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The laundry list

As activities in the area of energy conservation in building systems unfolded from 1974 through 1979, we saw a slow but nonetheless steady trend toward a growing technical maturity. Undoubtedly, the oversimplified techniques proposed by those without a true understanding of the technical aspects of the problem, the fads used as a crutch by those who lack the time or the inclination to address the problem in specifics, and the cure-all products born of mass production manufacturing systems will always be present. A growing segment of both the engineering profession and the building management profession, however, is now recognizing the true value of proper direction toward the technical aspects of the problem and the relentless need for ongoing management of energy conversion systems.

Simple lists ineffective

In the early days of the then-popular movement toward "energy conservation" in building systems, the so-called laundry list approach prevailed. Such efforts were simple lists from less than a page in length to several hundred pages (the latter, of course, being government funded), which were intended to serve as checklists. The presumption was that if a building owner or systems designer simply went down the list and "did" things to his building or its energy system that were on the list, he would conserve energy. For several reasons, such lists very likely consumed more energy in the processing of the paper they were printed on than they have since conserved in building systems.

- In most cases, they did not prepare the user for the reduction in performance that would result from the actions recommended. In some cases, the reduction would be direct; in others, it would be the result of a detrimental effect on another integrated system.
- In other cases, the result of taking the recommended action would be the consumption of more energy, often resulting in *increased* operating costs. For example, reducing the cooling load by adding reflective film on the glass simply might increase the heat consumption if the cooling system used reheat control.
- In their simplicity, they lacked the ability to incorporate cost effectiveness as one element of each item.

Thus, it might be concluded that although the laundry list approach might have some limited use, it is certainly not the effective tool it was once thought to be. We have now had the experience of some five to seven years of conducting detailed, accurate energy audits on numerous operating buildings of all ages and use types. The majority of these audits were performed by independent analysts on commercial and institutional buildings. Since they were funded by the owners of the buildings, the studies understandably were performed on larger buildings and on buildings that, in the opinion of their owners, consumed excessive energy. The value of this free enterprise effect cannot be faulted since it is these buildings in which efforts toward energy management can be most immediately effective in use reduction. The other obvious value of this effort is that these buildings turned out to be the institutional and commercial buildings designed and constructed between the mid-1950s and early 1970s. As a result, the buildings studied had employed in their designs the materials and systems techniques currently employed, and the results of the audits lead us to those areas in which we can most effectively concentrate our conservation efforts in the current design of new buildings.

Audits provide better lists

The audits, then, give us the background information on which we can now start to build more useful laundry lists. These lists, unlike the original ones, are not cure-all type checklists but rather what might be called *memory joggers* for competent designers and analysts.

The audit of a typical relatively large educational institution might yield the categories of use for fuel and electric energy shown in Table 30-1. With this information available, the areas in which efforts should be directed in either energy retrofit of existing buildings or design of new buildings and systems become evident.

A brief discussion of each of the use areas in the example audit of Table 30-1 follows. The categories for fuel energy are:

- *Space heat—60 percent.* This value actually breaks down into major components, transmission losses and ventilation, with values of 25 percent and 35 percent, respectively. The immediate indication is that reductions in either the amount of ventilation air *or* the hours of providing it can be as energy conserving as adding insulation, and at a fraction of the investment cost.

- *Control heat—30 percent.* Control heat is the major source of excessive energy use (or energy waste) that lacked recognition in most earlier efforts. Whenever there is simultaneous heating and cooling (whether it be to cope with moving loads on a design day or the daily reduction from the design day), there is a use of control heat. This also shows up in the compressor energy on the electrical side of the audit. It must be recognized that dehumidification requires this simultaneous heating and cooling, but the backlash approach of "outlawing" it should be avoided. Designers, however, should avoid the use of runaround energy whenever it is used for any purpose other than dehumidification if at all possible.

- *Domestic hot water—10 percent.* Although it might be thought that little can be done about the energy used for domestic hot water, an inventive designer might see numerous opportunities. As an example, in large commercial office buildings, some studies have shown that the thermal losses from storage and piping systems, time integrated, have accounted for approximately 90 percent of the energy inputs to the systems. In such cases, point-of-use heating, although more costly on the basis of unit energy, is found to be much more economical on an annual basis, and usually in investment cost as well!

Table 30-1. Energy use percentages for various categories based on an energy audit of a "typical" building.

Use category	Percent
Fuel energy—	
Space heat	60
Control heat	30
Domestic hot water	10
Total	100
Electric energy—	
Supply, return, and exhaust fans	40
Lighting	25
Refrigeration compressors	20
Cooling/heating auxiliaries	10
Miscellaneous	5
Total	100

Electric energy use areas

The use categories for electric energy are:

- *Supply, return, and exhaust fans—40 percent.* Of all the energy use divisions as they line up from highest to lowest use, the fan energy category most often comes up on top. This is a result of three past practices:

1) The extensive use of high-pressure fan systems during the past 20 years.

2) The lack of both designer consideration and operator understanding of the value of shutting down the fan systems during unoccupied periods.

3) The almost universal concept of constant air flow, with temperature differential reductions to cope with load reductions.

Designers, as a result of this, should make every reasonable effort to minimize air delivery rates and air system pressures and to provide for unoccupied cycle operation with the fans turned off.

• *Lighting—25 percent.* Once thought to be the largest energy consumer, lighting has been fairly well relegated to second place. Still, it is a major area for attention in both retrofit and new building designs. The designer should accept the challenge of providing the most beneficial lighting levels for both general environment and tasks with the minimum number of installed watts and switching systems that may sacrifice a few hours of lamp life for the savings of many times that monetary value in electricity. (As an example, some designs were found to achieve perfectly adequate lighting levels in classrooms with approximately 2 watts per sq ft while others were found to use more than 6 watts per sq ft!)

• *Refrigeration compressor energy—20 percent.* It is not unusual that the refrigeration energy is only one-half of the fan energy. It is still generally quite significant in absolute value, however. One of the more interesting aspects of these systems is the interrelationships of the different use categories. As examples, the control energy in the fuel summary has an equal and opposite component in refrigeration energy; a large portion of lighting heat may conceivably impose loads on the refrigeration compressor; and the majority of the fan energy will ultimately impact the refrigeration system in most system configurations.

Considering the refrigeration system itself, much can be done to reduce the ratio of output refrigeration effect to input energy (COP). Some of these concepts are discussed in other chapters.

• *Cooling/heating auxiliaries—10 percent.* Although this is a relatively small component of the whole, it is one in which considerable reductions can be achieved both in retrofit and new building design. In the simple selection of cooling towers, product literature reveals components available from less than 0.1 to 0.25 hp per ton of capacity. The largest annual energy consumers are pumps, the energy consumption of which is directly proportional to hours of use, flow rate, and head. Thus, reducing any of these three either at design conditions or with load reductions can prove beneficial.

• *Miscellaneous—5 percent.* This category includes such items as elevators, office machines, vending machines, and the like. For each and every one of these, the building owner essentially loses control over the energy consumption once the device is purchased. Therefore, the best approach to energy reduction in this category is the inclusion of energy requirements (time integrated) at the time of purchase.

The above is a "laundry list" of the major categories of energy consumption in large commercial and institutional buildings, based on a "typical" audit developed for existing buildings. It is intended to illustrate the major categories of energy consumption, the reasons for that consumption, and the extent to which both designers and building management teams have control over the consumption. The underlying caution, which relates to all such laundry lists, however, is that change should not be instigated or designs modified until and unless all of the implications of that action are thoroughly understood.