The Computerized Commercial Building Energy and Load Management Simulation Analysis/Audit System

L.J. Lightfoot

ABSTRACT

The computerized commercial building energy and load management simulation analysis/audit system consists of two building analysis programs developed on a small microprocessor: the energy consultation program (ecp) and computerized commercial energy analysis (ccea) simulation program. The system is an integral part of an Arizona utility company's load management program to permanently reduce power plant capacity by 2170800 MJ/hr (603 megawatts) by 1992.

Ecp is used initially to screen a facility's energy use and load profile. This profile is compared against energy consumption and peak demands of similar businesses within one of four climatic regions located in the utility's service area.

Ccea provides a framework for evaluating the thermal performance of the building and the effects of proposed modifications within the building shell. The variables affecting heat gain and loss load calculations are numerous, often difficult to define precisely, and intricately interrelated. Ccea's thermal analysis is based on the characteristics of a structure, including: building materials, component size, shape, external surface color, location, structure orientation, external shading, and indoor conditions such as temperature, ventilation rates, lighting schedules, and occupant/equipment profiles that contribute to the internal thermal loads. An ASHRAE-modified degree-day method is employed to simulate the heating and cooling loads. Six-hour temperature and solar insolation data averages from each climatic zone are used in the simulation.

Relative comparisons are made between a building's actual (historical) energy use and a baseline simulation. This information provides a framework for evaluating the energy savings and load reduction costs/benefits of retrofit actions that may include any combination of structural enhancements, employment of precoolers, load controllers, lighting system efficiencies, etc.

The ccea program is useful in evaluating both existing buildings (whose energy performance is known) and design alternatives in new buildings. Its accuracy compares very favorably to simulations performed on the Department of Energy's DOE-2.1 program and its operating cost is negligible. The intent of this paper is to describe the design and use of the ecp/ccea programming system in analyzing commercial facilities.

Linda Lightfoot, Energy Management Engineer, Arizona Public Service Company, Phoenix, Arizona

INTRODUCTION

Energy has become one of the most important issues in the U.S. today. In the past, inexpensive, abundant energy supplies helped encourage industrial, commercial, agricultural, and residential growth in the nation. However, recent price escalations, supply depletions, and environmental concerns have changed the focus on electrical-energy marketing within the utility industry.

Utility companies have had to change from promoting the unlimited use of electricity to being leaders in the management of electrical use and load growth, as indicated by energy management action seminars, demand reduction programs, and programs that subsidize for end-use results. Pricing policies and rate structures for electricity have also changed to encourage load management by the large residential, as well as the commercial and industrial, customer. These programs aim to level-out peak loads by changing the magnitude of hour-to-hour and season-to-season variations in electrical demands. They shave the peaks and fill the valleys in the demand-time curve. These programs are beneficial to utilities by maximizing the use of less expensive base-loaded electrical generation. Further, load management is the alternative available to electrical suppliers to avoid the rising cost of peak power and the skyrocketing cost of adding new capacity.

The utility's new and existing load management programs must achieve at least a 158400 MJ/hr (44-Mw) peak reduction per year to meet a goal of a 2170800 MJ/hr (603-Mw) reduction by 1992. Reaching the 1992 peak load reduction objective will be the equivalent of avoiding or deferring construction of two generating units of a somewhat larger capacity than two of the utility's largest existing coal-fired units.

This paper will deal with the design and use of the energy consultation program and computerized commercial energy analysis (ccea-II) programming system as an important load management tool in analyzing commercial facilities. Before a sample test case is presented, the programming system will be discussed and a work flowchart will be described. The heating and cooling load data of the sample test case will be presented in both graphic and table form. For comparison purposes, data from an identical DOE-2.1 run will also be presented.[1]

ENERGY AND LOAD MANAGEMENT PROGRAMS

Commercial and industrial users represent 12% of the company's customers, who, in turn, consume up to 50% of the electricity produced. As a step in addressing the load and energy management problems associated with this class of customers, the ecp, a computer program that recommends the appropriate load management action plan to the energy user, was developed. Ecp has load management steps for the full spectrum of commercial and industrial customers, whether the small commercial business that may need just a do-it-yourself handbook or an industrial processing plant that may need to invest in an air-conditioning waste heat recovery system.

Ecp utilizes business description, standard industrial classification code, facility space utilization, type of energy consumed, type of space conditioning equipment used, and consumption history to create a monthly consumption and demand profile on the customer. The energy use and demand data are then used to establish desired goals, as compared to 50% of all similar businesses in a particular Arizona climatic area. A recommended action plan is provided to assist in capitalizing on these and additional potential savings. Action steps include a commercial and industrial consumers' guide for reducing energy cost, energy-management action courses, a commercial and industrial air-conditioner waste heat recovery program, a commercial and industrial demand reduction program and the computerized commercial energy analysis (ccea-II). As shown in Fig. 1, ecp ties together these programs to make a complete commercial and industrial load-management package.

The use of ecp as a pre-audit program is valuable because it specifies the profile of energy use for a customer and provides a basis for the commercial energy analysis. The pre-audit program allows an existing building's energy bills to be examined and compared against an existing data base so that non-normal energy consumption can be noted and later examined by a more detailed energy audit.

CCEA-II OVERVIEW

The computerized commercial energy analysis of an existing building consists of the following steps:

1. Identifying historical patterns of energy consumption by the facility
2. Studying and understanding the factors affecting the energy usage of the building or facility
3. Formulating a mathematical model of the building and system thermal performance

Step 1, collection of past energy-usage data, is completed by the pre-audit program. This procedure requires a minimum of data input, most of which comes from the building's previous 12 months' utility history.

Step 2, (studying and understanding the factors affecting the energy usage by the building) is the main body of the audit. The operation, maintenance, and scheduling of these factors is studied to obtain an understanding of the energy usage of the building. These factors include:

--the exterior envelope
--HVAC systems and equipment
--electrical systems
--lighting systems
--appliances and equipment
--other internal loads created within the building.

A detailed energy audit also includes a review of the building's architectural, electrical, and mechanical plans, as well as specifications and as-built drawings (if available). It is necessary to identify each piece of equipment and determine how much energy it should be consuming, based on its size in terms of kilowatts. Without a detailed analysis, optimization of energy consumption and demand is exceedingly difficult because of the many variables involved in the operation of a building. Once such an analysis has been made, like the heating/cooling load calculations, as long as it is kept up to date, it is a valid and valuable tool for the life of the building.

The cooperation of the operating staff of the building is a must. Their assistance is necessary for the analyst to become familiar with the location of energy-using equipment, meters, and systems; operating patterns; and how the building is used, operated, and maintained. All unusual conditions that occurred during the year being analyzed must be recalled and explained as best as possible.

Attention is initially directed primarily at those elements that use energy, cause energy to be used, or establish time frames and quantities of energy utilization. After the energy-use profiles have been developed and verified, the focus switches to a more detailed analysis to identify those areas where changes, modifications, additions, replacements, or eliminations will produce benefits.

