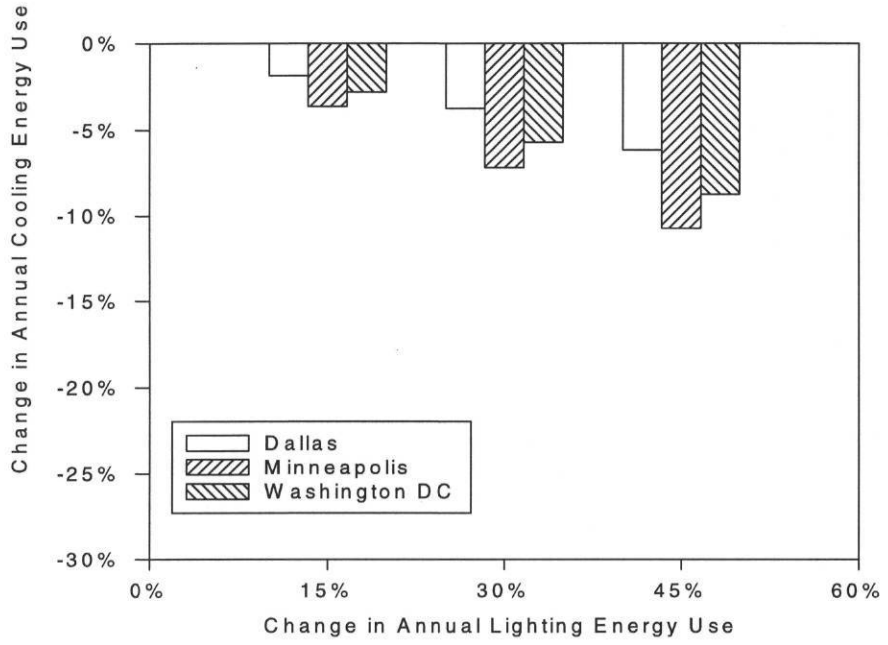

FIGURE 3b - Impact of lighting energy reduction on cooling energy use in the school

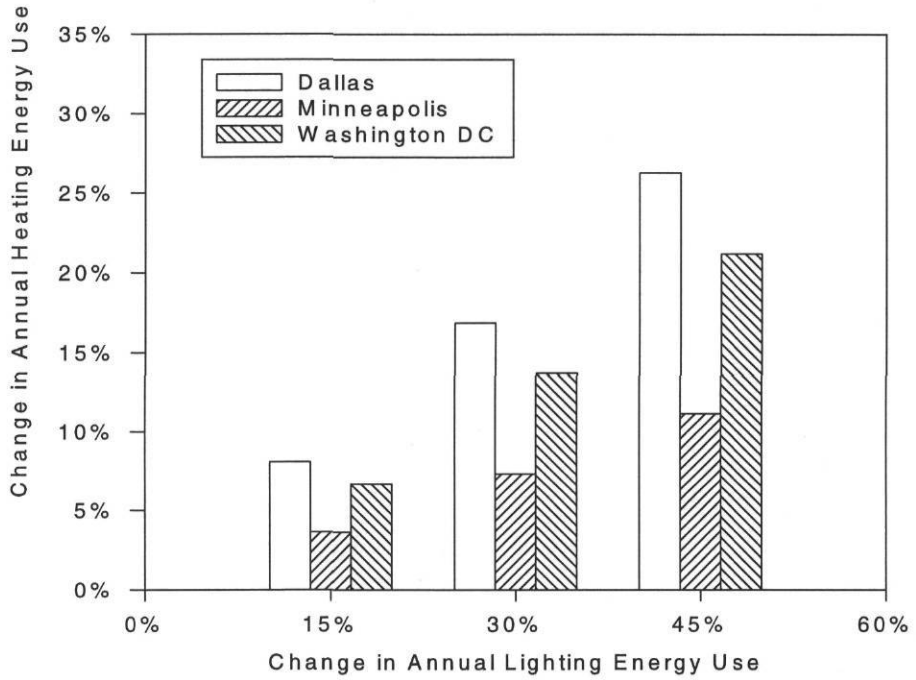

FIGURE 4a - Impact of lighting energy reduction on heating energy use in the large hotel

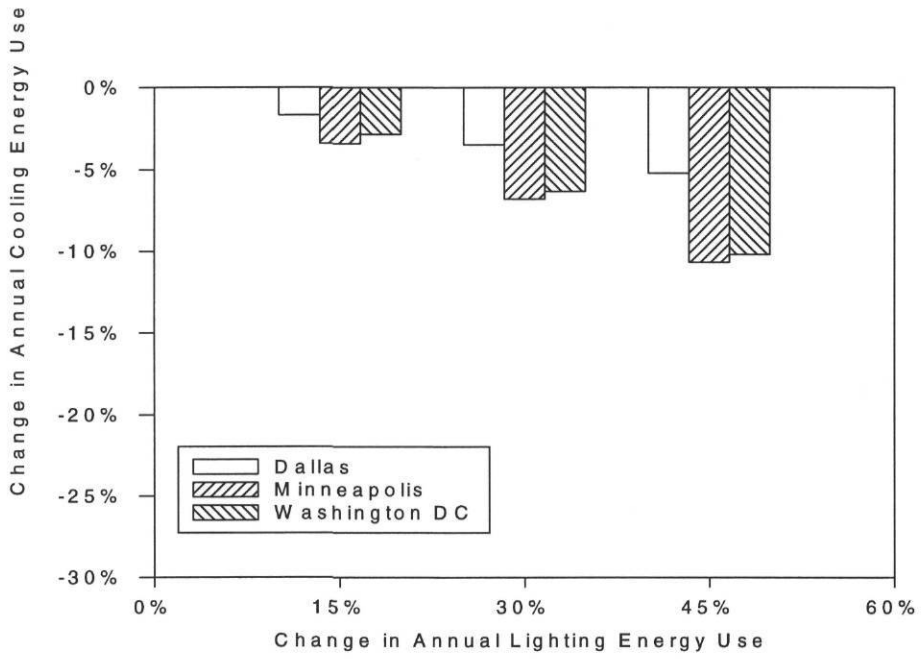

FIGURE 4b - Impact of lighting energy reduction on cooling energy use in the large hotel

