CHAPTER 72-2 ENERGY MANAGEMENT PROGRAM

72-2.1 INTRODUCTION

This chapter provides an overview of the IHS energy management program (EMP) and summarizes other documents, guidelines, and standards. This chapter and the IHS energy policy serve as a framework for conducting the energy program. Several common activities have critical bearing on the program success. These include training, analyzing historical utility billing records, conducting energy audits, analyzing energy conservation opportunities (ECOs), and identifying supplemental metering needs.

72-2.2 LEGISLATION

A. ENERGY PERFORMANCE TARGETS

(1) Executive Order 12902 dated March 8, 1994, established fiscal year (FY) 2005 an energy performance goal for Federal buildings. Each agency must develop and implement a program with the intent of reducing energy consumption by 30 percent by the year 2005, based on energy consumption per gross square meter of its buldings in use, to the extent that these measures minimize life cycle costs and are cost-effective in accordance with 10 CFR Part 436. The 30 percent reduction should be measured relative to the 1985 energy use. This Executive Order contains new requirements for Prioritization Surveys and Comprehensive Facility Audits (see paragraph 72.2.5), and the use of Energy Savings Performance Contracts (ESPC)(see paragraph 72-2.2C).

(2) Energy Policy Act of 1992, Public Law 102-486, establishes a comprehensive measure to promote energy efficiency in federal facilities. It requires federal agencies to install energy efficiency measures in federal buildings, directs utility regulators to encourage demand-side management (DSM) programs and other energy efficiency investments, and establishes efficiency standards for

HVAC, lighting and electric motors. It contains provisions regarding energy management requirements, life cycle cost methodology, budget treatment for energy conservation measures,incentives for Federal agencies, reporting requirements, and new technology demonstrations. It amends the National Energy Conservation Policy Act (NECPA) by replacing “Goals” with “Requirements” for reducing energy consumption rates in Federal buildings by 20 percent in use in the year 2000 from usage rates in 1985.

(3) Executive Order 12759 dated April 17, 1991, established fiscal year (FY) 2000 an energy performance goal for Federal buildings. Each agency must develop and implement a plan to meet the 1995 energy management goals of the National Energy Conservation Policy Act, as amended, 42 U.S.C. 8251, etc. By FY 2000, agencies must reduce the overall energy use of kilojoule per gross square meter (Btu per gross square foot) of the Federal buildings it operates, taking into account utilization, by 20 percent from FY 1985 energy use levels, to the extent that these measures minimize life cycle costs and are cost-effective in accordance with 10 CFR Part 436.

(4) National Energy Conservation Policy Act (NECPA) mandates existing federal buildings to; establish and achieve energy performance targets for federal buildings, and retrofit all federal buildings with 90 m^2 (1,000 square feet) or more by January 1, 1990, in accordance with preliminary energy audits conducted to improve efficiency and to minimize life-cycle cost.

(5) Federal Energy Management Improvement Act of 1988 established energy performance goals for Federal buildings. The Act requires that each agency apply energy conservation measures and improve the design of new construction such that the energy consumption per gross square meter of its buildings in use in fiscal year (FY) 1995 is 10 percent less than the energy consumption per gross square meter in FY 1985. To achieve this goal and identify high priority projects, each agency is required to:

a. Prepare or update a plan for achieving the 10 percent reduction in energy use;

b. Perform energy surveys of its facilities to the extent necessary; and

c. Apply life-cycle costing (LCC) methods in the design of new buildings and in the selection of conservation measures for existing buildings.

B. ENERGY-EFFICIENCY STANDARDS

(1) Omnibus Reconciliation Act of 1981 established building standards in the Federal facilities program. It requires that energy-efficiency standards for Federal buildings be developed and disseminated to Federal agencies.

(2) Department of Energy (DOE) Standard was first issued in November 1988 and is voluntary for the private sector, but mandatory for Federal buildings. The DOE Standard is a slightly modified version of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)/Illuminating Engineering Society (IES) Standard 90.1. It was developed for new buildings, but it is applicable as a cost-effective method for retrofitting existing buildings when it is coupled with DOE's LCC procedures.