Step 3, (formulating a mathematical model of the building and system thermal balance) consists of calculating the energy usage of the various load-creating systems in the building. The sum of the energy usage by the individual systems should come close to the data on the actual energy usage collected in step 1. The baseline model formulation and a retrofitted model can be run simultaneously. A retrofitted model is the baseline building with one or more energy-efficient modifications. The ccea-II program then takes the difference between the modeled baseline building, the modeled retrofitted building and calculates a change in heating and cooling load. This difference represents the energy savings produced by making that particular energy-management enhancement to the building. The energy savings are then applied to the actual consumption history to determine the projected energy consumption and demand for the facility. The usefulness of a good mathematical model is evident in providing a better understanding of the energy-usage patterns of a building.

CCEA-II INTRODUCTION

The ccea-II program discussed here is a self-contained simulation program that is run on a microcomputer. The software has been written in BASIC to run on a 48-k byte machine. Its operation is completely independent of any large computer. All the calculations needed are done locally. The auditor is prompted for all necessary information. This program allows the user flexibility in selecting conservation measures, yet simplifies the input so that an analysis may be performed quickly and efficiently.

Ccea-II was developed because other programs were too expensive to use in a production mode on a large commercial and industrial base and calculation methodologies of simplified programs were generally not adequate to meet specific needs. It provides lower analysis costs, because the use of expensive time-share computer services are avoided and also provides state-of-the-art hourly simulation methodology.

This program was designed to give accurate answers on most of the popular building envelope/internal load combinations found in the small-to-medium commercial class. Ccea-II allows the analyst/auditor to prepare a simple energy analysis when a more rigorous time-consuming solution such as that provided by DOE-2.1 is not necessary. The analyst is given a lot of flexibility in deciding how to input the necessary data. For example, the auditor has the choice of entering the total thermal resistance, if known, or may choose to input the specific layers of the envelope component, where the R-values are then retrieved from an already existing data base. In addition, the ccea-II software provides the ability to enter the exact wattage and number of incandescent, fluorescent, mercury, and sodium light fixtures. A total of 15 possible energy-conservation measures (retrofits) may be tested on any one building.

Various methods of studying the thermal performance of commercial and industrial buildings are available. ASHRAE[2] explains how to calculate the design heating and cooling load of a building by calculating the load contribution of each component of the building. The methodology used in this program first calculates the loads from heat transfer across the building's envelope components. This calculation is performed by using auditor input data, in addition to the actual hourly dry-bulb temperature and solar insolation data (averaged over four 6-hr periods for 365 days), ASHRAE thermal properties, ASHRAE heat gain factors, ASHRAE solar heat gain factors, and ASHRAE heat gain factors attributable to occupant activity that are already stored on disk and accessible to the program. Calculation of space heating and cooling load from heat transfer by conduction through roof and walls (including glass and door surfaces) involves the concept of sol-air temperature discussed in chapter 25.4 of Ref. 2. Conduction heat-transfer calculations are also used for the floor and any internal partitions. A solar radiation term is also present. After the solar and thermal gains and losses for each of the elements are calculated, the lighting, equipment, occupant, and ventilation/infiltration loads are similarly calculated and summed on to the total load. The lighting and equipment loads are found to depend on watt input, usage factor, ASHRAE heat gain factors, and a conversion factor to Btu/hr. Load contributed by occupants is found by multiplying the number of occupants by the ASHRAE heat gain factor for occupant activity. Finally, the loads from ventilation/infiltration are calculated by using the standard cfm, inside-outside air temperature difference and inside-outside air humidity ratio difference. Running simultaneously with the baseline are retrofit areas chosen by the customer.

The analyst receives monthly cooling and heating energy values, along with the peak heating and cooling demand (kilowatts) experienced each month for the baseline and all specified retrofit areas. At the completion of the simulated 1-yr period, the audit results are printed with each conservation measure's energy consumption, peak load, and dollar savings for the first year. An investment-cost data base is available to calculate a payback period for each conservation measure. The report is concise and easy to explain to the customer. Figure 2 represents the work flowchart of the building modelling and energy analysis.

SAMPLE CASE

The sample case is concerned with a 6700 ft^2 (622 m^2) health laboratory that does blood and chemical analysis work for hospitals. The actual winter monthly energy consumption for this facility is between 93600 and 100800 MJ (26000 and 28000 kwh), with a metered demand between 288 and 317 MJ/hr (80 and 88 kw). Summer monthly consumption increases to between 136800 and 162000 MJ (38000 and 45000 kwh), while metered demand falls to between 274 and 288 MJ/hr (76 and 80 kw). An ecp analysis, as shown in app A, described the customer's energy usage as high and a ccea-II recommendation was made.

The flat, medium-colored roof has an R-value of 14.8. The 18 ft (5.5 m)-high, light-colored brick walls have an R-value of 14.6. Acrylic, dark-gray-tinted windows makes up only 0.5% of the wall space, resulting in a minimal solar heat gain through glass surface. Standard concrete floor and wood doors are present. The equipment in the building, two digital computer systems with peripherals, eight refrigerators, small cafeteria appliances, and standard laboratory equipment. Lighting requirements were found to be 58 MJ/hr (16 kw).

Maintaining a 75°F (24°C) indoor temperature under the high equipment usage, laboratory lighting conditions, and relatively mild Phoenix winters requires that the 14½ tons of heating, ventilating, and air-conditioning equipment be always in a cooling mode. An unusual occupant schedule of 66% of the staff on duty from midnight until 8:00 a.m., and 90% appliance utilization during those hours, creates a building peak demand in the very early morning.

After the data returned from the pre-audit program and the actual building audit had been studied, two areas were chosen as offering retrofit opportunity. A thermostat setup of 3°F (2°C) for all 12 months was chosen because air-conditioning equipment was required year-round to maintain an indoor temperature of 75°F (24°C). The second area offering potential was lighting. A lighting conversion from incandescent to fluorescent for 13 fixtures was chosen because the required cooling from internal lights was suspected to be high.

Figures 3 through 11 show a bar graph of the simulated monthly cooling energy and peak cooling loads for the baseline and the two previously described retrofit cases. Graphs for the ccea-II data and DOE-2.1 data are shown. Tables 1 through 8 show monthly heating and cooling energy and demand data for the baseline and retrofit opportunity areas chosen; both ccea-II and DOE-2.1 data are included in table form.

Figure 3 is the ccea-II consumption profile for the baseline facility with the thermostat setup profile overlaid. The simulated thermostat setup is 3°F (2°C) to 78°F (26°C) for the entire year. Monthly savings of between 5560 and 5872 MJ (5.27 and 5.84 Mbtu) are calculated, the value depending on the number of days in the month. An annual savings of 72479 MJ (68.70 Mbtu) provides a 3.66% energy savings for the 3°F (2°C) setup.

Figure 4 shows the DOE-2.1 consumption profile for the baseline and thermostat setup run with input data identical to that entered in the ccea-II program. The 3°F (2°C) setup produced monthly savings of between 4948 and 5486 MJ (4.69 and 5.20 Mbtu). An annual savings of 64460 MJ (61.10 Mbtu) provides a 3.58% savings for the 3°F (2°C) setup.

