Ideas That Shape the Energy-Efficient Operations Manual

I. Energy-Efficient Operation: Goal and Required Capabilities

A building is operating efficiently if each significant energy-consuming device is using only as much energy as is necessary to perform its intended function.

The achievement of this goal requires the following capabilities:

A. The ability to determine which energy consumers have the most significant potential for excess energy use.
B. The ability to regularly determine each significant consumer's **actual** energy performance.
C. The ability to determine what energy performance is **required** to serve the current need.
D. The ability to compare the "required" to the "actual" for the purpose of detecting excess energy use.
E. The ability to correct an energy-wasting malfunction shortly after it is detected.

II. Common Facility Management Practices Do Not Ensure Energy-Efficient Operation

The operation and maintenance of energy-consuming devices in buildings is typically focused on two goals. The first is to ensure that they consistently perform their intended function (cooling, heating, illumination, etc.). The achievement of this goal is determined by a lack of occupant complaints.

The second goal is reliability, and is achieved by performing key preventative maintenance tasks. The achievement of this goal is determined by a lack of premature equipment failure.

A fundamental cause of energy waste in buildings is the erroneous assumption that energy-consuming devices that are performing their intended function, and are not prematurely breaking down, are also operating efficiently. Energy-efficiency studies consistently discover excess energy consumption by devices that are satisfying the customer and operating reliably.

The Energy-Efficient Operation process recognizes additional tasks must be added to current facility management procedures if sustained energy-efficiency is to be achieved.

III. Energy Waste in Buildings is not Self-Announcing

A common misconception in facility management is the notion that excess energy use will be self-announcing. It is believed that excess energy consumption by a heating system or cooling system would manifest itself as overheated or overcooled spaces. Energy consumers such as lights and office equipment are believed to be operating efficiently if they are meeting occupant needs and generating no complaints.

The truth is that almost every energy-consuming device is capable of using excess energy in ways that are imperceptible to their customers and operators.

Energy-efficient operation can only be achieved by the periodic performance of monitoring tasks designed to detect excess energy use. The B3 Energy-Efficient Operations Manual defines the monitoring tasks appropriate to that building and indicates a task performance schedule appropriate for the excess energy consumption risk.

IV. Minimizing Energy Waste through Prevention vs. Early Detection

It is well-documented that most energy-consuming devices can use more energy than is necessary to perform their intended function, and that this energy waste can go undetected. One approach to preventing this waste is to perform sufficient preventative maintenance to ensure that no operating inefficiencies occur. In most cases, this approach is not practical, as the following example illustrates:

The optimal energy-efficient operation of an air handling unit "economizer" mixed air temperature control depends upon the accurate performance of three temperature/RH sensors, three sets of dampers, linkages and actuators, the controlling computer software and hardware and the integrity of the signals sent between sensors, computer and actuators. Few facilities organizations have the resources to verify the performance of all these components, and the temporary employment of people who can do this work ("existing building commissioning") is expensive and therefore done once every 5 years at the very most.

The B3 Energy-Efficient Operations Manual is based upon devising simple, inexpensive methods of detecting energy wasting malfunctions soon after they occur. Devising a simple detection method for the "economizer" example above is facilitated by the fact that the accurate performance of all components will result in a predictable relationship between the outside air temperature and the mixed air temperature. A facilities staff person, provided with a simple chart or graph, would require little skill or time to detect if these two temperatures are in the correct relationship to one another. Only when the relationship is found to be incorrect would higher skills be necessary to identify and correct the malfunctioning component.

The B3 Energy-Efficient Operations Manual accepts that the avoidance of excess energy waste through preventative maintenance is not practical. The focus is instead upon devising and scheduling the performance of inexpensive diagnostic tasks that will ensure that any significant energy-wasting malfunction will be detected soon after it occurs.

V. Rationale for Simplified Energy Waste Detection Tasks

- **Buildings Waste Energy**
  Studies consistently show that most energy-consuming devices in buildings can - and often do - use more energy than necessary to perform their intended function.

- **The Current Method for Finding Energy Waste Are "Existing Building Commissioning" Studies**

These studies analyze how energy-consuming systems in buildings currently operate as compared to how they were designed to operate. This process commonly uncovers energy-wasting malfunctions.