These standards are expected to be used in the following way for any major building retrofit project:

a. Building will be audited to compare the energy efficiency of its walls, roof, HVAC equipment, and other components with those specified for that climate in the DOE Standard;

b. Retrofit measures necessary to bring the building close to the DOE Standard would be subject to the net benefit analysis of the LCC procedure to determine the applicability of each energy-savings measure. The measures would then be ranked according to the savings-to-investment ratio (SIR) calculation of the LCC procedure; and

c. Retrofit plan would be developed to include those measures that are cost-effective under the DOE LCC procedures.

C. ENERGY SAVINGS PERFORMANCE CONTRACTING

(1) Definition: Energy Savings Performance Contracting (ESPCs) is a contracting method whereby the contractor incurs "costs of implementing energy savings measures, including at least the costs (if any) of providing energy audits, acquiring and installing equipment, and training personnel, in exchange for a share of any energy savings directly resulting from implementation of such measures during the term of the contract.

The ESPC shall provide that the contractor will incur costs of implementing energy savings measures, including at least the cost of making energy audits, acquiring and installing equipment, and training personnel, in exchange for a share of any energy savings directly resulting from implementation of such measures during the term of the contract.

The ESPC shall provide that the contractor is responsible for maintenance and repair services for any energy related equipment, including computer software systems.

The ESPC shall be implemented in a facility not to exceed 25 years.

(2) Authority to Enter into a ESPC: Section 155 of the Energy Policy Act of 1992 amends NECPA, Sections 801 to 804, relating to shared energy savings. Title VIII, Energy Savings Performance Contracts, Section 801, provides new language giving agencies the authority to enter into energy performance contracts and describes the methodology of contract implementation.

(3) Steps Required to Implement an ESPC: Training will be required for Engineering Services (ES) Project Officers and Procurement Specialists, and Area offices Project Officers. They will be required to take training on appropriate procedures and methods for use by Federal agencies to select, monitor, and terminate contracts with energy service contractors. ES would then take the following steps:

a. Select firms from a list prepared by the Secretary of Energy, and request technical and price proposals from these firms;

b. Select from the list of firms the most qualified firm, and provide energy savings services based on technical and price proposals;

c. Permit receipt of unsolicited proposals from qualified firms, and require agency facility managers to place a notice in the Commerce Business Daily announcing they have received such a proposal and invite other similarly qualified firms to submit competing proposals; and

d. Enter into an energy savings performance contract with a firm that is qualified.

(4) Benefits: The ESPC benefits are as follows:

a. Energy audits can be performed on IHS facilities at no cost up-front.

b. The facilities will become state-of-the-art. This may force some facility managers or mechanics to increase their skill level.

c. Firms will be fully responsible for designing, installing, and modifying all equipment. As a result, the success rate will be much higher than in the past. In the past, the commissioning of direct digital control (DDC) systems did not worked because there were many designers who lacked hands-on experience and installers who were quick to issue change orders. The ESPC method will eliminate some of the issues that goes with conventional contracts.

(5) Drawbacks: The ESPC drawbacks are as follows:

a. In most cases, these energy audits will not meet the requirements of comprehensive facility audits set forth by Executive Order 12902. Since these firms are performing energy audits with no compensation upfront, they are likely will not spend the time and money that would be necessary for a comprehensive survey.

b. ESPCs have many hidden costs such as future service contracts, training, government contracting and project management. The contracting and project management will have significant impact on the Area and Service Unit workload. Training is other hidden cost often overlooked. For example, once a Building Automation System (BAS) has been properly designed, programmed, and installed, the process of training facility staff should start to enable them to maintain the new systems. It takes a combination of available staffing and trainable people. Other hidden cost is to require a future BAS service contracts. A new BAS may be beyond the facility manager's current and future capacity to maintain, even with available and competent staff.

