BUILDING ENERGY MANAGEMENT AND REDESIGN RETROFIT (BEMARR)

GENERAL CONSIDERATIONS FOR ELECTRICAL SYSTEMS

CONTENTS PAGE

1. GENERAL

1.01 Although the Building Electrical Distribution System is itself very efficient, important savings can be achieved at low cost by attention to proper operation. The following six energy and cost savings recommendations are discussed in this section:

- Reduction in peak demand
- Transformer operation
- Voltage levels
- Phase voltage unbalance
- Investigate items to turn off
- Utility rate schedule.

The material used in this section has been extracted from the *Building Energy Management and Redesign Retrofit (BEMARR) Manual* issued with GL 76-10-077 (EL 4758) dated October 7, 1976, and updated to reflect recent experience.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

2. DEMAND

2.01 The electric bill usually shows only one amount but there can be four charges:

- Fuel adjustment
- Power factor
- Kilowatt-hour consumption
- Demand.

2.02 Fuel adjustment is usually set by the utility company's tariff.

2.03 Power factor charges are generally not significant in telephone buildings.

2.04 This leaves kilowatt-hours and kilowatts as the elements of the bill where the building owner can exercise some control. Without affecting service or employee comfort, loads such as heating and air conditioning might be turned off for short periods of time. This will reduce consumption and demand.

2.05 The demand charge is included because the electric utility must provide the necessary equipment (generators, transformers, and transmission lines) based on peak demand. Customers who have a high peak demand but low kilowatt-hour consumption would not pay their fair share. The demand charge varies with each utility and the average charge per kilowatt is $15.

2.06 The block-interval method used by electric utilities to record demand measures kilowatt-hours for 15 or 30 minutes, then divides the reading by the elapsed time to obtain the average rate of power consumption. A building may have an instantaneous demand of 1000 kilowatts at 8:00 am caused by starting a 200-horsepower refrigeration compressor. During the next 15 minutes, the kilowatt consumption may vary widely. At 8:15 am the block-interval demand meter ignores the peaks and valleys, takes the total kilowatt-hours used during the 15 minutes, divides that by the time elapsed, and reaches an average kilowatt rate for the period. In a telephone building, the average kilowatt consumption might peak at 400 kilowatts over a 15-minute period. Assuming a $15 kilowatt demand rate, the demand charge would be $6000 for the month. This charge is added to the kilowatt-hour charge.

2.07 In many parts of the country, a portion of the high peak demand may be added to the bill for an entire year, even though the actual power consumption never comes close to that peak again. This is often referred to as a "ratchet clause."

2.08 It is obvious that the greatest effort to effect demand reduction should be concentrated in those buildings subject to "ratchet clauses," and those buildings where the demand charge per kilowatt is high. The key to demand control is to even out the peaks and valleys in the daily demand usage. The following procedures are suggested to economically minimize demand charges:

(a) List all buildings with peak demand over 500 kilowatts, omitting electronic central offices and computer buildings. The demand in these buildings is usually fairly constant, leaving little opportunity for "peak shaving."

(b) Investigate the possibility of turning off air-conditioning compressors, fans, and pumps for short periods of time to reduce peak demand. This can be done by a minicomputer-type controller on a time basis or a controller tied into power usage.

3. TRANSFORMERS

3.01 Proper management of transformer operation can result in significant energy savings. Since transformers are soon forgotten after they are installed, many are left connected to a circuit even after the load has been removed or are used only during certain seasons. A survey should be made of all transformers as to their loading and function.

A. Transformers With No Load

3.02 An energized transformer with no load on the secondary will still consume energy. Although these no-load losses are low, they go on for 8760 hours per year. This can add up to substantial annual costs. The following is a list of candidates for energy waste:

- Refrigeration chiller transformers during the heating system
- Heating equipment transformers during the cooling system
- Unloaded transformers
- Transformers supplying unoccupied or unused spaces.

B. Heat

3.03 Excess heat will increase the losses in a transformer. Shade should be provided for exterior transformers to prevent solar radiation and resultant losses. Interior transformers should be ventilated to keep them cool.

4. VOLTAGE

4.01 Overvoltage, like undervoltage, can adversely affect electrical equipment. Therefore, it is important to operate a building as close to the design voltage as economically possible. Adverse effects on performance, life, or energy consumption can be expected whenever the voltage at the load varies from the nameplate rating.

A. Effects of High and Low Voltage on Induction Motors

4.02 The principal effects of low voltage on induction motors are reduction in starting torque, higher current, higher I^2R losses, and increased full-load temperature rise. The principal effects of high voltage on induction motors are increased torque, increased starting current, and decreased power factor.

B. Effects of Voltage Variation on Incandescent Lamps

4.03 The life and light output of incandescent lamps are affected greatly by the applied voltage. A 1 percent deviation from rated voltage causes a 3 percent change in light output. Figure 1 shows that a 10 percent reduction in voltage reduces the lumen output 30 percent and the wattage input by 15 percent. If the voltage is increased above normal, the life of the lamp will decrease so drastically that the increase in lumens is not warranted.

C. Effect of High and Low Voltage on Fluorescent Lamps

4.04 Change from rated voltage has far less effect on fluorescent lamps than on incandescent lamps. A 1 percent variation in lamp voltage changes the lumen output about 1 percent.

D. Voltage and Load Unbalance

4.05 It is extremely important that the phase voltages in 3-phase systems be very nearly identical. Even very small differences (less than 2 percent) can cause problems. The principle disadvantage of unbalanced phase voltages is its adverse effect on the performance and efficiency of induction motors. Unbalanced voltages will also cause additional losses in transformers.