The ccea-II demand profile for the baseline facility with the thermostat setup profile overlaid is shown in Fig. 5. Monthly savings of 8271 KJ/hr (7.84 Kbtu/hr) are evident, translating to 1.1 cooling kw. Savings of 99254 KJ/hr (94.08 Kbtu/hr) annually equals a 48240 cooling KJ/hr (13.4 cooling kw) reduction.

Figure 6 represents the DOE-2.1 demand profile for the baseline and thermostat setup run with input data identical to that entered in the ccea-II program. The 3°F (2°C) setup produced monthly savings of 7385 KJ/hr (7.00 Kbtu/hr) which is 3600 cooling KJ/hr (1 cooling kw) and annual savings of 88178 KJ/hr (83.58 Kbtu/hr), which is equal to 43200 cooling KJ (12 cooling kw) saved per year.

A 3½% savings for a 3°F (2°C) setup is less than has been observed by load research of similar buildings. The ccea-II and DOE programs both showed similar energy savings.

In Fig. 7, the ccea-II baseline consumption profile is seen representing lighting-conversion retrofit. A total annual savings in cooling for this energy-management recommendation is 33043 MJ (31.32 Mbtu), which is 16106 cooling MJ/year (4474 cooling kwh/year).

Fig. 8, the DOE-2.1 graph, shows the savings acquired when making the same lighting conversion as represented in Fig. 3. A total annual savings of 41830 MJ (39.65 Mbtu), which is 20390 MJ/year (5664 cooling kwh/year) is found.

Fig. 9 illustrates the ccea-II baseline demand profile plotted with the lighting conversion retrofit data. A total annual savings in cooling for this energy-management recommendation is 46462 KJ/hr (44.04 Kbtu/hr), which is 22.68 MJ/hr/year (6.3 cooling kw/year).

The DOE-2.1 graph showing the savings from making the same lighting conversion as represented in Fig. 9 is found in Fig. 10. A total annual savings of 55050 KJ/hr (52.18 Kbtu/hr) which is 27 MJ/hr/year (7.5 cooling kw/year) is found.

CONCLUSIONS

The pre-audit and computer analysis programs discussed earlier indicate the importance of analyst expertise in performing a reliable audit. The auditor must understand the original design and the observed operation of the systems in a building. It should be realized that performing an energy audit involves more than gathering information for prescribed forms and that a computerized energy-analysis package must be flexible enough to incorporate this additional information.

Generally, most computer simulation programs receive initial input in the form of data relating to installed systems and climatic conditions varying in quantity of data needed and degree of complexity. Output, whether a basic heating/cooling analysis or a full customer version report, should provide a reasonably accurate estimate of actual monthly and annual energy consumption that has been experienced. If monthly or annual estimates vary from metered data, the cause must be determined.

The sample case provides data to back up claims that a computer program written for a microcomputer can return accurate results comparable to those of large systems software. The relative energy and demand savings computed by the ccea-II software has been found to be very reasonable in comparison with the utility's load research findings. A secondary objective was for the ccea-II simulated energy and demand savings to compare well with the DOE-2.1 savings and this comparison produced very favorable results.

Reliability of the microcomputer hardware was found to be no major problem. The most obvious drawback was not limited memory size, as was first expected in the design phase of the program. The limited memory problem was eliminated by designing five small program modules instead of one large program with only one module residing in core memory at any one time. Instead, the major problem was found to be length of execution time. The data input and report output segments are relatively fast, but the hour-by-hour calculation to support the simulation proved to be very slow.

The ccea-II program is being rewritten in FORTRAN to run on a mainframe computer. This new version, ccea-III, makes use of the ccea-II methodology and ASHRAE design data while running on a more sophisticated machine, using a more calculation-oriented computer language. This conversion will decrease execution time considerably. Both versions will be kept up to date and will be utilized by the utility as valuable load-management analysis tools.

REFERENCES

1. U.S., Department of Energy, DOE-2 Reference Manual, Volume 2, Loads (Washington: Department of Energy, 1979), p. 1-79.

2. ASHRAE Handbook--1977 Fundamentals Volume, "Air-Conditioning Loads", p. 1-44.

TABLE 1

CCEA-II CONSUMPTION PROFILE BASELINE VS. THERMOSTAT SETUP

	Baseline			Thermostat Setup			Delta	
	Cooling Energy		Heating Energy	Cooling Energy		Heating Energy	Cooling Energy	
Month	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)
Jan.	136791.	(129.66)	0.0	130630.	(123.82)	0.0	6161.	(5.84)
Feb.	126748.	(120.14)	0.0	121135.	(114.87)	0.0	5560.	(5.27)
March	149440.	(141.65)	0.0	143280.	(135.81)	0.0	6161.	(5.84)
April	157469.	(149.26)	0.0	151519.	(143.62)	0.0	5950.	(5.64)
May	168905.	(160.10)	0.0	162681.	(154.27)	0.0	6150.	(5.83)
June	191345.	(181.37)	0.0	185395.	(175.73)	0.0	5950.	(5.64)
July	197538.	(187.24)	0.0	191388.	(181.41)	0.0	6150.	(5.83)
Aug.	198857.	(188.49)	0.0	192696.	(182.65)	0.0	6161.	(5.84)
Sept.	183242.	(173.69)	0.0	177282.	(168.04)	0.0	5961.	(5.65)
Oct.	172756.	(163.75)	0.0	166606.	(157.92)	0.0	6150.	(5.83)
Nov.	157585.	(149.37)	0.0	151625.	(143.72)	0.0	5961.	(5.65)
Dec.	137910.	(130.72)	0.0	131748.	(124.88)	0.0	6161.	(5.84)
Total	1978589.	(1875.44)	0.0	1906111.	(1806.74)	0.0	72478.	(68.70)

TABLE 2

CCEA-II DEMAND PROFILE BASELINE VS. THERMOSTAT SETUP

	Baseline			Thermostat Setup				
	Maximum Cooling Load		Maximum Heating Load	Maximum Cooling Load		Maximum Heating Load	Delta Maximum Cooling Load	
Month	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)
Jan.	235.56	(223.28)	0.0	227.29	(215.44)	0.0	8.27	(7.84)
Feb.	241.56	(228.97)	0.0	233.29	(221.13)	0.0	8.27	(7.84)
March	249.98	(236.95)	0.0	241.71	(229.11)	0.0	8.27	(7.84)
April	261.32	(247.70)	0.0	253.04	(239.86)	0.0	8.27	(7.84)
May	264.14	(250.37)	0.0	255.87	(242.53)	0.0	8.27	(7.84)
June	302.70	(286.92)	0.0	294.43	(279.08)	0.0	8.27	(7.84)
July	302.95	(287.16)	0.0	294.68	(279.32)	0.0	8.27	(7.84)
Aug.	307.51	(291.48)	0.0	299.24	(283.64)	0.0	8.27	(7.84)
Sept.	294.33	(278.99)	0.0	286.06	(271.15)	0.0	8.27	(7.84)
Oct.	279.49	(264.92)	0.0	271.22	(257.08)	0.0	8.27	(7.84)
Nov.	268.73	(254.72)	0.0	260.46	(246.88)	0.0	8.27	(7.84)
Dec.	233.77	(221.58)	0.0	225.50	(213.74)	0.0	8.27	(7.84)
Max.	307.51	(291.48)	0.0	299.24	(283.64)	0.0	99.25	(94.08)