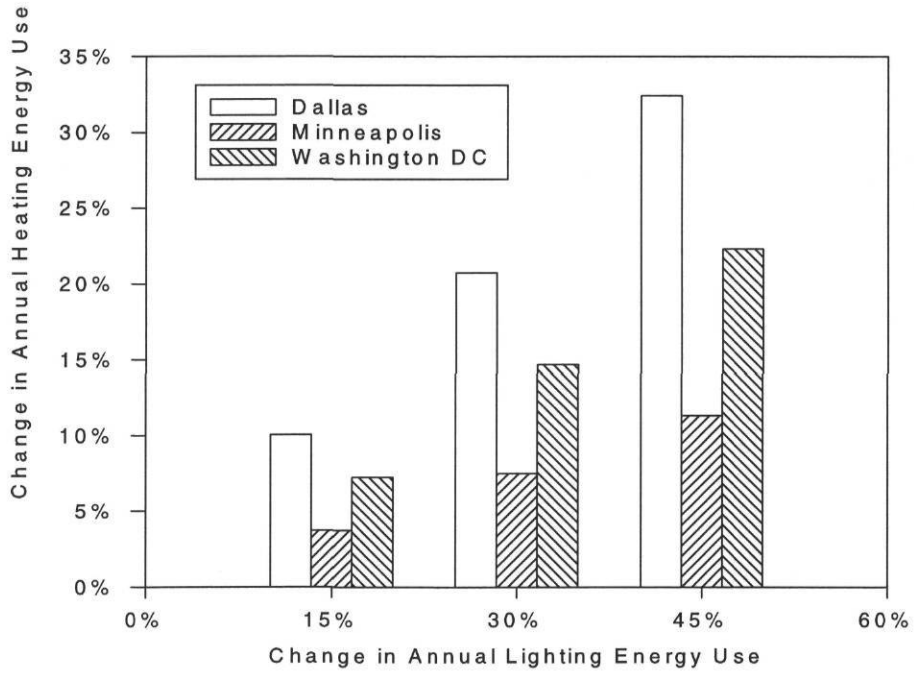

FIGURE 5a - Impact of lighting energy reduction on heating energy use in the motel

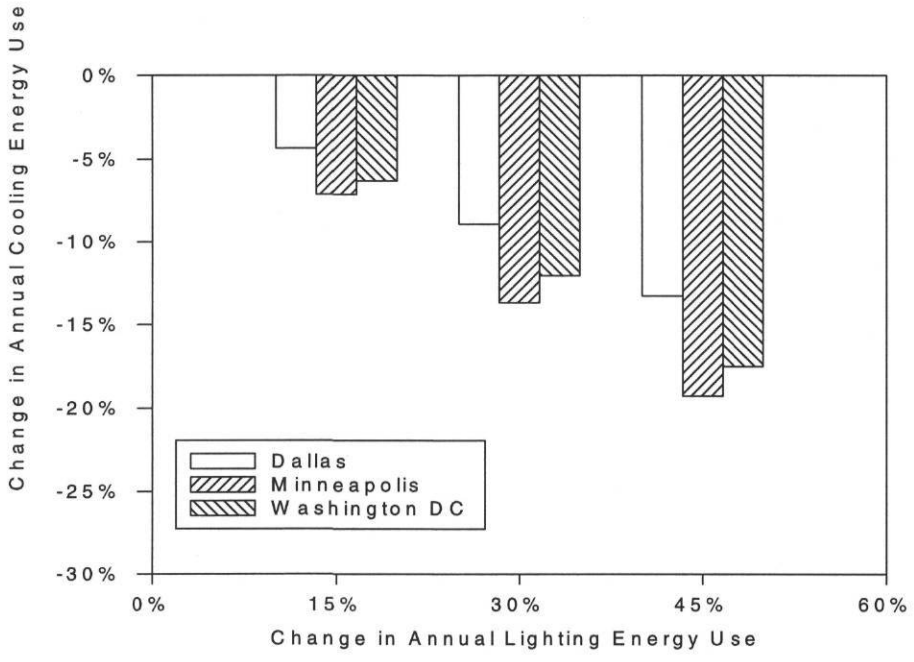

FIGURE 5b - Impact of lighting energy reduction on cooling energy use in the motel