4.06 In addition to unbalanced supply voltage, the principle cause of voltage unbalance is phase loading. In a 3-phase system where a large number of single-phase loads are connected, there is a good chance for a serious load unbalance. This load unbalance can cause a variation of voltage between phases. A major cause of unbalance is changes or additions. Too often, single-phase loads are added to an existing system without any study of the balance of the system.

4.07 In a 3-phase, 4-wire system, the neutral wire carries the unbalanced current. Since the power loss in a system depends on the I^2R loss in the wire, the lower the current in the neutral, the lower the I^2R loss.

4.08 The solution to an unbalanced system is simple: Use a clamp-on ammeter to analyze the

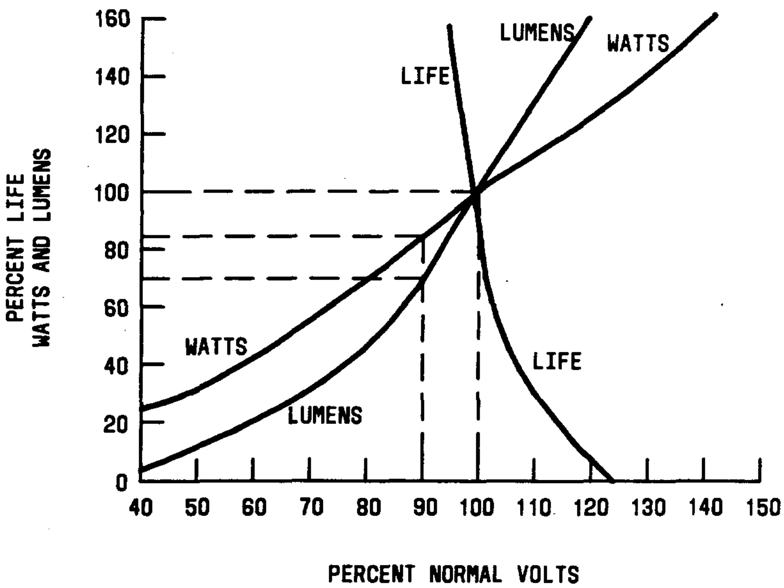

Fig. 1—Watts and Lumens

unbalance and change the circuits at the panelboard until the loads are evenly divided. The following steps should be performed when an unbalanced condition is found:

(a) Measure each feeder with a clamp-on ammeter and record the readings.

(b) In a 3-phase, 4-wire system, measure the amount of current in the neutral circuit.

(c) Measure the amount of current in each branch circuit and record the phase or phases to which each branch circuit is connected.

(d) Change the circuiting until all three phases are close to being balanced. Ideally, the amount of current in the neutral circuit should approach zero, except in fluorescent lighting circuits where it will approach the value of the phase currents due to third harmonics.

E. Transformer Voltage Tap Adjustment

4.09 Most standard transformers rated 30 through 500 kilovolt-amperes are available with six voltage taps: four taps, each of which provide a 2-1/2 percent reduction in supply voltage, and two each of which provide a 2-1/2 percent increase in supply voltage. This arrangement provides a 15-percent range of voltage adjustment. These taps do not improve voltage regulation but change the voltage level of the distribution system.

4.10 The following recommendations are provided to determine if the supply voltage is correct:

(a) Connect a recording voltmeter at the main service entrance. This meter should record the voltage for a minimum of 3 days. If the incoming voltage is more than 2-1/2 percent above or below the rated voltage of the equipment, the taps on the service transformer should be adjusted by the serving utility. ***Warning: The incoming voltage at full load should not be above the rated voltage of the equipment. During an off-peak load, the voltage could rise 3 to 4 percent.*** Also, the utility should be requested to correct any phase voltage unbalance.

(b) After the incoming voltage has been adjusted to rated voltage, the following steps should be taken:

(1) Take voltage readings at the load side of each building transformer. Set the taps as close as possible to the rated voltage of the equipment.

(2) Take voltage readings at load centers and at the loads. If a low- or unbalanced-voltage condition is found, an engineering study should be made to determine the cause and the necessary corrective action to be taken. For example, the excessive voltage drop could be due to feeder length or overloaded conductors. Refer to Section 760-400-110 for voltage-drop calculations.

5. INVESTIGATING ITEMS TO TURN OFF

5.01 A survey should be made of a building to determine which items should be turned off permanently, or even part of the time. The amount of energy saved in each building may seem small but if one considers all buildings, this can represent a considerable savings.

5.02 The following items are some ways energy can be conserved, as well as reducing the operating costs:

(a) Power down computer systems that will not be used during the next 24 hours. This, of course, should be discussed in advance with the computer user and perhaps a representative of the computer manufacturer.

(b) Unplug soldering irons when not in use.

(c) Turn off elevator fans.

(d) Keep display lighting to a minimum.

(e) Use outside lighting only for security and personnel safety.

6. UTILITY RATE SCHEDULE

6.01 The rate schedule for each building should be reviewed with the electric utility company to ensure that the most favorable rates available are in effect. In a few instances, it has been found that the Bell Operating Companies were paying higher rates than necessary because an incorrect schedule had been selected initially. While this will not save energy, it could save money.

7. REFERENCES

7.01 The information in this section is based on the following references:

- C. Siskind, *Electrical Machines,* 1957
- D. Beeman, *Industrial Power Systems Handbook,* 1955
- Reuben Wasserman and Paul Nathan, *Ironing Out Those Energy Consumption Peaks and Valleys,* 1975.

7.02 For additional information refer to the following sections.

SECTION	TITLE
760-400-415	Building Energy Management and Redesign Retrofit (BEMARR)—Lighting
760-400-605	Building Energy Management and Redesign Retrofit (BEMARR)—Electric Motors
790-100-660	AC Power for Telecommunications Systems
IL 79-09-067	Transformer Selection—Energy Savings
IL 80-06-013	Transformer Selection—Cost Versus Energy Savings