TABLE 3

DOE-2.1 CONSUMPTION PROFILE BASELINE VS. THERMOSTAT SETUP

	Baseline			Thermostat Setup			Delta	
	Cooling Energy		Heating Energy	Cooling Energy		Heating Energy	Cooling Energy	
Month	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)
Jan.	123245.	(116.82)	0.0	117770.	(111.63)	0.0	5475.	(5.19)
Feb.	114942.	(108.95)	0.0	109994.	(104.26)	0.0	4948.	(4.69)
March	135567.	(128.45)	0.0	130029.	(123.25)	0.0	5486.	(5.20)
April	142731.	(135.29)	0.0	137414.	(130.25)	0.0	5317.	(5.04)
May	162523.	(154.05)	0.0	157026.	(148.84)	0.0	5497.	(5.21)
June	167945.	(159.19)	0.0	162628.	(154.15)	0.0	5317.	(5.04)
July	185395.	(175.73)	0.0	179909.	(170.53)	0.0	5486.	(5.20)
Aug.	180616.	(171.20)	0.0	175140.	(166.01)	0.0	5475.	(5.19)
Sept.	168800.	(160.00)	0.0	163514.	(154.99)	0.0	5275.	(5.00)
Oct.	157427.	(149.22)	0.0	151926.	(144.04)	0.0	5465.	(5.18)
Nov.	134671.	(127.65)	0.0	129396.	(122.65)	0.0	5275.	(5.00)
Dec.	126473.	(119.88)	0.0	121009.	(114.70)	0.0	5465.	(5.18)
Total	1800263.	(1706.41)	0.0	1735802.	(1645.31)	0.0	64461.	(61.10)

TABLE 4

DOE-2.1 DEMAND PROFILE BASELINE VS. THERMOSTAT SETUP

	Baseline			Thermostat Setup			Delta Maximum Cooling Load	
	Maximum Cooling Load		Maximum Heating Load	Maximum Cooling Load		Maximum Heating Load		
Month	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)
Jan.	201.21	(190.72)	0.0	193.87	(183.76)	0.0	7.06	(6.96)
Feb.	205.54	(194.82)	0.0	198.15	(187.82)	0.0	7.39	(7.00)
March	216.61	(205.32)	0.0	209.30	(198.39)	0.0	7.35	(6.93)
April	227.50	(215.64)	0.0	220.12	(208.64)	0.0	7.39	(7.00)
May	259.75	(246.21)	0.0	252.40	(239.24)	0.0	7.35	(6.97)
June	264.90	(251.09)	0.0	257.53	(244.10)	0.0	7.37	(6.99)
July	276.02	(261.63)	0.0	268.67	(254.66)	0.0	7.35	(6.97)
Aug.	274.11	(259.82)	0.0	266.67	(252.77)	0.0	7.44	(7.05)
Sept.	261.13	(247.52)	0.0	253.82	(240.59)	0.0	7.35	(6.93)
Oct.	245.14	(232.36)	0.0	237.82	(225.42)	0.0	7.32	(6.94)
Nov.	213.65	(202.51)	0.0	206.37	(195.58)	0.0	7.35	(6.93)
Dec.	202.70	(192.13)	0.0	195.40	(185.21)	0.0	7.30	(6.92)
Max.	276.02	(261.63)	0.0	268.67	(254.66)	0.0	88.18	(83.58)

TABLE 5

CCEA-II CONSUMPTION PROFILE BASELINE VS.LIGHTING CONVERSION

Month	Baseline Cooling Energy (MJ)	Baseline Cooling Energy (Mbtu)	Baseline Heating Energy (MJ)	Lighting Conversion Cooling Energy (MJ)	Lighting Conversion Cooling Energy (Mbtu)	Lighting Conversion Heating Energy (MJ)	Delta Cooling Energy (MJ)	Delta Cooling Energy (Mbtu)
Jan.	136791.	(129.66)	0.0	133985.	(127.00)	0.0	2806.	(2.66)
Feb.	126748.	(120.14)	0.0	124205.	(117.73)	0.0	2543.	(2.41)
March	149441.	(141.65)	0.0	146634.	(138.99)	0.0	2806.	(2.66)
April	157469.	(149.26)	0.0	154758.	(146.69)	0.0	2711.	(2.57)
May	168906.	(160.10)	0.0	166099.	(157.44)	0.0	2806.	(2.66)
June	191345.	(181.37)	0.0	188634.	(178.80)	0.0	2711.	(2.57)
July	197538.	(187.24)	0.0	194732.	(184.58)	0.0	2806.	(2.66)
Aug.	198857.	(188.49)	0.0	196051.	(185.83)	0.0	2806.	(2.66)
Sept.	183243.	(173.69)	0.0	180532.	(171.12)	0.0	2711.	(2.57)
Oct.	172756.	(163.75)	0.0	169950.	(161.09)	0.0	2806.	(2.66)
Nov.	157585.	(149.37)	0.0	154863.	(146.79)	0.0	2711.	(2.57)
Dec.	137910.	(130.72)	0.0	135103.	(128.06)	0.0	2806.	(2.66)
Total	1978589.	(1875.44)	0.0	1945547.	(1844.12)	0.0	33043.	(31.32)

TABLE 6

CCEA-II DEMAND PROFILE BASELINE VS. LIGHTING CONVERSION

Month	Baseline Maximum Cooling Load (MJ/hr)	Baseline Maximum Cooling Load (Kbtu/hr)	Baseline Maximum Heating Load (MJ/hr)	Lighting Conversion Maximum Cooling Load (MJ/hr)	Lighting Conversion Maximum Cooling Load (Kbtu/hr)	Lighting Conversion Maximum Heating Load (MJ/hr)	Delta Maximum Cooling Load (MJ/hr)	Delta Maximum Cooling Load (Kbtu/hr)
Jan.	235.56	(223.28)	0.0	232.00	(219.91)	0.0	3.56	(3.37)
Feb.	241.56	(228.97)	0.0	237.59	(225.20)	0.0	3.98	(3.77)
March	249.98	(236.95)	0.0	246.00	(233.18)	0.0	3.98	(3.77)
April	261.32	(247.70)	0.0	257.35	(243.93)	0.0	3.98	(3.77)
May	264.14	(250.37)	0.0	260.59	(247.00)	0.0	3.56	(3.37)
June	302.70	(286.92)	0.0	298.72	(283.15)	0.0	3.98	(3.77)
July	302.95	(287.16)	0.0	299.40	(283.79)	0.0	3.56	(3.37)
Aug.	307.51	(291.48)	0.0	303.53	(287.71)	0.0	3.98	(3.77)
Sept.	294.33	(278.99)	0.0	290.36	(275.22)	0.0	3.98	(3.77)
Oct.	279.49	(264.92)	0.0	275.51	(261.15)	0.0	3.98	(3.77)
Nov.	268.73	(254.72)	0.0	264.75	(250.95)	0.0	3.98	(3.77)
Dec.	233.77	(221.58)	0.0	229.79	(217.81)	0.0	3.98	(3.77)
Max.	307.51	(291.48)	0.0	303.53	(287.71)	0.0	46.46	(44.04)