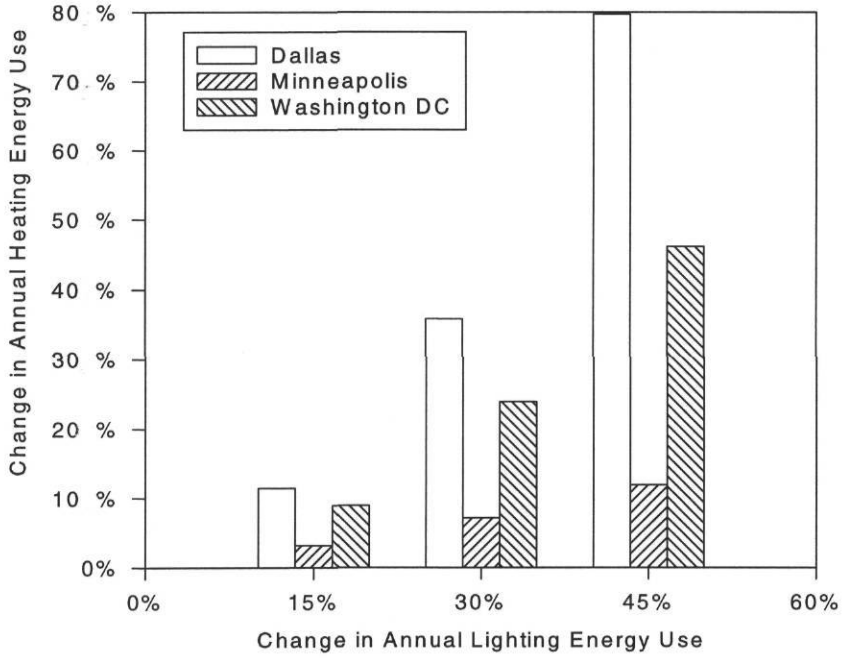

FIGURE 6a - Impact of lighting energy reduction on heating energy use in the large retail building

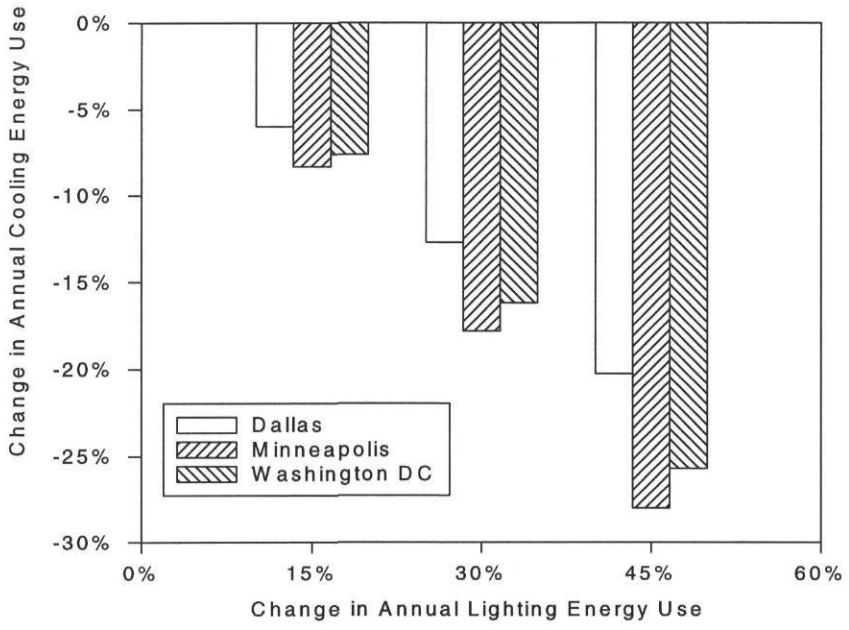

FIGURE 6b - Impact of lighting energy reduction on cooling energy use in the large retail building

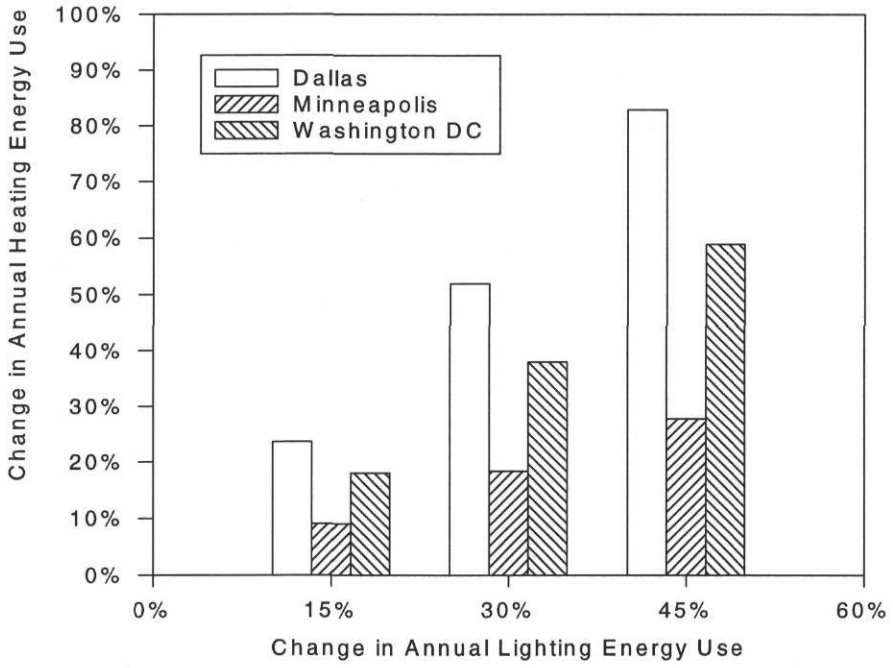

FIGURE 7a - Impact of lighting energy reduction on heating energy use in the small retail building