(6) Alternatives: Alternatives to Energy Savings Performance Contracting are as follows;

a. The Agency is required by law to perform comprehensive audits on 10 percent of Federal facilities every year. The comprehensive audits will analyze all facets of the energy consuming systems such as boilers, chillers, piping distribution, HVAC, electrical, and building envelopes. Energy conservation opportunities will be identified and life cycle cost methods will be employed to select and rank the most effective opportunities. These life cycle cost methods should take into account future service contracts.

b. If a facility is able to pay for these projects up-front, a Facility Manager will not need to tap into IHS professional resources and still be able to achieve energy savings.

D. UTILITY SYSTEM REBATE PROGRAMS

IHS Areas are authorized and encouraged to participate in programs to manage electricity demand conducted by gas, water, or electric utilities. If a proposed program satisfies the criteria which generally apply to other customers of a utility incentive program, the Area may not be denied collection of rebates or other incentives. An amount equal to 50 percent of the energy and water cost savings realized by an Area shall, subject to appropriation, remain available for expenditure by such Area for additional energy efficiency measures which may include related employee incentive programs, particularly at those facilities which energy savings were achieved. Areas shall establish a fund and maintain strict financial accounting and controls for savings realized and expenditures made with the collection of rebates or other incentives.

E. LIFE-CYCLE COSTING (LCC)

Life-cycle costing methods and procedures as set forth in 10CFR, Part 436, Subpart A, are to be followed by all Federal agencies, unless specifically exempted, in evaluating the cost effectiveness of potential energy conservation and renewable energy investments in federally owned and leased buildings. The LCC methodology is used as the primary criterion for allocating funding for energy conservation retrofit measures to existing Federal buildings.

For a brief description of the LCC methods, refer to Section 72-2.6, Analysis of Energy Conservation Opportunities, paragraph D. For a complete description of LCC methods refer to the following manuals and software program:

(1) Life Cycle Costing Manual for the Federal Energy Management Program. Call (202)586-5772 (no fee).

(2) Energy Prices and Discount Factors for Life Cycle Cost Analysis. Call (202)586-5772 (no fee).

(3) NIST "Building Life Cycle Cost" BLCC, software program. Call (202)586-5772 (no fee).

72-2.3 TRAINING

A. ENERGY COORDINATOR AND AREA FACILITIES ENGINEERS

The Energy Policy Act of 1992, enacted October 24, 1992, requires all Federal agencies to "establish and maintain a program to ensure that facility energy managers are trained energy managers." The Act defines a trained energy manager as " a person who has demonstrated proficiency or who has completed a course of study in the areas of:

(1) Building energy systems

(2) Building energy codes and applicable professional standards

(3) Energy accounting and analysis

(4) Life-cycle cost methodologies

(5) Instrumentation for energy surveys and audits

B. FACILITIES MANAGERS

Facilities managers should have working knowledge of the following subjects:

(1) Fundamentals of building energy systems

(2) Applicable professional standards

(3) Energy accounting and analysis

(4) Instrumentation for energy surveys

C. TRAINING SOURCES

(1) Periodicals and Bulletins

a. Energy Design Update Newsletter. Call 1(800)888-8939 (fee @ $150.00/year).

b. Federal Energy Management Program (FEMP) Focus, Bi-monthly Bulletin. Call (202)586-5772 (no fee).

(2) Training Courses

a. Energy Management Training

Description: The short course is one and a half days days designed for facility managers who are not interested in passing a 4 hour exam adminstered by the Association of Energy Engineers. It is tailored to meet the specific needs of the facility managers and will usually consist of Codes and Standards, Economics, Energy Audits, Electrical, Mechanical and HVAC Systems, Control Strategies, and the Maintenance Program.

The four day course covers all the necessary technical training to prepare for a 4 hour exam adminstered by the Association of Energy Engineers (AEE). Those who pass the exam are certified by AEE as a Certified Energy Manager (CEM). The course outline includes; Codes and Standards, Economics, Energy Audits, Electrical, Mechanical and HVAC Systems, Building Envelope, Cogeneration, Procurement of Fuel, Energy Management Systems, Control Strategies, Thermal Energy Sources, Lighting, and the Maintenance Program. The course involves a lot of calculations.