TABLE 7

DOE-2.1 CONSUMPTION PROFILE BASELINE VS. LIGHTING CONVERSION

Month	Baseline			Lighting Conversion			Delta	
	Cooling Energy		Heating Energy	Cooling Energy		Heating Energy	Cooling Energy	
	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)	(MJ)	(MJ)	(Mbtu)
Jan.	123245.	(116.82)	0.0	119690.	(113.45)	0.0	3555.	(3.37)
Feb.	114942.	(108.95)	0.0	111735.	(105.91)	0.0	3207.	(3.04)
March	135567.	(128.45)	0.0	131959.	(125.08)	0.0	3555.	(3.37)
April	142731.	(135.29)	0.0	139292.	(132.03)	0.0	3439.	(3.26)
May	162523.	(154.05)	0.0	158967.	(150.68)	0.0	3555.	(3.37)
June	167945.	(159.19)	0.0	164506.	(155.93)	0.0	3439.	(3.26)
July	185395.	(175.73)	0.0	181840.	(172.36)	0.0	3555.	(3.37)
Aug.	180616.	(171.20)	0.0	177061.	(167.83)	0.0	3555.	(3.37)
Sept.	168800.	(160.00)	0.0	165361.	(156.74)	0.0	3439.	(3.26)
Oct.	157427.	(149.22)	0.0	153882.	(145.86)	0.0	3545.	(3.36)
Nov.	134671.	(127.65)	0.0	131231.	(124.39)	0.0	3439.	(3.26)
Dec.	126473.	(119.88)	0.0	122918.	(116.51)	0.0	3555.	(3.37)
Total	1800263.	(1706.41)	0.0	1758442.	(1666.77)	0.0	41831.	(39.65)

TABLE 8

DOE-2.1 DEMAND PROFILE BASELINE VS. LIGHTING CONVERSION

Month	Baseline			Lighting Conversion				
	Maximum Cooling Load		Maximum Heating Load	Maximum Cooling Load		Maximum Heating Load	Delta Maximum Cooling Load	
	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)	(MJ/hr)	(MJ/hr)	(Kbtu/hr)
Jan.	201.21	(190.72)	0.0	196.62	(186.37)	0.0	4.59	(4.35)
Feb.	205.54	(194.82)	0.0	200.95	(190.47)	0.0	4.59	(4.35)
March	216.61	(205.32)	0.0	212.02	(200.97)	0.0	4.59	(4.35)
April	227.50	(215.64)	0.0	222.91	(211.29)	0.0	4.59	(4.35)
May	259.75	(246.21)	0.0	255.16	(241.86)	0.0	4.59	(4.35)
June	264.90	(251.09)	0.0	260.31	(246.74)	0.0	4.59	(4.35)
July	276.02	(261.63)	0.0	271.43	(257.28)	0.0	4.59	(4.35)
Aug.	274.11	(259.82)	0.0	269.53	(255.48)	0.0	4.58	(4.34)
Sept.	261.13	(247.52)	0.0	256.54	(243.17)	0.0	4.59	(4.35)
Oct.	245.14	(232.26)	0.0	240.55	(228.01)	0.0	4.59	(4.35)
Nov.	213.65	(202.51)	0.0	209.08	(198.18)	0.0	4.57	(4.33)
Dec.	202.70	(192.13)	0.0	198.10	(187.77)	0.0	4.60	(4.36)
Max.	276.02	(261.63)	0.0	271.43	(257.28)	0.0	55.05	(52.18)

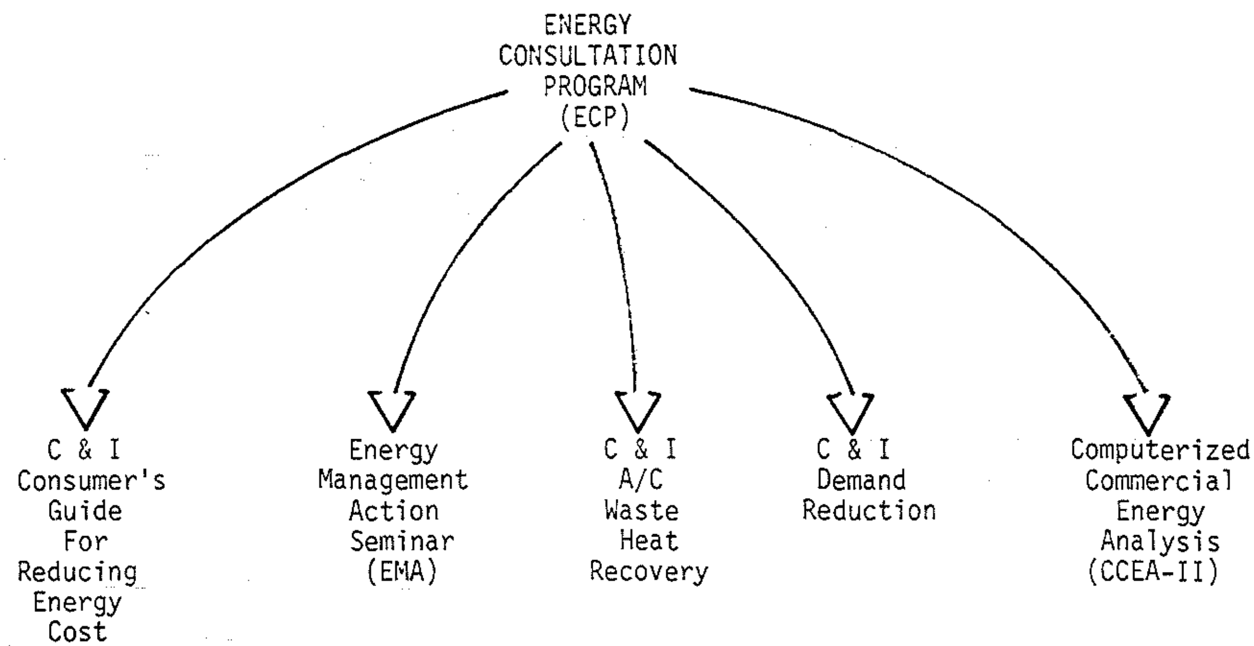
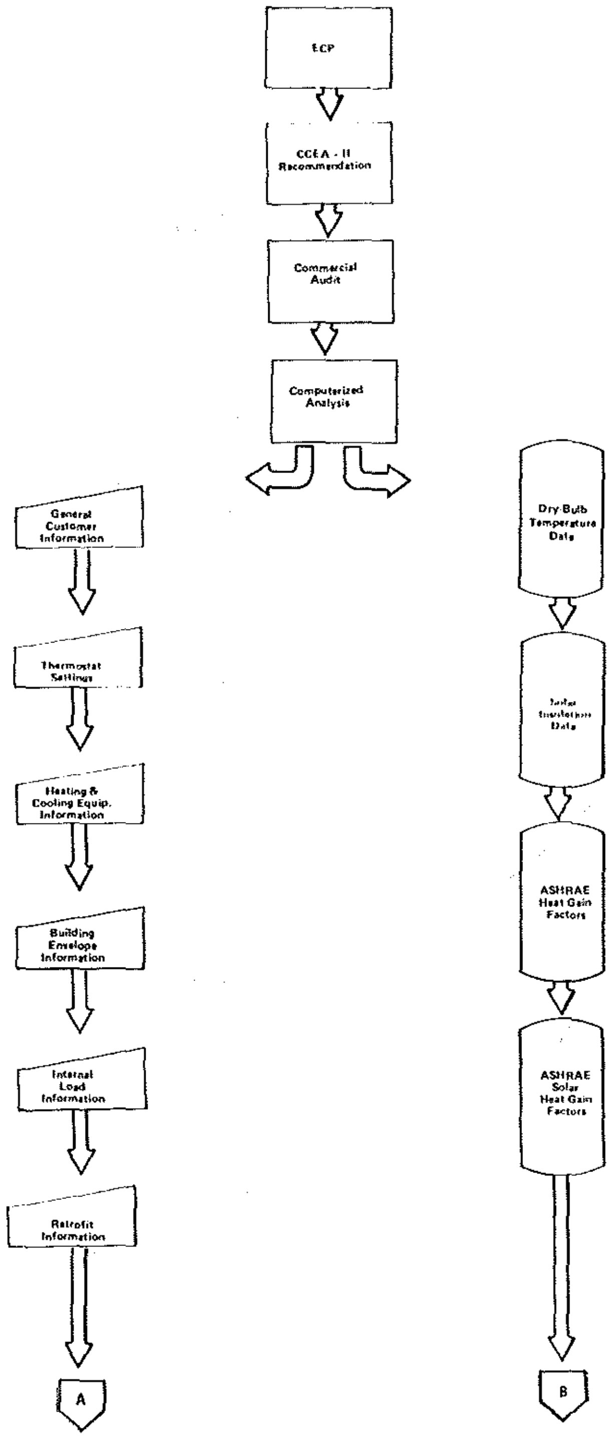