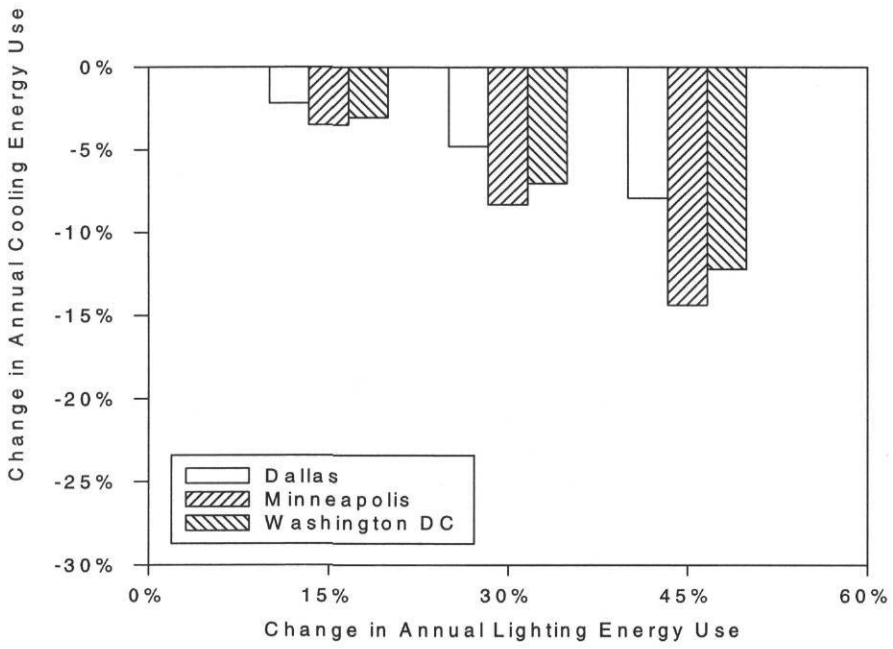

FIGURE 7b - Impact of lighting energy reduction on cooling energy use in the small retail building

The interaction effects varied widely from one building type to another. Alternate ways of presenting the data were evaluated in an effort to summarize the simulation results. A new term, the percentage change in energy use (for heating or cooling), was defined as the total change in annual energy use of the building divided by the total change in lighting energy use. This value was found to be almost independent of the fractional change in lighting levels and is only dependent on building type and location. Table 8 presents these fractional reduction values by location and building type. Thus, for a large office building in Dallas, cooling energy use will decrease by 7.2% when total lighting energy is reduced by 100%, while heating energy use will increase by 5.6%. We note that though changes are small in certain cases, the interaction effects are generally important and should not be overlooked.

Another study (Bou-Saada et al., 1996) analyzed changes in monitoted heating and cooling energy in the US Department of Energy (DOE) Forrestal Building at Washington D.C. as a result of a 37,000 fixture lighting retrofit in September 1993. They found after weather normalizing that a 52% decrease in lighting electricity use (i.e., a reduction of 5,520 million kWh/year) led to an increase of 27% in annual thermal hot water steam energy use and a decrease in 18% in annual chilled water energy use. In terms of the percentage change in source energy use defined earlier, the values are -39% and 12% for heating and cooling energy use respectively. These figures are higher than those obtained by our simulation study for the Large Office Building type at Washington D.C. (see Table 8.) There is a seven-fold difference in heating energy while the cooling energy use are off by about 50% only. This comparison further emphasizes the need to account for the interaction effects of different energy types if the simulation output of the CSD module of EIA-NEMS is to be realistic.

Table 8. Changes in heating and cooling energy use with change in lighting levels. Percentage change has been defined as the change in total annual heating or cooling energy use from the base case divided by the total change in lighting electricity use from the base case.

	Cooling change/Lighting change (%)			Heating change/Lighting change (%)		
Bldg Type	Dallas	Minneapolis	Washington	Dallas	Minneapolis	Washington
Large Office	-7.20	-1.80	-3.80	5.60	5.80	7.70
Small Office	-4.90	-8.60	-7.30	20.10	50.50	34.40
School	-0.58	-0.42	-0.58	28.10	57.20	44.10
Large Hotel	-7.32	-7.62	-9.30	14.80	30.40	22.80
Motel	-38.30	-20.50	-28.50	28.40	55.70	46.40
Large Retail	-11.60	-7.55	-10.40	3.01	30.20	9.98
Small Retail	-8.50	-7.32	-9.25	18.50	46.80	34.10

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The LoanSTAR end-use monitored data showed much higher values of total, heating and cooling use than the NEMS data for the health care and large office buildings. The differences were over an **order of magnitude** in space cooling for both types of building. While differences of a factor of one or two may be expected in view of the small sample sizes, the order of magnitude difference was a cause for concern. The health care buildings in the sample tended to be large medical facilities, which may have accounted for some of the difference. However, the large office buildings in the sample (consisting of state facilities in Austin as well as large offices at some of the universities) were similar to large buildings in large cities. No satisfactory explanation could be given for the big differences between the sample and the NEMS values. It is possible the cooling and heating energy use allocation scheme used by NEMS was severely under-representing the amount of heating and cooling use in these two building types. In conclusion, significant differences between the EUIs computed from the Texas LoanSTAR database and those currently used by NEMS were found.