- **Efficiencies Gained By Commissioning Projects Are Not Permanent**
  The causes of energy-wasting malfunctions are numerous and unpredictable, and not capable of being permanently "fixed". They can and often do recur.

- **Energy-Efficient Operation Requires Regular Monitoring**
  Sustained energy-efficient operation requires regular monitoring to detect energy-wasting malfunctions soon after they occur.

- **Inexpensive Energy Waste Detection Methods Are Needed**
  Commissioning studies employ considerable expertise and time in performing detailed analyses of the performance of the many components of energy-consuming systems and their controls. There is no return on investment for this work if the system under study proves to be operating efficiently. This level of analysis would be cost-effective if it was performed only on systems or devices where evidence of an energy-wasting malfunction has already been found by some simple and inexpensive waste-detection method.
  Methods to detect energy waste must be devised that are inexpensive enough to allow them to be done as often as is necessary to prevent persistent energy waste.

- **Inexpensive Waste Detection Is Possible**
  The "Energy-Efficient Operations" process has devised detection methods that require little skill or time, and use data provided by existing building control systems.

- **Existing Building Commissioning Studies Should Identify Diagnostic Tasks**
  Existing building commissioning studies should include in their scope of work the identification of the diagnostic tasks that – if performed on the schedule recommended – would ensure the early detection of energy-wasting malfunctions.

VI. How Energy-Efficient Operation Tasks Are Selected

- Almost all energy-consuming devices have the potential to use more energy than is necessary to perform their intended function.

- In general, the largest energy-consuming devices or systems have the largest potential for excess energy consumption.

- Most facilities have limited resources to expend on ensuring that energy-consuming devices use only as much energy as necessary.

- An annual energy use allocation is a procedure for assigning the annual total metered or modeled energy use to the buildings' various energy-consuming devices or systems. The assignment of operating-efficiency tasks should begin with the largest consumers identified in the allocation,

and proceed towards the smaller until approximately 80% of the annual energy consumption will be monitored by the energy-efficient operation tasks.

- Most energy-consuming devices are vulnerable to excess energy use in a number of ways. The highest priority in the selection of energy-efficient operation tasks should be given to the vulnerabilities with the highest waste potential and/or the highest likelihood to occur.

  For example: a large AHU may be vulnerable to operating more hours than necessary (possibly wasting $8,000 per year) and also vulnerable to excess humidification (possibly wasting $200 per year). In this example, a high priority would be given to a task to ensure that the unit only operates when necessary.

  Selecting energy-efficient operations tasks based upon an understanding of annual energy use and waste vulnerabilities will ensure the maximum benefits from the tasks.

VII. How Energy-Efficient Monitoring Tasks Are Designed

- Measure performance at the energy-consuming device
  While utility meters yield useful information about building energy consumption, assessing the performance of individual devices is far more accurate if based upon measurements taken at or near to the device.

- The monitoring of energy-efficient operation does not require measuring or metering units of energy
  Few energy-consuming devices are equipped with meters to measure their actual energy consumption. However, the direct measurement of energy units (e.g., kilowatt-hours, Btus) is not necessary to assess the operating efficiency of an energy-consuming device. In most cases, it is possible to identify a secondary or indirect indication of energy consumption for which performance data is readily available. Monitoring this secondary source will determine operating efficiency.

  For example, the energy consumed by an air handler's heating coil is directly proportional to the degrees of heat imparted to the air stream flowing across the coil. A monitoring task would consist of periodically reviewing available temperature data to verify that the temperature rise across the coil is no more than necessary. Also, many large energy consumers - such as lighting and constant-rate motors – use energy at a constant rate when operating. The task of determining their operating efficiency therefore becomes a task of periodically verifying that they are operating only when necessary.

- Base monitoring tasks on readily available performance data
  Most energy-consuming devices and/or their system of control have the ability to display the information necessary to assess their operating efficiency. Energy-efficient monitoring tasks are designed to use the most easily accessible data available.

