AIC 604 #1003

Energy Reduction Opportunities In Small Commercial Buildings

Small commercial buildings, because of greater infiltration from traffic loads and poor construction, are more energy intensive than large office buildings. Analysis of the energy consumption patterns of 600 branch banks has resulted in some definitive recommendations for cost effective reduction.

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The following article is the culmination of a detailed computer analysis of the energy consumption of branch bank buildings of The Bank of Nova Scotia, spread across Canada.

ENERGY management may be divided into three main categories: energy waste, energy conservation, and energy efficient design.

Energy waste

This implies unsophisticated opportunities to reduce energy consumption which are cost effective and conveniently within the control of the occupants of the building and include:

Lighting

- Switching "off" lights when not required.
- Maintaining the cleanliness (by contract if necessary) of lamps, lenses and luminaires.
- Replacing defective lamps, ballasts.
- Reducing excessive lighting levels by delamping or substituting lower wattage lamps.
- Rewiring lighting circuits so that only minimum security lighting requirements are maintained during non-business hours.
- Controlling illuminated signage with photo cells and/or time clocks to yield the greatest market advantage from advertising with minimum waste.

Heating and air conditioning

- Maintaining the complete system through regular contractual inspection to properly clean, lubricate and adjust all components of the system including thermostats, combustion parts, dampers, linkages and motors, ducts, grilles, treatment for water systems, filters and fan and pump motors.

Ventilation-Infiltration

- Controlling operation of all exhaust fans and providing weather seals for fabric voids such as exterior door seals, openable windows (including louvered windows) and gravity dampers on air extraction fans. Note: Check that existing weather seals are in proper position with the door face, etc.).

In smaller structures, the consequences of energy reduction measures are often quite different from that of larger structures.

If spaces are wide open, there is little requirement for "core" cooling. As a result, a reduction in lighting load will result in a higher fuel consumption, particularly during colder weather. There is some extra fuel required during mild weather as well because of the lag effect of the contribution of heat to the structure after initial illumination. The degree of lag is directly proportional to the thermal mass of the building.

Reductions in lighting load will result in a lower mechanical cooling requirement in summer. Excessively illuminated locations may not be uncomfortably bright because of soil on the components of the lighting system. During mild weather, the air temperature may reach uncomfortably high levels. Where a "free cooling" addition to the HVAC system may seem the logical solution, a proper lighting maintenance contract would allow delamping to normal lighting levels, thus relieving the uncomfortable conditions.

Reductions in lighting through delamping will result in lower lighting maintenance costs. In addition, spare lamps can be used for future replacements in spot relamping.

Reduction in ventilation and infiltration rates will result in a lower dissipation rate of internally generated latent heat. Higher humidity levels negate the need for humidifiers, some of which are costly to maintain and consume substantial amounts of energy.

Comfortable lighting, temperature and humidity levels in a draught-free working environment will yield better employee job satisfaction and potentially reduce absenteeism and turnover and increase work efficiency.

Energy conservation

This step is best defined as employment of sophisticated opportunities to reduce energy consumption which are still cost effective but probably not available to the occupants without more expert assistance.

Lighting

- Substituting more efficient lighting systems especially in high ceiling locations.
- Photo cell control of perimeter lighting adjacent to large window expanses.
- Task lighting systems.

Heating and air conditioning

- Night and weekend temperature setback.
- Economizer accessories.
- System balancing.
- Combustion efficiency adjustments.
- Time control on perimeter heating.
- Ambient temperature compensation for hot water boilers.
- Conversion from oil.

Ventilation and infiltration

- Concealed fabric voids.
- Time controls on exhaust systems and fresh air inlets.
- Vestibule.

There are several important technical points to watch for in small commercial applications.

Some high intensity discharge (HID) systems are slow to restrike following even a momentary power failure. For security and safety, fluorescent or incandescent lamps should be retained in strategic locations.

Time controls for temperature setback can easily be embellished to shut off fans and supplementary heat. If supplementary heat is provided by a hot water system, however, care must be taken to ensure that piping in vestibules or near outside walls is well insulated or heated with tracing cable to prevent freezing. Setback for heat pump systems is not yet considered cost effective.