This study also indicated energy interaction effects should not be neglected. Future modeling refinements to NEMS should include interaction effects. One possible way of doing so would be to follow the approach used in this study. Computer simulations could be performed for each of the geographic census divisions of the United States and for each of the 11 different building types and generate a correction-matrix such as Table 8 which can subsequently be used to correct the basic NEMS-EUI matrix whenever required. Note that in this study, we have looked at how lighting changes affect heating and cooling energy consumption. Other energy interaction effects involve effect of lighting or equipment intensities changes on parasitic energy use (fan and blower electricity use), a critical issue identified in FY95 by EIA modelers (see section 1.0). If the simulations are properly and realistically performed, one could obtain census location and building type dependent correction factors for different types of energy use interactions that are meaningful.

Additional issues were also investigated. The extent to which energy retrofits (all of them with payback periods of less than 4 years) have reduced energy use in the Texas LoanSTAR buildings has also been determined. The average reductions are 14.8%, 26.7% and 29% for WB Electric, WB Heating and WB Cooling respectively for the Large Office building category. These numbers are 28.2%, 18.9% and 6.4% for Health Care buildings. For Education buildings, WB

Electric and WB Heating savings due to energy retrofits are 9.4% and 29.3% respectively. How these values compare with the corresponding NEMS numbers should be investigated.

The types of building operation and HVAC system control which would decrease energy use (Task 3 of section 1) fall under the general category of O&M and HVAC system tune ups. Extensive ongoing work in the LoanSTAR program could provide concrete recommendations and suggestions on the most commonly used ones and their energy saving potential which could be included in future refinements of the EIA-CSD module.

REFERENCES

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Appendix - Sample ASEAM 3.0 loads and system input files for the Large Office Building

DATA ECHO FOR LOADS INPUT FILE: LGOFFEX.LID

BUILDING/PROJECT DATA

Building File Name : lgoffnew
Building Name : large office building
Project Number :

Building Address : Spokane, Washington

Building Type : High Rise Office

Building gross floor area : 408000 ft2
Building net conditioned area : 408000 ft2
Number of zones : 9

Building Location
North latitude : 47.4 deg
West longitude : 117.3 deg
Time Zone Number : 8
Daylight Savings Time : Yes

Typical Weekday Operating Schedule
Occupancy start hour : 07
Operating hours/day : 10

Summer Thermostat Schedule
Beginning month : April
Ending month : October

Typical Occupied Schedule
Weekdays ..... from : 700 to 500
Saturdays ..... from : 800 to 1200
Sundays ..... from : 0 to 0

ZONE DATA FOR ZONE 1 - First Floor Lobby

Zone label : First Floor Lobby
Zone function :
Zone area : 13000 ft2
Zone volume : 23400 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 1 - First Floor Lobby

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	: lobby	NA	NA	NA
Function area (ft2)	: 13000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 1 - First Floor Lobby

Number of people in zone : 58
Sensible load per person : 230 BTUH per person

Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

WALL DATA FOR ZONE 1 - First Floor Lobby

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: NORTH	SOUTH	NA	NA
Wall orientation	: North	South		
Area (ft2)	: 1470	1470		
U-Factor (BTUH/ft2-deg F)	: 0.150	0.150		
Wall construction group	: D	D		
Color correction	: Medium	Medium		

WINDOW DATA FOR ZONE 1 - First Floor Lobby

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	NA	NA
Window orientation	: North	South		
Fenestration area (ft2)	: 351	351		
Shading coefficient	: .55	.55		
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56		
Space mass code	: Heavy	Heavy		
Crack length (lin ft)	: 0	0		
Leakage coefficient	: 00	0		

Inputs Required for Shading

Window shading model number	: 0	0
Percent window area	:	

DOOR (EXTERNAL) DATA FOR ZONE 1 - First Floor Lobby

	Type 1	Type 2
Name	: SOUTH	NORTH
Area (ft2)	: 168	168
U-Factor (BTUH/ft2-deg F)	: 0.81	0.81
Crack length (lin ft)	: 0	0
Leakage coefficient	: 0	0

INFILTRATION DATA FOR ZONE 1 - First Floor Lobby

Occupied air change rate : 0.5 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
lobby	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Miscellaneous Sensible Loads				
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			

ZONE DATA FOR ZONE 2 - INTERIOR CORE

Zone label : INTERIOR CORE
Zone function : INTERIOR
Zone area : 215600 ft2
Zone volume : 2802800 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 2 - INTERIOR CORE

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	: lobby	NA	NA	NA
Function area (ft2)	: 215600			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 2 - INTERIOR CORE

Number of people in zone : 968
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100

Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 2 - INTERIOR CORE

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

INFILTRATION DATA FOR ZONE 2 - INTERIOR CORE

Occupied air change rate : 0.01 air changes per hour
Unoccupied air change rate : 0.01 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
lobby	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			
Miscellaneous Sensible Loads				
NA	- Avg % of installed capacity :			

NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 3 - OUTER ZONE - WEST

Zone label : OUTER ZONE - WEST
Zone function : PERIMETER
Zone area : 33000 ft2
Zone volume : 429000 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 3 - OUTER ZONE - WEST

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	33000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 3 - OUTER ZONE - WEST

Number of people in zone : 154
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 3 - OUTER ZONE - WEST

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 3 - OUTER ZONE - WEST

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: NORTH	SOUTH	WEST	NA
Wall orientation	: North	South	West	
Area (ft2)	: 3003	3003	20020	
U-Factor (BTUH/ft2-deg F)	: 0.150	0.15	0.15	
Wall construction group	: D	D	D	
Color correction	: Medium	Medium	Medium	