Figure 1. Commercial and Industrial Umbrella Program


ECP
CCEA - II Recommendation
Commercial Audit
Computerized Analysis
General Customer Information
Thermostat Settings
Heating & Cooling Equip. Information
Building Envelope Information
Internal Load Information
Retrofit Information
A
Dry-Bulb Temperature Data
ASHRAE Heat Gain Factors
ASHRAE Solar Heat Gain Factors
B

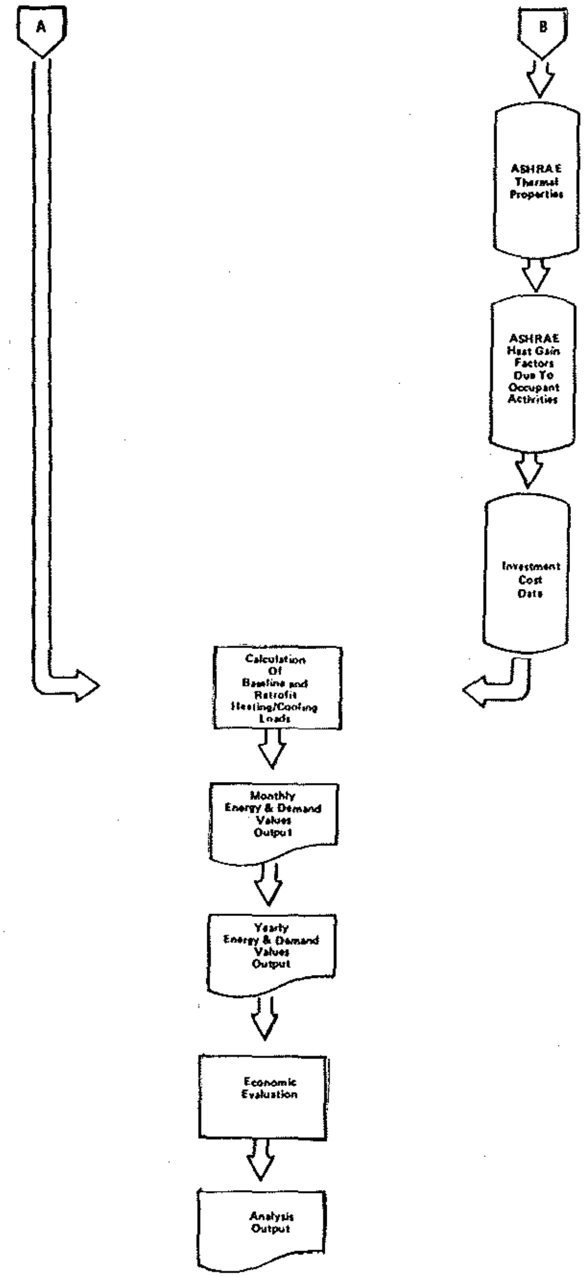


Figure 2. CCEA-II Work Flowchart

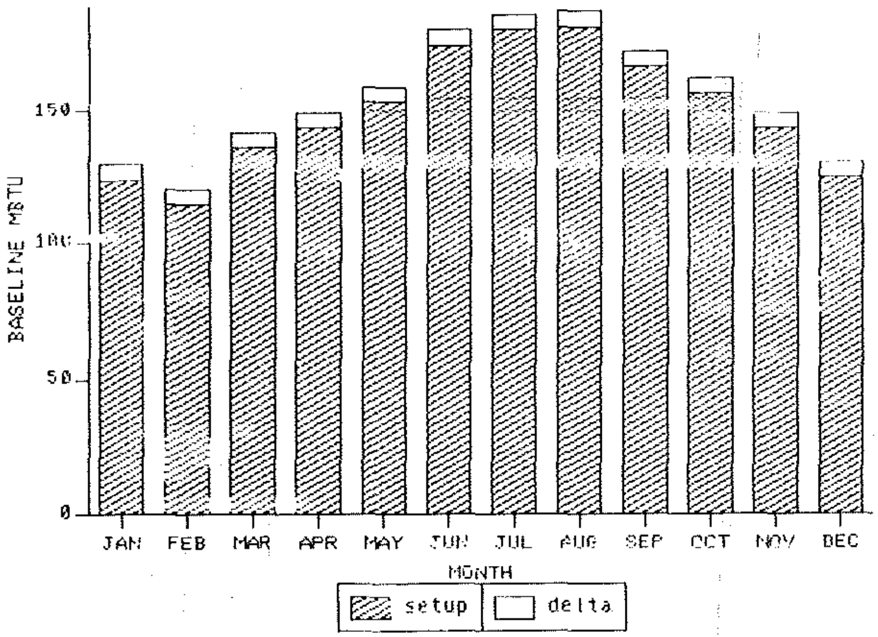


Figure 3. CCEA-II Consumption Profile

