Chapter 10

Savings/Cost Estimating

Every EMS should be economically justifiable. Every single point added to the system must contribute to the total simple payback of the capital investment for the system. The payback can be generated by energy savings, operational/labor savings, and reduced maintenance savings.

Do not be mislead that DDC alone will provide significant savings. Often the closer control achieved by DDC can increase energy consumption by eliminating the offset or the amount of time specified control conditions were not met. How a system is controlled and what controllers are installed make a big difference in how much the costs will be. After the engineer has defined the existing controls and knows what the building energy envelope is over a period of a year, he can categorize the energy-intensive areas and potential savings.

The new EMS must have changed and improved control strategies to insure savings. Dynamic control, a theory of control that involves the building mass in the control equation is a strategy that can provide savings from 5-15% over conventional control theories.

Another method to increase savings is to schedule some loads at other than peak-load times. Energy used during periods of high demand is premium priced and rescheduling loads can bring about considerable savings.

If building users are willing to accept certain inconveniences or discomforts, other savings can result. For example, room temperatures could be allowed to float from 75 to 80°F, thereby keeping costs down. Fans in some air conditioning units operate continuously simply because it has never been convenient or desirable to shut them off; shutting off the fans at night can save a lot of energy money. If fans must run continuously, then variable speed drives should be installed and through the DDC-EMS, reduced to half speed (thus saving 85% of the power) during no or low occupancy periods.

Load cycling has been a popular function of an EMS but be aware, the savings of 50% reduction in electricity consumption (fan ON 10 minutes, then OFF 10 minutes) will not offset the added maintenance costs that will appear over time (usually within a year). Motors and drives are built for continuous operation. Each time a fan system is turned on/off, belts and pulleys wear, starters are being abused, automatic valves, dampers, and controls are continually cycling; so how much money will actually be saved? It could amount to a transfer of dollars from electrical energy savings to maintenance costs.

Controllable loads will be either critical or noncritical. Critical loads are those that cannot be interrupted, deferred or reduced; noncritical loads can be altered without adversely affecting the function of the facility. Once the controls have been identified and the critical and noncritical areas delineated, the specifying engineer will know what he has to work with and what the magnitude of energy consumption is, and he can proceed to the selection process.

Maintenance savings available by utilizing the latest state-of-the-art DDC-EMS are significant. Older control systems, both computerized and conventional, often had annual maintenance costs of 10-15% of the initial capital cost. (A $250,000 EMS required a annual maintenance contract of $28,000.) The current DDC-EMS maintenance costs are in the area of 2-4% of capital cost. In spite of this lower cost, it is advisable NOT to enter into an annual maintenance agreement. The 2-4% generally requires no maintenance at all, but rather a replacement factor if something should fail. Almost like maintenance on a light bulb … if it fails, replace it. This is obviously over-simplified. The owner of EMS should provide for proper training of their maintenance staff so that most routine tasks can be handled in-house. It is important, however, to maintain a regular contact between the vendor and the system. A typical agreement might include six (6) one-day inspections per year.

Energy Management Systems in general will save 5-10% of annual electricity costs when only start/stop scheduling, optimized start/stop, demand monitoring and limiting, and night set-back are used. In other words, these savings result without either lighting control, chilled water reset, condenser water reset, or chiller optimization. But these are savings which normally result in existing buildings even where the building operators have been very energy conscious. These systems can improve upon normal manual operation and can save on demand charges where manual or time-clock operation can not. For example, if:

	Annual	5% Savings	10% Savings
Energy and Fuel Charges	$665,700	$33,285	$66,570
Demand Charges	$589,272	$29,464	$58,927
Total	$1,254,972	$62,749	$125,497

A payback criteria of three years would permit an economic expenditure of three times the above savings.

3 × $ 62,749 = $188,247
3 × $125,497 = $376,491

With DDC-EMS control, the optimum start/stop program is discussed:

> The single conventional time clock on the engineer's central control panel can be adjusted to start units at a fixed time before occupancy to permit pre-cooling of the building.
>
> The DDC-EMS program saves energy by starting the heating or cooling system only *as early as is necessary* to achieve desired indoor comfort conditions, with the start time based on outside and inside temperatures.
>
> Energy Savings: For 1000 kW of fans, the optimum start/stop program will save an estimated one to two hours for each operating day of the year, for a savings of $4,324 to $8,648.
>
> (1 hour)(5)(52)(1000)(.6)($.02772) = $4324

If a building has multiple chillers, various features of the *chiller control program* can be incorporated.