- Task performance requires minimal skill

While engineering expertise is necessary to design and set up the monitoring tasks, their execution requires little or no special technical skill. This is possible by designing the tasks with the goal of uncovering the existence of a malfunction but not necessarily determining its cause or defining its remedy. This focus on detection, but not cause or remedy, results in monitoring tasks that are simple and non-technical.

- Task performance requires minimal time
  In order to minimize the time burden on building operations staff, tasks should be simple, and reference material like contact information and zone maps should be included in task documentation.

- Tasks are performed only when necessary
  The schedule for executing energy-efficient monitoring tasks is determined by the conditions that present the highest energy-wasting risk of each device monitored.
  For example, a malfunction in an air handler mixed air control would waste the most energy in the extremes of the heating and cooling season, and therefore the monitoring tasks should be scheduled for those times.
  Another example – the potential for a classroom area air handler to operate more hours than necessary is greatest at times of reduced occupancy such as the start of a summer session or a winter break. Tasks to verify that the operating schedule represents current occupancy should be performed at these times.

VIII. How Accountability for Energy-Efficient Operation Tasks Is Assigned

To assign accountability for the energy-efficient operation of a device or system it is necessary to identify the persons whose needs it serves (the customers) and the persons who decide how and when the device functions (the operators), and how they relate in the organizational structure.

For some energy-consuming equipment, the facilities staff is both the customer and the operator. They decide, for example, when the building needs heating water and they operate boilers and pumps to meet that need. Accountability for the energy-efficient operation of such devices must be assigned to facilities management.

For other energy consumers, the occupants are the customer and facilities staff is the operator. As an example, for a timer-controlled air handling unit the occupants of the space served by that unit determine when they require an acceptable climate, and the facilities staff sets up the appropriate time schedule. Someone who manages the occupants must be accountable to negotiate the shortest acceptable operating schedule, and to review that schedule whenever a change in occupancy may make a shorter schedule possible. Someone in facilities must be accountable to set up the timer control with the appropriate on-off schedule, and periodically verify that the control is working as intended.

A third category of energy-consuming devices are ones where the occupants are both the customers and the operators. All manually switched lighting is in this category, as well as most plug load energy consumers such as computers, monitors and copiers. Other examples are laboratory hoods and

manually controlled exhaust fans. The accountability for the efficient operation of these energy consumers must be placed with the persons who manage the devices' customers/operators.

Note that it is not reasonable to place all accountability for energy-efficient operation with facilities staff. In the second category of consumer above, facilities has no authority over the customers, and in the third category, they have no authority over the customers or the operators.

IX. B3 Energy Efficient Operations Manual website tasks

The B3 project has developed a website to enable creation of a customized Manual, documentation of task status, and management of the set of tasks for a specific building. There are currently modules for timer-operated lights, timer-operated air handlers, and air handler mixed air temperature. Following is an outline describing the elements that comprise these tasks:

1) Timer-operated devices (lights and air handlers)
    a) Negotiate a "tight" (minimized) schedule that meets the needs of occupants
        i) Intent and Process statements
        ii) List of occupant representatives
        iii) Zone map
        iv) List of key questions to negotiate
        v) Matrix for entry of negotiated schedule
        vi) Task checkoff to acknowledge completion
    b) Verify Schedule is implemented in the timer control
        i) Intent and Process statements
        ii) Display of current negotiated schedule
        iii) Screenshot sequence showing the steps to get into the appropriate section of the timer control
        iv) Task checkoff to acknowledge completion
    c) Verify timer operation (device turns "off" when signaled by the controller)
        i) Intent and Process statements
        ii) Display of the current schedule implemented in the timer
        iii) Detailed instructions for verification that the device is "off" (several optional methods, depending on the specifics of the building, device, and staff skill level)
        iv) Task checkoff to acknowledge completion
2) Air handler mixed air temperature (MAT) verification for air handlers with economizer control (this task is based on the fact that the correct MAT can be predicted based on outdoor air temperature, and a few building specific variables).
        i) Intent and Process statements
        ii) Screenshot sequence showing the steps to get into the appropriate section of the air handler's automation system
        iii) Graph and table showing the correct range for MAT as a function of outdoor air temperature (templates for nine air handler types are included)
        iv) Task checkoff to acknowledge completion