An optional “Energy Managers Exam” will be offered on the day following the course with no fee. For assistance, call Indian Health Service, Office of Public Health, Division of Facilities and Environmental Engineering, at extension (301)443-7998.

(3) Manuals and Books

a. Architect's and Engineer's Guide to Energy Conservation in Existing Buildings, Volume 1 - Energy Use Assessments and Simulation Methods, April 1990. Call (202)586-5772 (no fee).

b. Architect/Engineer’s Guide to Energy Conservation in Existing Buildings, Volume 2 - Energy Conservation Opportunities, April 1990. Call (202)586-5772 (no fee).

c. Life Cycle Costing Manual for the Federal Energy Management Program. Call (202)586-5772 (no fee).

d. Energy Prices and Discount Factors for Life Cycle Cost Analysis. Call (202)586-5772 (no fee).

e. ASEAM 5.0 User's Manual. Call (703)243-4900 (no fee).

(4) Computer Software Programs

a. NIST "Building Life Cycle Cost" BLCC. Call (202)586-5772 (no fee)

b. DISCOUNT - Calculates the present worth, future worth, and annual values for any discount rate and study period; Call (202)586-5772 (no fee).

c. A Simplified Energy Analysis Method - Estimates energy consumption for new designs or renovations. Call (202)586-5772 (no fee).

(5) Video Tapes

a. Introduction to Life Cycle Costing and a manual (60 minutes tape) with a fee of $19.00 (shipping is included with the cost). Call Video Transfer Incorporated @ (301)881-0270 or write to 5709 B Arundel Ave., Rockville, MD 20852.

72-2.4 ANALYSIS OF UTILITY DATA

A. PRIOR ENERGY STUDIES

Most of the major facilities in IHS have had energy assessments in the mid 1980's. The Area energy manager should collect this information and make a list of those facilities that have been audited, and the date of the audit. In addition, the list should include those facilities that have not been audited.

B. BILLING RECORDS

The Areas should keep prior billing records dating back to 1985. The billing records should include the quantities of energy consumed, the meter reading dates, and the utility rate structures.

C. CLIMATOLOGICAL SUMMARIES

The Area energy manager and service unit facility manager should obtain climatological summaries for each service unit indicating heating and cooling degree days and the daily minimum and maximum temperatures. The National Climatic Data Center collects data in 300 sites located throughout the United States.

D. SALIENT CHARACTERISTICS OF EACH FACILITY

The Area should collect and file salient characteristics and documents pertaining to the facility, such as the square meter of the buildings; construction documents; history of additions, demolitions, or other changes in the building stock or tenancy; central plant capacities and operation logs; and prior energy studies or conservation initiatives.

72-2.5 SCREENING FOR ENERGY-EFFICIENCY OPPORTUNITIES

A. Types of Energy Audits for Buildings

The first task to be undertaken when screening a facility (or facilities) for energy-efficiency improvements is to assemble accurate information on the facility's characteristics and on conservation opportunities. The three types of audits that should be undertaken as discussed in this section.

These energy audits should fall into one of the three categories or types:

(1) Ranking or Walk-Through Surveys - Each Area should conduct a ranking survey of all IHS-owned facilities. In accordance with Executive Order 12902 Section 302, this survey should have been completed for all facilities by November 1995. The survey should be used to establish priorities for conducting comprehensive facility audits.

a. The information to be gathered during the ranking survey can be divided into four categories:

- Overall facility information
- Information on major energy-using systems/equipment
- Types of systems/equipment contained in the building
- Energy billing data.

b. Of particular importance are the billing data, which are used to calculate the energy use per gross square meter (kJ/m^2) or (Btu/ft^2). These data can be compared with other facilities under study to focus on the poorest performers in the group. Also the energy consumption per gross square meter for one building can be compared to others of similar function. The energy consumption per gross square meter for one building can be compared over time to note any significant changes.

c. Conducting a walk-through audit of the building to allow the energy analyst to identify functional areas or zones of the building that will be useful for the next audit step. A zone consists of a portion of the building that shares common features such as operating schedule, thermostat set points, similar loads, type of HVAC system, outside wall/roof exposure.

d. If possible, architectural, electrical, and mechanical systems contract drawings should be used for zoning, ensuring that all updates to the systems have been noted.

e. Also on the walk-through audit, a description and location of all major energy systems should be obtained, including HVAC equipment, lighting systems, and control equipment. Any other major uses of energy in the building, such as computers, laundry, food services, should also be noted. Additionally, the fuel and energy usage of the equipment should be noted, if possible.