WINDOW DATA FOR ZONE 3 - OUTER ZONE - WEST

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	WEST	NA
Window orientation	: North	South	West	
Fenestration area (ft2)	: 1287	1287	8580	
Shading coefficient	: .55	.55	.55	
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56	0.56	
Space mass code	: Heavy	Heavy	Heavy	
Crack length (lin ft)	: 0	0	0	
Leakage coefficient	: 00	0	0	

Inputs Required for Shading

Window shading model number	: 0	0	0
Percent window area	:		

INFILTRATION DATA FOR ZONE 3 - OUTER ZONE - WEST

Occupied air change rate : 0.00 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			
Miscellaneous Sensible Loads				
NA	- Avg % of installed capacity :			

NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

Zone label : FIRST FLOOR - WEST PERIMETER
Zone function : OFFICE
Zone area : 2000 ft2
Zone volume : 36000 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	2000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

Number of people in zone : 9
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: NORTH	SOUTH	WEST	NA
Wall orientation	: North	South	West	
Area (ft2)	: 360	360	1260.5	
U-Factor (BTUH/ft2-deg F)	: 0.150	0.150	0.150	
Wall construction group	: D	D	D	
Color correction	: Medium	Medium	Medium	

WINDOW DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	WEST	NA
Window orientation	: North	South	West	
Fenestration area (ft2)	: 108	108	539.50	
Shading coefficient	: .55	.55	.55	
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56	0.56	
Space mass code	: Heavy	Heavy	Heavy	
Crack length (lin ft)	: 0	0	0	
Leakage coefficient	: 00	0	0	

Inputs Required for Shading

Window shading model number	: 0	0	0
Percent window area	:		

INFILTRATION DATA FOR ZONE 4 - FIRST FLOOR - WEST PERIMETER

Occupied air change rate : 0.5 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			

Miscellaneous Sensible Loads

NA - Avg % of installed capacity :
NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 5 - PERIMETER - EAST

Zone label : PERIMETER - EAST
Zone function : PERIMETER
Zone area : 33000 ft2
Zone volume : 429000 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 5 - PERIMETER - EAST

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	33000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 5 - PERIMETER - EAST

Number of people in zone : 154
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 5 - PERIMETER - EAST

	Type 1	Type 2
Electric equipment name	EQUIPMENT	NA
Installed watts/ft2	2.0	
(times) Percent of zone area	100	
Hooded	No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 5 - PERIMETER - EAST

	Wall 1	Wall 2	Wall 3	Wall 4
Name	NORTH	SOUTH	EAST	NA
Wall orientation	North	South	East	
Area (ft2)	3003	3003	20020	
U-Factor (BTUH/ft2-deg F)	0.150	0.150	0.150	
Wall construction group	D	D	D	
Color correction	Medium	Medium	Medium	

WINDOW DATA FOR ZONE 5 - PERIMETER - EAST

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	EAST	NA
Window orientation	: North	South	East	
Fenestration area (ft2)	: 1287	1287	8580	
Shading coefficient	: .55	.55	.55	
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56	0.56	
Space mass code	: Heavy	Heavy	Heavy	
Crack length (lin ft)	: 0	0	0	
Leakage coefficient	: 00	0	0	

Inputs Required for Shading

Window shading model number	: 0	0	0
Percent window area	:		

INFILTRATION DATA FOR ZONE 5 - PERIMETER - EAST

Occupied air change rate : 0.00 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			

Miscellaneous Sensible Loads

NA - Avg % of installed capacity :
NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

Zone label : FIRST FLOOR - EAST PERIMETER
Zone function : OFFICE
Zone area : 2000 ft2
Zone volume : 36000 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	2000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

Number of people in zone : 9
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

	Type 1	Type 2
Electric equipment name	EQUIPMENT	NA
Installed watts/ft2	2.0	
(times) Percent of zone area	100	
Hooded	No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

	Wall 1	Wall 2	Wall 3	Wall 4
Name	NORTH	SOUTH	EAST	NA
Wall orientation	North	South	East	
Area (ft2)	360	360	1260.5	
U-Factor (BTUH/ft2-deg F)	0.150	0.150	0.150	
Wall construction group	D	D	D	
Color correction	Medium	Medium	Medium	

WINDOW DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	EAST	NA
Window orientation	: North	South	East	
Fenestration area (ft2)	: 108	108	539.50	
Shading coefficient	: .55	.55	.55	
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56	0.56	
Space mass code	: Heavy	Heavy	Heavy	
Crack length (lin ft)	: 0	0	0	
Leakage coefficient	: 00	0	0	

Inputs Required for Shading

Window shading model number	: 0	0	0
Percent window area	:		

INFILTRATION DATA FOR ZONE 6 - FIRST FLOOR - EAST PERIMETER

Occupied air change rate : 0.00 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			

Miscellaneous Sensible Loads

NA - Avg % of installed capacity :
NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 7 - PERIMETER - SOUTH

Zone label : PERIMETER - SOUTH
Zone function : PERIMETER
Zone area : 46200 ft2
Zone volume : 600600 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 7 - PERIMETER - SOUTH

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	46200			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 7 - PERIMETER - SOUTH

Number of people in zone : 198
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 7 - PERIMETER - SOUTH

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 7 - PERIMETER - SOUTH

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: SOUTH	NA	NA	NA
Wall orientation	: South			
Area (ft2)	: 28028			
U-Factor (BTUH/ft2-deg F)	: 0.150			
Wall construction group	: D			
Color correction	: Medium	Medium	Medium	