One timer can control multiple systems serving one area by means of a multi-pole relay controlled by the timer contacts and night thermostat.

Economizers are presently only recommended for locations with high continuous internal load and/or low heat loss (enclosed mall store). Normally, the cost of mechanical cooling

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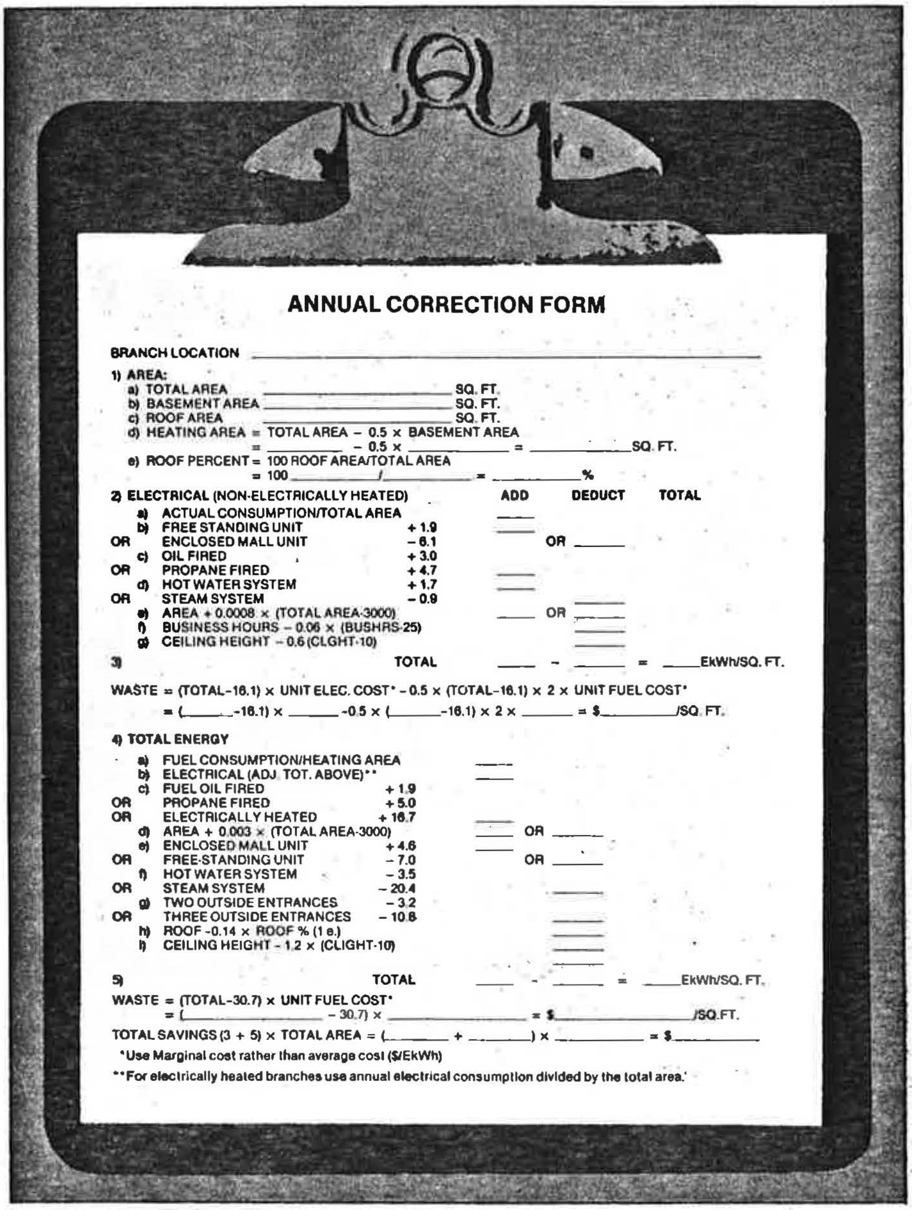