(2) Comprehensive Facility Audits - Each Area should conduct these audits based on a 10 percent of their facilities every year. According to Executive Order 12902 Section 102, this audit is a survey of a building that provides detailed information to allow an agency to enter into energy performance contracts or to invite inspection and bids by private contractor for direct agency funded energy or water efficiency investments.

a. While the priority survey may be conducted by the building manager, the comprehensive facility audit may be done cost-effectively by a professional audit company. The information gathered during this survey will be used to model the energy use of the building, as well as to identify ECOs. The model used should be able to show the effect of implementing various ECOs.

b. The audit-information is divided into the following five categories of types of data:

- Building envelope or shell
- Process loads
- Heating, ventilating, and air conditioning
- Lighting and electrical systems
- Weather

(3) End-Use/Equipment Audits - Each Area should conduct the end-use and equipment audits based on the following:

a. The end-use/equipment audit should be undertaken only if the building audit shows a need for further information on a particular ECO. For example, a complete boiler analysis may be identified as a need in the building audit. In most cases, a professional boiler expert or engineer will needed to perform this audit. Similarly, a professional HVAC engineer will be needed to evaluate the performance of the cooling plant components.

b. Another method of gathering detailed data for some systems (e.g., lighting and electrical) is to provide meter or monitor the end-uses of energy in the building. This method allows the total energy use in the building to be desegregated to a significant degree. The metering of end-uses is very expensive and time-consuming, and this is only undertaken if it seems that significant savings will result from the identification of ECOs.

B. <u>ENERGY CONSERVATION OPPORTUNITIES (ECOS)</u>

This paragraph provides a brief overview of Energy Conservation Opportunities (ECOs). Refer to the following documents for a complete description of ECOs:

(1) Architect/Engineer's (A/E) Guide to Energy Conservation in Existing Buildings, Volume 1 - Energy Use Assessments and Simulation Methods, April 1990. Call (202)586-5772 (no fee).

(2) A/E’s Guide to Energy Conservation in Existing Buildings, Volume 2 - Energy Conservation Opportunities, April 1990. Call (202)586-5772 (no fee).

72-2.6 ANALYSIS OF ENERGY CONSERVATION OPPORTUNITIES (ECO)

A. <u>ECO Category</u>

An ECO may be realized either by implementing operation and maintenance (O&M) measures or by incorporating available technologies. The most common ECOs found in existing buildings fall into one of the following categories, each of these energy conservation areas is briefly described below:

(1) Building Equipment Operation - An enormous amount of energy is wasted because building equipment is operated improperly and unnecessarily. When the building is not occupied, the building systems should be turned off or their operation must be reduced to minimum. Depending on building operations, the operating hours can be curtailed during low demand for HVAC systems, water heating systems, lighting systems, escalators and elevators, and other equipment and machinery. Care must be taken to ensure that the reduction in hours has no impact on building operations and systems.