WINDOW DATA FOR ZONE 7 - PERIMETER - SOUTH

	Window 1	Window 2	Window 3	Window 4
Name	: SOUTH	NA	NA	NA

Window orientation : South
Fenestration area (ft2) : 12012
Shading coefficient : .55
U-Factor (BTUH/ft2-deg F) : 0.56
Space mass code : Heavy
Crack length (lin ft) : 0
Leakage coefficient : 00

Inputs Required for Shading

Window shading model number : 0
Percent window area :

INFILTRATION DATA FOR ZONE 7 - PERIMETER - SOUTH

Occupied air change rate : 0.00 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			

Miscellaneous Sensible Loads

NA - Avg % of installed capacity :
NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 8 - PERIMETER - NORTH

Zone label : PERIMETER - NORTH
Zone function : PERIMETER
Zone area : 46200 ft2
Zone volume : 600600 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 8 - PERIMETER - NORTH

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	PERIMETER	NA	NA	NA
Function area (ft2)	46200			
Installed watts/ft2	2.0			
(times) Percent function area	100			
Daylighting analysis	No			
Lighting system type	fluor			
Percent light heat to space	80			
`A' Classification	.65			
`B' Classification	C			
Diversity factors - occupied	66			
Diversity factors - unoccupied	10			
Monthly diversity table number	1			

PEOPLE DATA FOR ZONE 8 - PERIMETER - NORTH

Number of people in zone : 198
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 8 - PERIMETER - NORTH

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 8 - PERIMETER - NORTH

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: NORTH	NA	NA	NA
Wall orientation	: North			
Area (ft2)	: 28028			
U-Factor (BTUH/ft2-deg F)	: 0.150			
Wall construction group	: D			
Color correction	: Medium	Medium	Medium	

WINDOW DATA FOR ZONE 8 - PERIMETER - NORTH

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	NA	NA	NA

Window orientation : North
Fenestration area (ft2) : 12012
Shading coefficient : .55
U-Factor (BTUH/ft2-deg F) : 0.56
Space mass code : Heavy
Crack length (lin ft) : 0
Leakage coefficient : 00

Inputs Required for Shading

Window shading model number : 0
Percent window area :

INFILTRATION DATA FOR ZONE 8 - PERIMETER - NORTH

Occupied air change rate : 0.00 air changes per hour
Unoccupied air change rate : 0.5 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
PERIMETER	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			

Miscellaneous Sensible Loads

NA - Avg % of installed capacity :
NA - Avg % of installed capacity :

ZONE DATA FOR ZONE 9 - TOP FLOOR

Zone label : TOP FLOOR
Zone function :
Zone area : 17000 ft2
Zone volume : 221000 ft3

Thermostat Set Point Temperatures
Summer occupied temperature : 74 deg F
Winter occupied temperature : 72 deg F
Winter unoccupied temperature : 62 deg F

LIGHTING DATA FOR ZONE 9 - TOP FLOOR

	Ltg Func 1	Ltg Func 2	Ltg Func 3	Ltg Func 4
Function name	: TOP	NA	NA	NA
Function area (ft2)	: 17000			

Installed watts/ft2 : 2.0
(times) Percent function area : 100

Daylighting analysis : No

Lighting system type : fluor
Percent light heat to space : 80
`A' Classification : .65
`B' Classification : C

Diversity factors - occupied : 66
Diversity factors - unoccupied : 10
Monthly diversity table number : 1

PEOPLE DATA FOR ZONE 9 - TOP FLOOR

Number of people in zone : 76
Sensible load per person : 230 BTUH per person
Latent load per person : 190 BTUH per person

Diversity factor - occupied : 100
Diversity factor - unoccupied : 0
Monthly diversity table number : 1

ELECTRIC EQUIPMENT DATA FOR ZONE 9 - TOP FLOOR

	Type 1	Type 2
Electric equipment name	: EQUIPMENT	NA
Installed watts/ft2	: 2.0	
(times) Percent of zone area	: 100	
Hooded	: No	

Diversity factors - occupied : 18
Diversity factors - unoccupied : 5
Monthly diversity table number : 1

WALL DATA FOR ZONE 9 - TOP FLOOR

	Wall 1	Wall 2	Wall 3	Wall 4
Name	: NORTH	SOUTH	EAST	WEST
Wall orientation	: North	South	East	West
Area (ft2)	: 1547	1547	910	910
U-Factor (BTUH/ft2-deg F)	: 0.150	0.150	0.150	0.150
Wall construction group	: D	D	D	D
Color correction	: Medium	Medium	Medium	Medium

ROOF DATA FOR ZONE 9 - TOP FLOOR

	Roof 1	Roof 2
Name	: ROOF	NA
Area (ft2)	: 17000	
U-Factor (BTUH/ft2-deg F)	: 0.050	
Roof construction code	: 12	
Color correction	: Dark	Light
Suspended ceiling plenum	: Yes	

WINDOW DATA FOR ZONE 9 - TOP FLOOR

	Window 1	Window 2	Window 3	Window 4
Name	: NORTH	SOUTH	EAST	WEST
Window orientation	: North	South	East	West
Fenestration area (ft2)	: 663	663	663	663
Shading coefficient	: .55	.55	.55	.55
U-Factor (BTUH/ft2-deg F)	: 0.56	0.56	0.56	0.56
Space mass code	: Heavy	Heavy	Heavy	Heavy
Crack length (lin ft)	: 0	0	0	0
Leakage coefficient	: 00	0	0	0