Without an EMS, the lead or first chiller with chiller water pump, condenser water pump, and cooling tower is started with a time clock. Additional chillers are started or stopped manually by the building operators. Building operators normally leave the chilled water temperature at the design setting. Condenser water temperature is controlled to the lowest permitted by the chiller manufacturer.

Discussion: The building operator will have to start and stop chillers for both day and evening use, based on the judgment of the operator. Specific starting and stopping sequences in an EMS program can save a large number of hours of chiller operation, compared to manual procedures. Many building operators begin the day by automatically starting 2 or 3 chillers at the same time on the hottest summer days and let them run all day. So the start/stop/selection procedure is important for savings.

Second, building operators normally do not change the leaving chiller water temperature of each chiller, even though that temperature is only required for the few days of the year that meet or exceed design conditions. An EMS can continually adjust the leaving water temperature, for a savings of over 1% for each degree the temperature is raised.

Third, condenser water temperature can be continually reset by an EMS in the same manner as the chiller water temperature, with a similar savings. An EMS can also reset the condenser water temperature by the ambient or outside wet bulb temperature and cycle off tower fans as the condenser water temperature approaches the outside wet bulb temperature, saving additional fan horsepower.

Fourth, an EMS can be designed to provide demand control for chillers. In addition to the savings possible through proper chiller selection to meet the instantaneous load, as already discussed, the demand limiter on each chiller can be used to set up digital outputs for stepped load capacity shedding of each chiller.

Refer to Figure 10-1 for an energy audit checklist.

There is no way to provide *demand monitoring and control* or limiting through local conventional controls. This function can only be provided through a microprocessor based DDC-EMS.

Peak demands may be classified as being of three general types:

- Morning start-up; Monday morning is usually the most pronounced, if the building cooling system has been shut down over the weekend.
- Daytime peaks
- Random peaks

Figure 10-1. Energy Audit Checklist

- Facility
  - Name
  - Use
  - Floor area
  - Number of stories
  - Roof area
- Building envelope
  - Roof construction
  - Wall construction
  - Window type
  - Floor construction
  - Exterior building dimension
- Operating schedules
  - People
  - Lights
  - Process
  - Janitorial
  - Etc.
- Day types
  - Weekday
  - Weekend
  - Holiday
  - Other
- Energy sources
  - Electricity
  - Gas
  - Oil
- Energy cost data
  - Elec. demand and consumption
  - Gas
  - Oil
  - Rate schedules
- Historical monthly energy demand, con. data for past 2 or 3 yrs
  - Electricity
  - Gas
  - Oil
- Standby power/energy sources
  - Type
  - Capacity
- Electrical characteristics
  - Voltage
  - Power factor
- Type of heating
  - Space
  - Domestic and service water
- Type of cooling
  - Space
  - Process
- HVAC systems
  - System number
  - Area served
  - Critical/noncritical
  - Type of air-side system
  - Type of water-side system
  - Type of control and existing control devices
- Outside air:
  - Minimum required
  - Maximum available
  - Measured running amps
- Energy-consuming device (other than HVAC systems)
  - Item
  - Energy demand
  - Operating requirements
  - Existing control
  - Critical/noncritical functions
  - Measured running amps
- Pumps
  - Service
  - Capacity
  - Critical/noncritical
  - Measured running amps
- Existing storage tanks
  - Item
  - Use
  - Capacity
  - Critical/noncritical
- Telephone system
  - Existing capability
  - Space capacity
- Other existing communications systems
  - Existing capability
  - Spare capacity

The manner in which these may appear on a graphical demand meter must be analyzed.

Morning Start-Up: The only effective way of controlling this type of peak is through use of some type of chiller control system which provides for a soft start.

Daytime Peaks: These peaks are caused by the natural simultaneous solar, transmission, outside air and internal load peaks and may last for several hours. In large office buildings, these peaks can be controlled only by limiting chiller loading and allowing some drift upward in space temperature.

It should be recognized that when a cooling system is designed and sized based on 1% design weather conditions, this means that, on the average, there will be only 30 hours during the year that are above these conditions.