(2) Building Envelope - a) The amount of sensible and latent heat supplied to or extracted from the indoors to maintain a comfortable indoor environment is directly proportional to the difference in temperature and humidity between indoors and outdoors. One ECO is to have the heating set points backward when the building is not occupied. Care must be taken to ensure that the slight discomfort of the occupants does not reduce their productivity; b) The amount of energy is saved when the heat exchange between the building and the outside environment is reduced and/or solar and internal heat gains are controlled. The primary way to reduce heat conduction through ceilings/roofs, walls, and floors is by adding insulation. Another method is to install vapor barriers in ceilings/roofs and walls. To control or reduce solar heat gains through the roof or glazing areas, a reflective surface or film can be used. For glazing areas, the installation of interior or exterior shading will also help control solar heat gain. The installation of storm window or multiple-glazed window will also reduce heat conduction and radiation through glazing areas; and c) The amount of air infiltration or unintended entry of unconditioned air into the building through doors, windows, and other openings in the building envelope can result in large increases in heating and cooling loads. Many air infiltration control strategies are inexpensive and relatively simple to implement. The amount of energy can be saved by sealing vertical shafts and stairways, caulking and weatherstripping doors and windows, or installing vestibules and revolving doors.

(3) HVAC Systems - The HVAC systems in the buildings are made up of energy conservation equipment that transforms

electrical or chemical energy to thermal energy, and the distribution and ventilation systems that transport the thermal energy and supply fresh outdoor air to the conditioned space. Energy may be saved in HVAC systems by reducing ventilation requirements; improving the performance of space conditioning equipment such as boilers, furnaces, chillers, air conditioners, and heat pumps; using energy-efficient cooling systems; and reducing the occurrence of reheating or re-cooling.

(4) HVAC Distribution Systems - The HVAC distribution systems transport the heating and cooling fluids (generally air, water, or steam) from the central plants (chillers, boilers, etc.) to the conditioned space. The system is made up of a network of pipes, ducts, fans, pumps, grills, etc. An energy is required by the fans and pumps to transport the working fluids. In addition, thermal energy is lost from the distribution system by reducing heating or cooling capacity. Consequently, ECOs for distribution systems fall into two areas: reduction of energy required to transport fluids, and reduction of energy losses during transport.

(5) Water Heating Systems - The heating and distribution of hot water requires less energy than space conditioning and lighting. However, for some cases such as hospitals, restaurants, kitchens, and laundries, water heating amounts to substantial energy consumption. Water heating energy is conserved by reducing load requirements and distribution losses, and improving the efficiency of the water heating systems.

(6) Lighting Systems - The lighting accounts for a significant fraction of energy consumption in a building. The energy is saved and the electric demand is lower by reducing illumination levels, improving lighting system efficiency, curtailing operating hours, and using day lighting. The reduction of lighting energy can also increase the energy use of building heating and decrease cooling system consumption, since internal heat gains are reduced. However, this heat generated by lighting is often an expensive method of heating a building. If the building cooling plant is to be replaced, implantation of lighting ECOs will reduce the required plant size.

(7) Power Systems - a) The inefficient operation of power systems stems mainly from a low power factor. Power

factor correction is cost-effective when utility penalties are imposed. Low power factors can be improved with power factor correction devices and high-efficiency motors. Additional energy can be saved by smaller and/or higher efficiency motors, or by installing variable-speed motor drives; b) The peak power demand can be reduced by load-shedding, or applying co-generation technology. Load-shedding may also reduce the total power consumption, as well as the demand. Co-generation systems will increase the use of on-site energy, but can also replace electricity consumption with less expensive fossil energy. Also, the waste heat from the co-generation equipment can meet thermal loads. Cool storage systems shift the chiller demand to off-peak periods, thus reducing on-peak demand; and c) The evaluation of these ECOs requires a determination of the building demand profile. Several weeks of data gathering in 15-minute intervals should be taken with a recording meter. The measurements will be taken both in the cooling and heating season. Most electric utilities will provide this service at a nominal charge.

(8) Energy Management Control Systems - a) The energy can be saved by providing an automatic control of energy systems though the use of energy management and control systems (EMCSs). Rising energy costs and decreasing prices for computers and microprocessors have encouraged the use of EMCSs. An EMCS can efficiently control the heating, ventilating, air conditioning, lighting, and other energy-consuming equipment in the building. It selects optimum equipment operating times and set points as a function of electrical demand, time, weather conditions, occupancy, and heating and cooling requirements. The basic control principles for building energy conservation are to operate equipment only when needed; to eliminate or minimize simultaneous heating and cooling; to supply heating and cooling according to actual needs; and to supply heating and cooling from the most efficient source; and b) Several companies manufacture EMCSs, and new technology is continually being developed. EMCSs are very sophisticated and it requires maintenance personnel to have an extensive training to analyze and fully use this system. Each service unit should procure their EMCSs from a single manufacturer, even if this requires developing an sole-source justification.