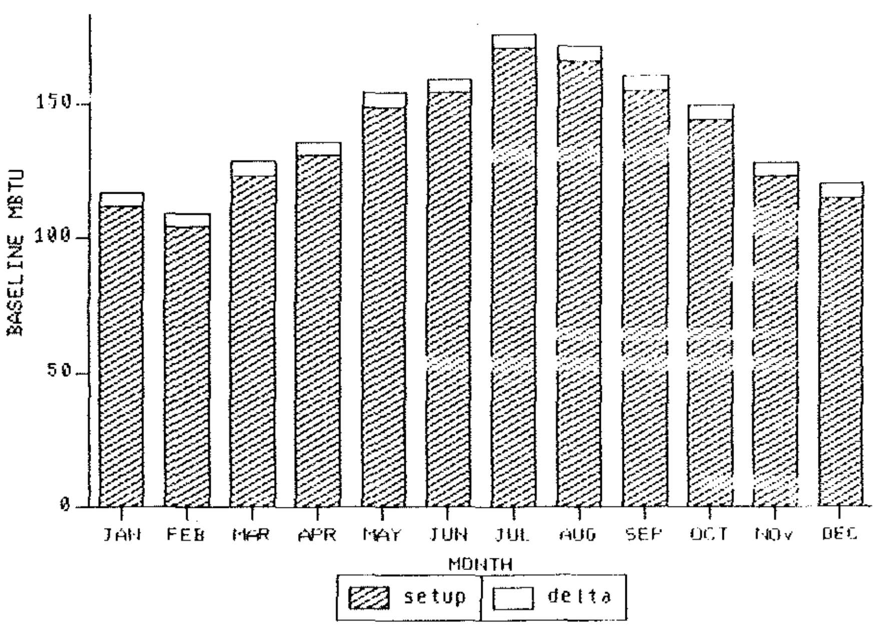


Figure 4. DCE-2.1 Consumption Profile
Baseline Building and Thermostat Setup Retrofit

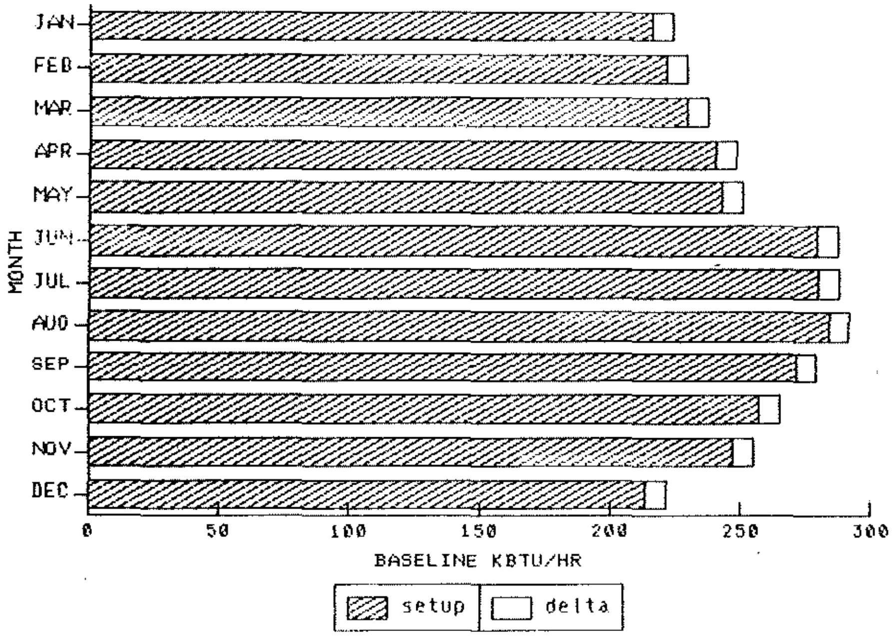


Figure 5. CCEA-II Demand Profile
Baseline Building and Thermostat Setup Retrofit

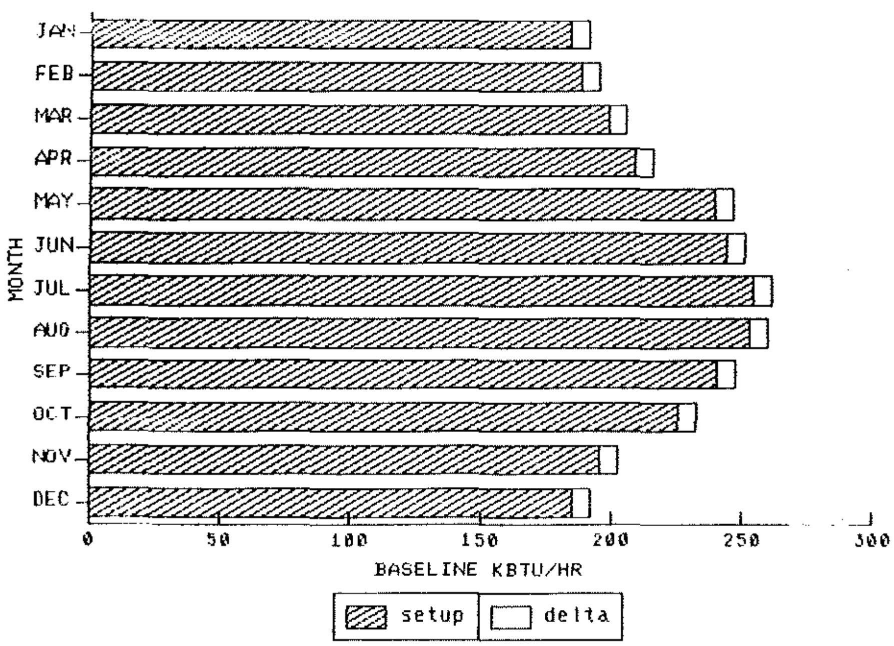


Figure 6. DOE-2.1 Demand Profile
Baseline Building and Thermostat Setup Retrofit

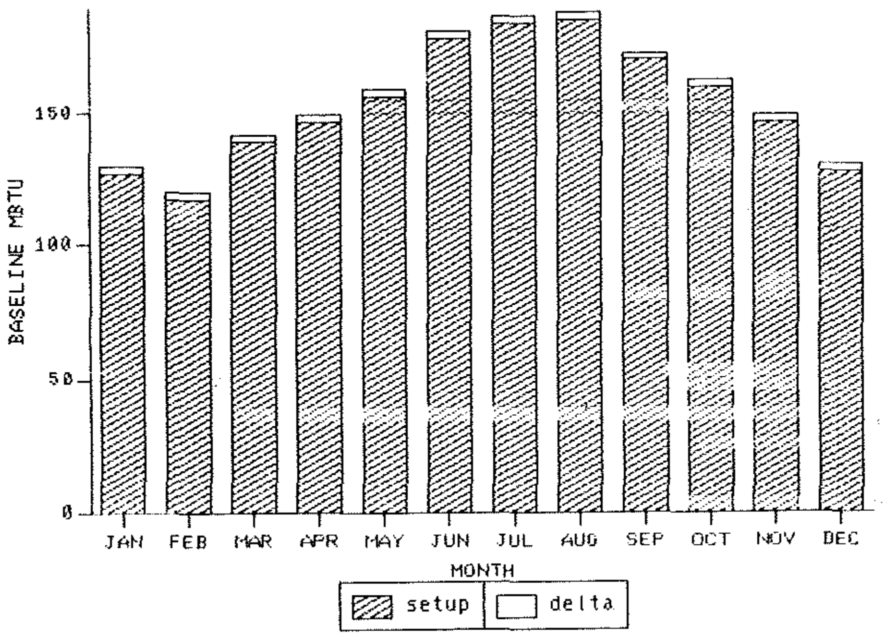


Figure 7. *CCEA-II Consumption Profile*
Baseline Building and Lighting Conversion Retrofit