Random Peaks: These peaks occur in most buildings and are caused by simultaneous operation of miscellaneous equipment: hot water heaters, fans, elevators, and the like. These peaks can be controlled by an EMS with demand monitoring and load shedding. Often a load will have to be shed for only one 15-minute demand interval. If the load to be shed is one step on a chiller, there will not be any discernible change in comfort conditions for such a short period of time.

For domestic *hot water control*, we use this example:

> Sixteen electric hot water heaters (52 gallons and 6 kW each) and sixteen 1/12 HP circulating pumps make up the hot water system. Each normally cycles on as required to maintain a set leaving water temperature, and the circulating pump runs continuously unless turned off.

Controlling these water heaters for energy savings alone is not economical. But when demand savings, discussed earlier, are included, such control does become feasible.

In addition to the savings identified herein, several unqualifiable benefits are derived from features such as allowing setpoint adjustment and control tuning from a central location. Trending of temperature and status also provides an extremely valuable tool in diagnosing problems.

Remember, the purpose of EMSs is to conserve as much fuel, energy and manpower as possible. Specifying these systems so that they do this efficiently, without needless and costly extras, is the best energy and cost-conserving program the engineer can follow.

The accurate analysis of an EMS requires accurate and reliable cost estimating data. Potential savings alone do not determine whether a particular function should be connected to the EMS. The cost of that function is equally important.

Several items implicate the cost estimating analysis. The first and most important is that no two EMS manufacturer's systems are identical. Another difficulty is from the reliability of budget estimates received from manufacturer's sales representatives since they are guarded about revealing detail cost information.

Each component of the system must be analyzed. The main cost components are:

1. General Cost
    — Estimation
    — System engineering
    — Shop drawing preparation
    — System testing/acceptance test
    — Training
    — Maintenance

2. Central Operator Station
3. Software/Graphics
4. Field Equipment
5. Sensors
6. Actuators
7. Control devices
8. Control Wiring/Piping
9. Transmission System/LAN

General costs involve a considerable amount of overhead time thus making them slightly dependent on the size of the EMS. These costs may be in the range of $10,000 to $15,000 depending on EMS size.

A central operator station consisting of an IBM PS/2 Model 80 with color monitor and a printer would cost approximately $5,000. Installation and check out may add $1,000.

Software is loaded into each DDC field panel, however, it is usually the same package which would cost $8,000 plus the labor (depending on number of panels). Color graphics packages vary between vendors with an average of $5,000 plus labor to build each graphic display. There may be a separate cost for specific application programs depending on the type of EMS.

Field equipment would consist of the DDC panels and any required sub-panels. The DDC panels (depending on size-number of points capacity) could be in a range of $2,000 to $5,000 each. Current DDC panels are constructed so that all point hardware is universal … inputs and output can be easily converted in the field.

Sensor costs vary depending on location, type, use, and accuracy requirements. In general, a digital/relay would be $100; an analog input/sensor $150; a transducer $250. Additional items to consider include the electric utility meter and any run-time sensing equipment.

Actuators would generally be pneumatic or electric with costs at and $200 and $400 respectively. In the past, control devices included receiver controllers, pilot positioners, servos, and other items required to make the EMS function. Today all control is with DDC which, for the most part, eliminates these devices.

Wiring and cable cost will vary and is a function of the number of connected points. Some wiring may require conduit. Control piping will require copper or polyethelene tubing. Average cost across the board might be $100 per 100' including labor.

The transmission system will depend on the manufacturer of the EMS. Some may use phone lines between field panels while some may use their own LAN configuration. Inter-Connecting within a single building may cost $5,000.

In the above cost descriptions, realizing they are certainly not scientific, but figuring 6 field panels with 200 sensors and 50 actuators (40 points/panel) for a total of 250 points, the cost totaled $140,000 or $560 per point. This is in line with EMS projects bid in the late 1980's.

After figuring the savings, the engineer must calculate the project payback. Generally, this is done on a simple payback method. If the calculation indicates that payback will take more than five years, there probably are too many items included in the project that may be nice to have but are not energy- or cost-effective. If the paycheck indicated is more than five years, the engineer should re-evaluate the system.

The specifying engineer should keep the EMS system simple but make it effective—do what is needed and forget the extras. It is important to justify everything that must be included. With the pace of current technological developments, it may be both extravagant and wasteful to specify a system whose components will become obsolete before they are put to use.