Inputs Required for Shading

Window shading model number	: 0	0	0	0
Percent window area	:			

INFILTRATION DATA FOR ZONE 9 - TOP FLOOR

Occupied air change rate	: 0.32 air changes per hour
Unoccupied air change rate	: 0.32 air changes per hour

OPERATING USE PROFILE (DIVERSITY) DATA

		Occupied Period	Unoccupied Period	Month Sched Table # (1-4)
People	- Avg % of full occupancy :	100	0	1
Lights				
TOP	- Avg % of installed capacity :	66	10	1
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			
Electric Equipment				
EQUIPMENT	- Avg % of installed capacity :	18	5	1
NA	- Avg % of installed capacity :			
Miscellaneous Sensible Loads				
NA	- Avg % of installed capacity :			
NA	- Avg % of installed capacity :			

MONTHLY DIVERSITY FACTORS

	Mon Sch 1	Mon Sch 2	Mon Sch 3	Mon Sch 4
January	: 100			
February	: 100			
March	: 100			
April	: 100			
May	: 100			
June	: 100			
July	: 100			
August	: 100			
September	: 100			
October	: 100			
November	: 100			
December	: 100			

DATA ECHO FOR SYSTEMS INPUT FILE - LGOFFEX.SID
SYSTEM TYPE - VAV REHEAT
SYSTEM LABEL - VARIABLE AIR VOLUME SYSTEM

ZONES ASSIGNED TO SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Load Zone	Zone Label
1	First Floor Lobby
2	INTERIOR CORE
3	OUTER ZONE - WEST
4	FIRST FLOOR - WEST PERIMETER
5	PERIMETER - EAST
6	FIRST FLOOR - EAST PERIMETER
7	PERIMETER - SOUTH
8	PERIMETER - NORTH
9	TOP FLOOR

HEATING PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Heating plant type : Electric Resistance
Heating available below : 60 deg F
Heating availability : Oct through Apr
Design heating discharge temperature : 100 deg F

COOLING PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Cooling plant type : Centrifugal
Outside temperature below which cooling is off : 0 deg F
Cooling availability : Jan through Dec
Design cooling coil discharge temperature : 60 deg F
Discriminator control : No

PREHEAT PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Preheat plant type : None

HUMIDIFICATION PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Humidification plant type : None

BASEBOARD PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Baseboard plant type : None

FAN PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Total supply fan power required : 250 KW
Supply fan temperature rise : 2.4 deg F
Total return fan power required : 112 KW
Return fan temperature rise : 1.2 deg F
Minimum percent of design air volume when heating (VAV): 40 %
Air volume control method (VAV) : Inlet Vanes
Unoccupied cycle fan control method : Cycles with Load

OUTSIDE AIR PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Occupied Cycle
Outside air damper control method : Dry Bulb Economizer
Minimum percent outside air intake : 15 %
Dry bulb switchover temperature : 74 deg F
Unoccupied Cycle
Outside air damper control method : No Outside Air

ZONE AIR PARAMETERS FOR SYSTEM 1 - VARIABLE AIR VOLUME SYSTEM

Zonal air volume method	: Autosized
Percent of design default air flow	: 90 %

DATA ECHO FOR PLANT INPUT FILE: LGOFFEX.PID

ENERGY COSTS/CONVERSIONS

Fuel Type	Energy Units	Unit Cost	Conversion Factors (BTU/Unit) Site	Source
Electricity	KWH	$0.0500	0	0
Natural Gas	Therms	$0.5000	0	0

MISCELLANEOUS ENERGY CONSUMPTION

CENTRIFUGAL CHILLER

	Type 1
Centrifugal Chiller Cooling Capacity (per chiller)	: 500 tons
Number of chillers of this capacity	: 2
Cooling Performance	
Design coefficient of performance	: 4.55
Minimum unloading ratio (percent of capacity)	: 40 %
Minimum part load ratio (percent of capacity)	: 10 %
Load management/operating method	: Always On
Chilled Water Parameters	
Chilled water temperature at maximum load	: 44 deg F
Chilled water temperature at minimum load	: 44 deg F
Chilled water flow rate	: Autosized
Chilled water pump KW	: Autosized

COOLING TOWER

Cooling Tower Heat Rejection Capacity	: 1200 tons
Tower Performance	
Number of tower cells	: 6
Fan KW per cell	: Autosized
Number of fan speeds	: 2
Approach temperature	: 10 deg F
Condenser Water Parameters	
Condenser water temperature at maximum load	: 95 deg F
Condenser water temperature at minimum load	: 85 deg F
Condenser water flow rate	: Autosized
Condenser water pump KW	: Autosized

DOMESTIC HOT WATER

Domestic Hot Water Energy Source	: Electric
Domestic Hot Water Heating Capacity	: 300 KBTUH
Average hourly DHW usage - occupied cycle	: 65 gal/hour
Average hourly DHW usage - unoccupied cycle	: 2 gal/hour
DHW Temperatures	
Domestic how water supply temperature	: 125 deg F
DHW inlet temperature - design summer	: 60 deg F
DHW inlet temperature - design winter	: 50 deg F
Circulating Pumps	
Circulating pump KW - occupied cycle	: 0 KW
Circulating pump KW - unoccupied cycle	: 0 KW
Domestic Hot Water Efficiency and Losses	
Design DHW heating efficiency	: 85 %
DHW losses - occupied cycle	: 0 BTUH
DHW losses - unoccupied cycle	: 0 BTUH