ANNUAL CORRECTION FORM

BRANCH LOCATION ______________________

1) AREA:
a) TOTAL AREA ______________ SQ. FT.
b) BASEMENT AREA ______________ SQ. FT.
c) ROOF AREA ______________ SQ. FT.
d) HEATING AREA = TOTAL AREA − 0.5 × BASEMENT AREA
= ________ − 0.5 × ________ = ________ SQ. FT.
e) ROOF PERCENT = 100 ROOF AREA/TOTAL AREA
= 100 ________ / ________ = ________ %

2) ELECTRICAL (NON-ELECTRICALLY HEATED) — ADD — DEDUCT — TOTAL
a) ACTUAL CONSUMPTION/TOTAL AREA ____
b) FREE STANDING UNIT + 1.9 ____
OR ENCLOSED MALL UNIT − 6.1 OR ____
c) OIL FIRED + 3.0
OR PROPANE FIRED + 4.7 ____
d) HOT WATER SYSTEM + 1.7 ____
OR STEAM SYSTEM − 0.9 ____
e) AREA + 0.0008 × (TOTAL AREA-3000) ____ OR ____
f) BUSINESS HOURS − 0.06 × (BUSHRS-25) ____
g) CEILING HEIGHT − 0.6 (CLGHT-10) ____
3) TOTAL ____ − ____ = ____ EkWh/SQ. FT.

WASTE = (TOTAL−16.1) × UNIT ELEC. COST* − 0.5 × (TOTAL−16.1) × 2 × UNIT FUEL COST*
= (____ −16.1) × ____ −0.5 × (____ −16.1) × 2 × ____ = $____ /SQ. FT.

4) TOTAL ENERGY
a) FUEL CONSUMPTION/HEATING AREA ____
b) ELECTRICAL (ADJ. TOT. ABOVE)** ____
c) FUEL OIL FIRED + 1.9
OR PROPANE FIRED + 5.0
OR ELECTRICALLY HEATED + 16.7 ____
d) AREA + 0.003 × (TOTAL AREA-3000) ____ OR ____
e) ENCLOSED MALL UNIT + 4.6 ____
OR FREE-STANDING UNIT − 7.0 OR ____
f) HOT WATER SYSTEM − 3.5
OR STEAM SYSTEM − 20.4 ____
g) TWO OUTSIDE ENTRANCES − 3.2
OR THREE OUTSIDE ENTRANCES − 10.8 ____
h) ROOF −0.14 × ROOF % (1 e.) ____
i) CEILING HEIGHT − 1.2 × (CLGHT-10) ____
5) TOTAL ____ − ____ = ____ EkWh/SQ. FT.

WASTE = (TOTAL−30.7) × UNIT FUEL COST*
= (________ − 30.7) × ________ = $________ /SQ.FT.

TOTAL SAVINGS (3 + 5) × TOTAL AREA = (____ + ____) × ________ = $________

*Use Marginal cost rather than average cost ($/EkWh)