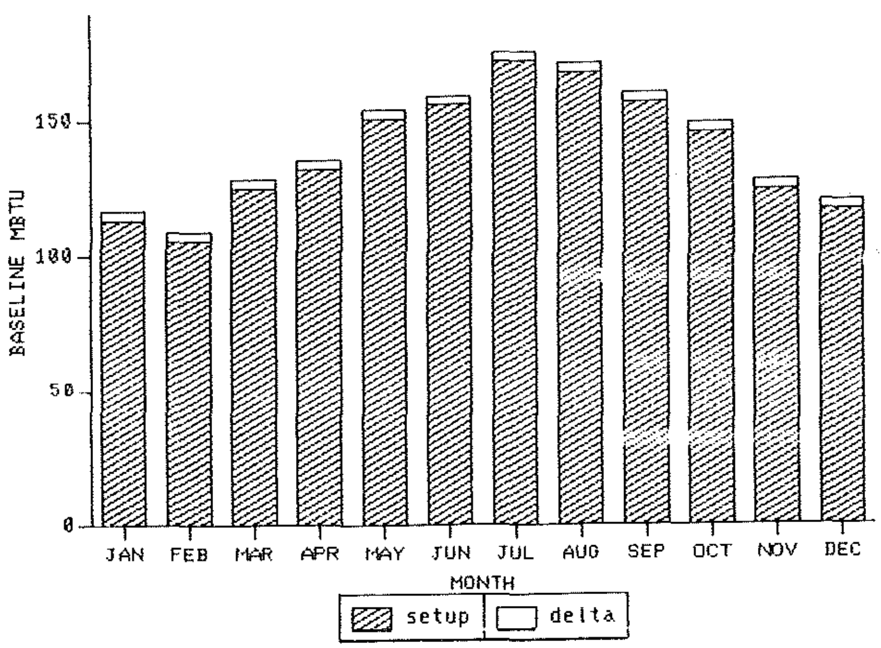


Figure 8. *DOE-2.1 Consumption Profile*
Baseline Building and Lighting Conversion Retrofit

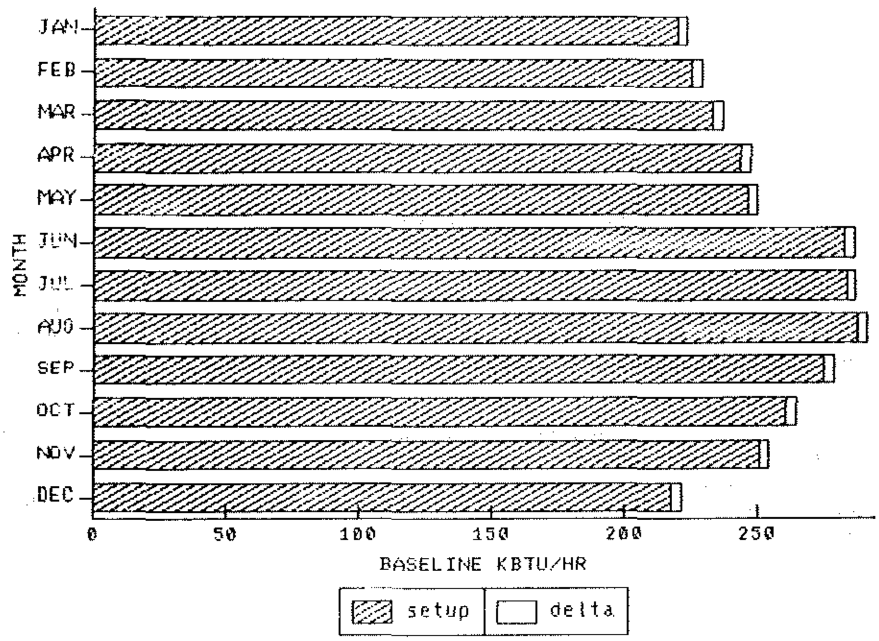


Figure 9. CCEA-II Demand Profile
Baseline Building and Lighting Conversion Retrofit

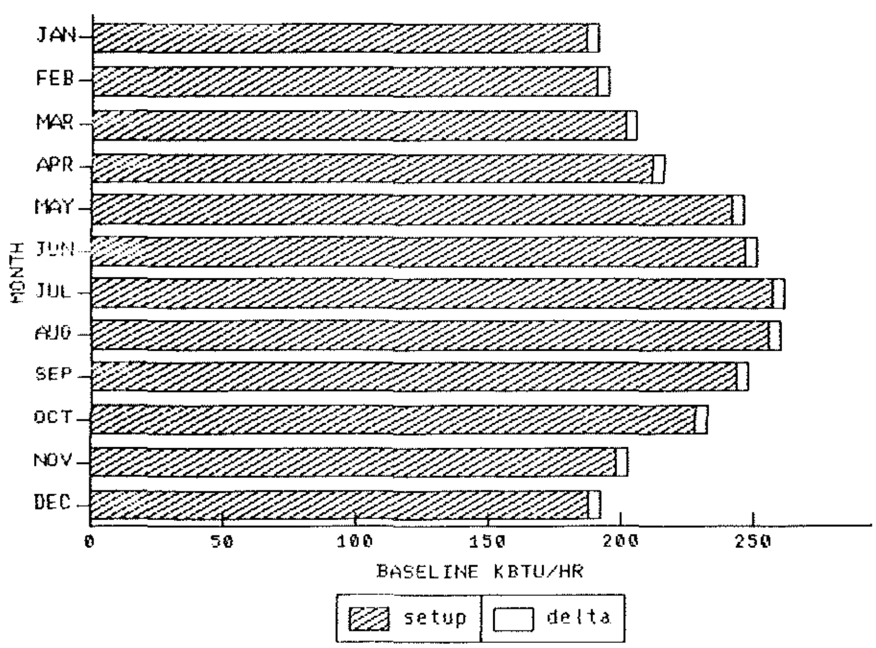


Figure 10. DOE-2.1 Demand Profile
Baseline Building and Lighting Conversion Retrofit

Discussion

L.J. Daughtry, Mississippi Power Co., Gulfport: Can the program compare efficiencies of HVAC equipment and compare heat pump with conventional system? Does your program provide energy useage for both gas and electric and corresponding rate analysis? How do you obtain the information for the program?

L.J. Lightfoot: In converting from heating and cooling BTU'S to KWH'S, the program does take into account the EER or the efficiency of the equipment. One of the possible retrofit areas is the upgrade to higher efficiency heating or cooling equipment. CCEA does simulate electric consumption, electric demand and therm usage. These simulated values are then put through the APS commercial electric and gas rates.