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Energy Conservation in Existing School Buildings

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Building requirements are responsible for roughly one-third of Canada's total energy consumption. Of this a significant proportion is consumed by school buildings, which comprise the fourth largest consumer group after dwellings, offices, and retail stores. Although a great deal of effort has been directed towards designing new buildings for energy conservation, it is most important not to lose sight of the energy reduction potential of existing buildings. In many instances modest capital investment and improved maintenance and operation could provide immediate and continuing energy and cost savings.

Because it will be many years before new construction will have any sizable effect on over-all energy consumption and because future construction will probably be controlled by energy codes, it is suggested that school boards concentrate their efforts on energy conservation in existing facilities. This digest briefly outlines how such an energy conservation program might be implemented.

Energy Conservation Program

Although energy conservation measures will not result in large percentage savings in the over-all operating budget (probably less than 1 per cent), in terms of actual dollars the benefit could well represent a considerable sum. Further, school boards should recognize the implications of possible disruptions in fuel supplies and a continuing, possibly rapid rise in energy costs.

To be successful an energy conservation program requires the full support of the school board, who should as a priority appoint an energy manager responsible for implementing the program. Ideally, the energy manager should have a background in building engineering services, be experienced in operation and maintenance techniques, and have an organization/administration bias. His expertise will be reflected in energy and dollar savings. An appropriate budget, including manpower, should be allocated for the program, for effective energy management cannot be carried out by an unqualified committee working in its spare time without funds.

Clearly, the scale of the program will depend on the size of school board (number of schools) and potential saving. An operating budget of up to 10 per cent of the current total school energy costs should ensure that the program will cost no more than it saves, at the same time achieving its goal of conserving energy.

Energy Audits

An energy audit should be the first step in any energy management program. In its simplest form this means collecting, examining and reviewing energy consumption records in order to identify schools with above-average energy use or abnormally high costs. The concept is

commonly extended to encompass the actual identification and method of alleviating specific energy waste.

It is wise to start with a simple approach to energy auditing before establishing more sophisticated procedures. Annual energy consumption and cost per unit of floor area for the individual fuels (oil, electricity, gas) should be tabulated for each school and schools grouped according to size (floor area). Elementary and secondary schools should be separated and community use noted even if only on some arbitrary scale such as none, some, extensive. Heating consumption normalized* to the average degree days of the location should also be added. For small school boards it may be worth while to compare energy use records with those of adjacent school boards to obtain a broader base for comparison.

The resulting tabulated record of energy use will permit comparison of consumption for similar facilities, indicating schools with above-average consumption. Similar schools are considered to be those of the same type (i.e., secondary or elementary), same size (since heat loss per unit of floor area tends to reduce as building size increases), and comparable hours of use. Consumption normalized to the average degree days will allow a year-to-year comparison to be made and provide a measure of the success of the energy management program. Schools identified as having excessive energy use can be singled out for special attention to try to determine the reason for their high consumption.

Because existing school buildings vary so widely in design, construction and operation, no two schools are likely to have the same potential for energy savings, nor will apparently similar schools necessarily use similar amounts of fuel. In order to determine this potential on a school-by-school basis more comprehensive energy audit procedures are required. Details of such advanced procedures [1] will be summarized:

1. *Public Schools Energy Conservation Service*

   A simple energy analysis computer program is used to predict the approximate potential for fuel and cost savings. The calculation is based on readily obtainable information about the school, its heating and ventilating plant, operation and fuel consumption. The service is offered by Educational Facilities Laboratories Inc., (3000 Sand Hill Road, Building 1, Suite 120, Menlo Park, California 94025) and costs between $60 and $90 per school building.

2. *Mini-Audit*

   This comprises a walk-through examination of the building by an individual or a small group of energy experts who report on inexpensive opportunities for energy conservation. This might take from 1 or 2 h to a half day per school, depending on the size of the school and the complexity of its heating and ventilating plant. The cost, including preparation of a report, might be between $150 and $400 if carried out on a commercial basis. It could, alternatively, be carried out by suitably qualified in-house staff.

3. *Maxi-Audit*

   This is a comprehensive study of the building and its energy systems by a consulting engineer. Such a study would probably involve computer simulations and should make recommendation on the energy and dollar economics of major capital investments. It should follow after either (1) or (2), or both, have failed to result in reduction of energy consumption to a reasonable level. The cost will depend on the size of the school and the complexity of its plant, and on the depth of the analysis; it is unlikely to cost less than $4000 and could cost as much as $15 000 or more per school building.

Operation and Maintenance

Probably the greatest savings and best return for investment will result from a good operation and maintenance program that has been developed in recognition of a need to save energy. Existing programs should be re-evaluated to see whether they satisfy the criteria of reducing energy waste. For example, a maintenance schedule may have been set up for boiler servicing, but it may not include a boiler efficiency test. Such a test and any necessary adjustment to improve efficiency should be carried out as part of a regular maintenance schedule. Maintenance should be carried out by skilled personnel, not left to untrained custodial staff. Where expertise for the servicing of sophisticated equipment cannot be covered adequately in-house, consideration should be given to the use of outside firms specializing in such service.