(9) Heat Recovery/Reclaim Systems - The heat recovery is the reclamation and use of energy that is otherwise rejected from the building. When applied properly, heat reclaim systems may be used to reduce energy consumption, as well as peak power demand. The effectiveness of a heat reclaim system for energy conservation depends on the quantity and temperature of the heat available for recovery, as well as the application of the reclaimed heat.

B. <u>Energy Models</u>

(1) For detailed information, refer to the following manuals and software programs:

a. ASEAM 5.0 User's Manual. Call (202)586-5772 (no fee).

b. A Simplified Energy Analysis Method software program. Call (202)586-5772 (no fee).

(2) By using an energy model rather than manual techniques, it offers the following improvements accurately:

a. Building parameters can be precisely scheduled.

b. The impact of weather can be precisely determined.

c. Equipment performance can be specified at part-load.

d. Variable interactions such as the effect of internal lighting reductions on heating and cooling loads can be calculated.

(3) Before personal computers were used, building energy analysts had limited choices of calculation methods for evaluating ECOs. They used manual calculation methods and nomographs. Those methods are simple and require a low level of effort from the user. However, those methods are not as accurate and comprehensive as automated methods of calculation.

(4) Automated calculation methods were usually available, however, mainframe computers and their use was costly, complicated, and time-consuming. These methods provided much greater accuracy and could evaluate building energy use hourly. With the availability of the personal computer, automated methods for analyzing building energy

became accessible to a wider range of building professionals. Today, many software packages for analyzing building energy are available for the personal computer.

(5) A simplified energy analysis method (ASEAM) is a model used to analyze the effects of several of the ECOs discussed above. ASEAM is a modified bin method program for calculating the energy consumption of residential and simple commercial buildings. ASEAM runs on an IBM-PC and compatibles with 256 kilobytes of memory and two disk drives. Like most building energy analysis programs, ASEAM performs calculations in four segments:

a. Loads - Thermal heating and cooling loads (both peak and diversified or average) are calculated for each zone by month and by outside bin temperature. Lighting and miscellaneous electrical consumption are calculated in this segment.

b. Systems - Thermal loads calculated in the loads segment are passed to the systems segment which calculates "coil" loads for boilers and chillers. The system coil loads are not equal to the zone loads calculated above because of ventilation requirements, latent cooling, humidification requirements, economizer cycles, reheat, mixing, etc. Some building energy requirements are calculated in the systems segment (e.g.,heat pump and fan electricity requirements).

c. Plant - All of the systems coil loads on the central heating and cooling plant equipment are then combined, and calculations are performed for each central plant type. Plant equipment can also impose loads on other plant equipment, such as cooling tower loads from chillers and boiler loads from absorption chillers of domestic hot water. The plant calculations result in monthly and yearly energy consumption figures for each plant type.

d. Economic - Energy consumption from all the building end-use categories is then totaled and reported. If specified, the LLCs of the total energy requirements combined with other parameters, are calculated and reported. In the parametric and ECO calculation mode, a baseline case may also be compare with alternative cases.

(6) The ASEAM program is recommended as the initial energy-use assessment tool for residential and commercial buildings. It is relatively simple and inexpensive to use, and a good program of accounting for the complexities of energy use.