Maintenance Schedule

As an energy conservation measure a maintenance schedule should include the following:

1. Checking the operation of outside air dampers. This should include measurements of air flow at minimum (minimum allowable to satisfy local code ventilation requirements) and closed positions.
2. Heating, ventilating and air-conditioning control sequence verification.
3. Checking and replacement of defective weather stripping and caulking, not only round windows and doors but round all construction joints.
4. Cleaning of heat transfer surfaces of combustion and refrigeration equipment and replacement or cleaning of air filters.
5. Ensuring operable windows capable of being tightly closed.

Operating Schedule

The superintendent of plant or energy manager should have the over-all responsibility for the operation of schools and for operating procedures developed to minimize energy waste; such procedures should be clearly defined where custodial operation is necessary. Automatic control through the use of time clocks or other automatic devices is strongly recommended for such functions as plant start-up and shut-down. In setting up an operating schedule for a school, consideration should be given to the following:

1. Night and weekend temperature set-back to 13°C or less during the heating season, depending upon the ability of the plant to return the building to comfort conditions in time for occupancy, and the vulnerability of water services to freezing. In mild weather (spring and fall) the heating plant can be shut off completely over the evening.
2. Minimizing the pre-heating period by delaying the early morning start-up of plant until there is just sufficient time prior to occupancy to raise the building to comfort conditions. The pre-heating time for each building will vary with the outside ambient temperature. Proprietary type controllers are available to carry out such a function.
3. Shutting down the heating and ventilating plant just before classes end.
4. Minimizing the period during which outside air dampers are open -- ventilation is not needed for pre-heating and is probably not necessary for minimal occupancy (cleaners and staff) after classes end. It is wise to schedule ventilation and heating differently.
5. Scheduling community use of school facilities to minimize the impact on energy consumption. It makes little sense to heat, ventilate and light an entire building for the convenience of a small group.
6. Turning off domestic hot water heaters and circulating pumps over evenings and weekends.

Custodians play a valuable role in energy management. They should be given encouragement and opportunity to increase their understanding of the operation of the heating and ventilating system they are expected to manage and of energy conservation techniques in general. In many instances where automatic control cannot be economically justified or is not flexible enough to perform a desired operation, or has to be manually overridden, custodial staff will be

required to carry out various control functions. A typical case occurs where a school is used for community activities; the only practical way for heat, light and ventilation to be provided on an optimum basis is to have manual control. Such an operation requires that the custodian know how to operate the plant in a minimum energy mode. Further, it is extremely important to have someone to ensure that lights are turned off when not required, that equipment is not left running in vocational areas when classes have ended, that thermostats are not tampered with, and that machinery is operating efficiently.

Students and teachers can also play their part in energy conservation: for example, by turning off lighting immediately after class or when daylighting is adequate, by turning off equipment that is no longer required, by minimizing door operation and ensuring that windows are tightly closed in cold weather, and by minimizing hot water usage. The appointment of student energy monitors might be a way of obtaining such student cooperation. Motivational and award strategies such as educational programs, poster campaigns, feedback to each school on its relative energy performance, and rewards for outstanding achievements should be considered as valuable means of achieving fuel savings.

Upgrading and Modernization

Modernization should be considered an integral part of an energy management program. It may be carried out in parallel with other parts of an energy conservation program, or better still as a series operation so that information obtained from the maintenance and audit processes is used in planning a program of upgrading and retrofitting. For example, the maintenance program might reveal that an old boiler nearing the end of its useful life could justifiably be replaced by newer plant with better efficiency. Similarly, buildings identified by the audit process as high energy users and in need of major retrofitting should be given priority for upgrading.

Many techniques that are economic for new buildings will not necessarily prove to be economic for retrofitting older ones owing to the possibility of a limited remaining useful life and the probable high cost of repair and redecoration. It is recommended that major capital expenditures be justified on an individual school-by-school basis by some form of long-term costing that weighs operation and maintenance costs. Details of options available for reducing energy use in buildings are generally widely publicized [2, 3, 4] .

Concluding Remarks

Because of the potential impact on cumulative fuel consumption over the next 50 years or more, steps should be taken to reduce energy requirements in existing school buildings. School boards are urged to make a commitment to save energy and are advised to institute energy management programs under the direction of a qualified energy manager. Energy auditing should be undertaken to identify energy waste and an operation and maintenance program drawn up to implement it through rational upgrading and modernization. The cooperation of all members of staff and students is essential for the success of the program.

References

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$$\text{Normalized consumption} = \text{Actual heat consumption} \times \frac{\text{Average Degree Days for Location}}{\text{Degree Days for years of recording}}$$

Non-heating consumption e.g. electricity (except where used for heating) should NOT be normalized in this way.