C. SELECTION OF SUPPLEMENTAL METERING POINTS

(1) An understanding of energy-use effectiveness is often constrained by a lack of data on energy system performance. The measurements taken on a regular basis are useful to assess energy-efficiency levels and the effects of operational or design changes. These measurements may be continuous such as utility meters, or may be for short periods of time such as combustion efficiency tests. Some of the most critical measurements are listed below:

a. Electrical consumption levels by day of the week (working and non-working days) and month of the year.

b. Electrical demand levels by hour of the day and season of the year.

c. Interior lighting levels, efficacy, and schedules.

d. Interior temperature levels by hour of the day and season of the year.

e. Chiller and boiler efficiency levels under partial loadings.

f. Make-up water requirements for steam and hot water distribution system.

g. Exterior temperature, humidity, and solar radiation.

h. Areas of heated, cooled, and unconditioned space.

i. Capacity ratings and hours of operation for major equipment such as pumps, fans, and street lighting systems.

j. Thermal conductance (U-value) of conditioned building envelopes.

k. Sub-metered electrical consumption for major building and equipment loads such as fans, pumps, lighting, and process equipment.

l. Sub-metered hot water, chilled water, and steam measurements for individual buildings and/or central plant headers.

m. Hours of operation and other facility production/use factors.

(2) The costs of collecting and processing data are significant barrier to scientific investigations of energy use and conservation potential. The need for accurate data must be balanced against the higher costs of collecting and processing. The developments in energy metering and analyses techniques are reducing the measurement costs while improving the quality and amount of data available. While some measurements identified require sophisticated equipment and skilled technicians, others may be readily available from the building designers, servicing utilities, or the National Weather Service.

(3) The energy analyst must verify the quality of the data before incorporating them to an analysis. This requires some judgement factor by the user on the comparison of measurements and/or use of engineering calculations. While errors cannot always be found, inaccuracies in major items such as meter readings, motor capacities, square meter calculations, and meter multipliers and reading dates found should be corrected.

D. LIFE CYCLE COST (LCC) ANALYSIS AND RANKING PROJECTS

(1) The LCC method of economic evaluation takes into account all costs (design, system, component, material, practice,etc.) of a building over a given period of time, adjusting for differences in the timing of these costs.

(2) The data on cost and savings from a project can be combined in a number of different ways to evaluate its economic performance. For evaluating potential projects, one or more of the following modes of analysis are required:

a. Total Life Cycle Costs (TLCC) - TLCC is the sum of all significant dollar costs of a project discounted to present value.

b. Net Life Cycle Savings (NS) - NS is the decrease in the TLCC of a building or building system that is attributable to an energy conservation or renewable energy project.

c. Savings-to-Investment Ratio (SIR) - The SIR is a numerical ratio, the numerator is the reduction in energy costs, net of increased non-fuel operation and maintenance costs; the denominator is the increase in investment cost, minus increased salvage values, plus increased replacement costs.

d. Payback Period (PB) - The PB is the elapsed time between the initial investment and the time at which cumulative savings in energy costs, net of other future costs associated with the project, are sufficient to offset the initial investment costs.

The four modes of analyses are not equally suitable for choosing among alternative new building designs, for designing and sizing projects for new and existing buildings, or for ranking available retrofit projects of the existing buildings, or for ranking available retrofit projects of their relative cost-effectiveness. For instance, TLCC is generally for choosing among alternative designs for a new building, while SIR is best for ranking retrofit projects according to their cost-effectiveness.

(3) Based on these analyses, priority is given to projects with the highest LCC savings-to-investment ratio. The NECPA requires that changes in operations and maintenance procedures have priority over measures requiring substantial structural modification or installation of equipment. The energy-efficiency considerations should not adversely impact the mission responsibilities of the agencies according to DOE standards.

(4) One of the first tasks of the energy management team is to determine the present energy end-uses and establish achievable goals for improving energy efficiency. These activities necessitate an accounting of energy flows and a reasonable comprehensive understanding of the characteristics of energy-using systems. Initial program

investments should be focused on identifying information gaps, and carrying out energy-use survey and metering projects.

(5) For a complete description of LCC methods refer to the following manuals and software program:

a. Life Cycle Costing Manual for the Federal Energy Management Program. Call (202)586-5772 (no fee).

b. Energy Prices and Discount Factors for Life Cycle Cost Analysis. Call (202)586-5772 (no fee).

c. NIST "Building Life Cycle Cost" BLCC software program. Call 202)586-5772 (no fee).