**For electrically heated branches use annual electrical consumption divided by the total area.

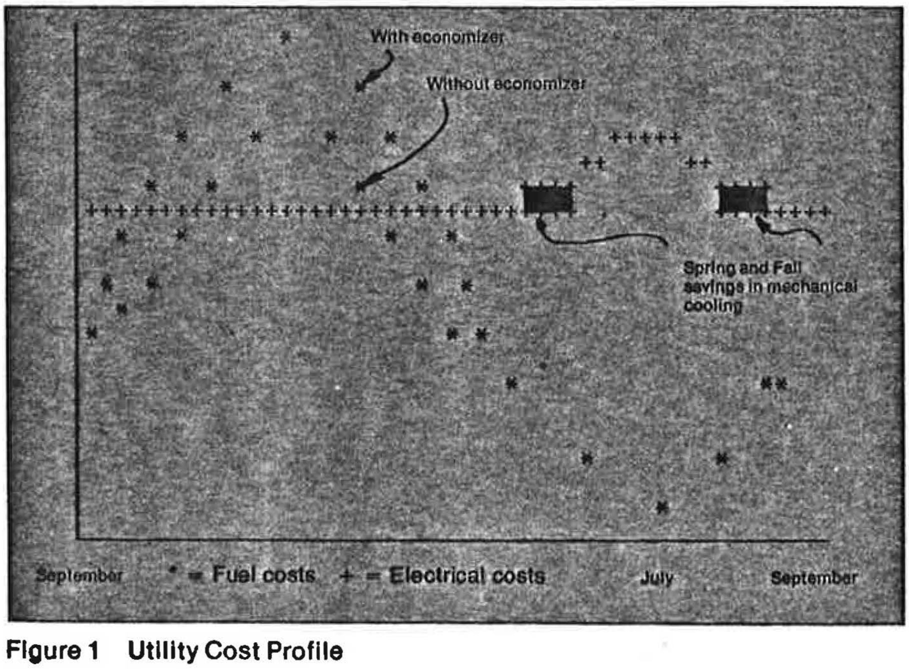


Figure 1 Utility Cost Profile

is no more than a few hundred dollars per year and the addition of an economizer will save only a small percentage of this in the spring and fall. As a result, this feature is rarely cost effective in less than 10 or 20 years. In addition, such dampers leak much more air in winter than is required for ventilation. Consequently, additional fuel costs in winter are far more than electrical savings in summer (Fig. 1).

The balancing of air and water systems should be restricted to contractors specializing in this field. They must be provided with an engineered drawing indicating the required air flow from each register.

Only power burners (not atmospheric) burners have any degree of adjustment or correction to improve combustion efficiency. This includes all oil fired burners but only some gas burners. Oxygen (O_2) in the flue gases is a more accurate determinant of combustion efficiency than is carbon dioxide (CO_2). No combustion test is complete, however, without the following:

(a) Carbon monoxide content in flue gases for natural gas systems.

(b) Smoke level test in flue gas for fuel oil.

(c) Draft measurement in the breaching for all systems.

(d) Recommendations for additional work necessary to improve combustion efficiency.

Ambient compensation of boiler water temperature will reduce the temperature of circulated water as the outside temperature rises. It will reduce standby losses and minimize large swings in space temperature during mild weather. Adjustments are required, however, to establish the actual relationship between hot water and outdoor temperatures—1:1 or 1½:1 (Fig. 2).

Conversions from oil should be dealt with through the local office of the alternate utility (gas or electricity). Substantial charges may be levied at installation time to introduce or increase the size of the service to the building.

Above many ceilings are construction voids in the building envelope which may have been left that way after construction or more likely from settling of the building or deterioration of old weather seals. Places to test (visually or with a smoke pencil) are the roof-wall joint, caulking around window and door frames, ventilated knee spaces, etc.

The use of vestibules (much less heated vestibules) is not cost effective for energy conservation, except in extremely cold climates, and or with inordinately high fuel rates. A drafty condition is not generally rectified with a vestibule since there are other openings in the structure for the entering air to escape.

Energy efficient design

Energy efficient design for small commercial structures should definitely include the following seven elements.

(1) Night and weekend setback control for all central heating systems to the setting on a night thermostat, and complete shut off central cooling systems.

(2) Disconnect power to all perimeter heating systems at night and on weekends with due precaution to water pipes in exterior walls.

(3) Disconnect power to all exhaust fans at night and on weekends.

Schematic drawings (Fig. A-Fig. D) are shown here for systems normally encountered. Manual override can be accomplished for each of these systems by substituting a chronotherm thermostat for the night thermostat. When the manual changeover switch is depressed, then daytime temperatures can be maintained. Trippers to revert to setback temperatures should be at two hour intervals after the normal closing time, so that the override will not last more than two hours. No riders are required to automatically switch to daytime temperatures since this will be accomplished automatically with the time clock.

(4) One hour maximum timer for exhaust fans requiring occasional operation (*i.e.*, lunchrooms, smoke extractors, etc.).

(5) Interlock between heating and cooling systems so that both do not operate simultaneously.

(6) Motorized minimum outside air damper on return air system. This damper should close automatically with the night and weekend timer and not cycle with the night thermostat.

(7) A schedule of required maintenance for mechanical equipment.

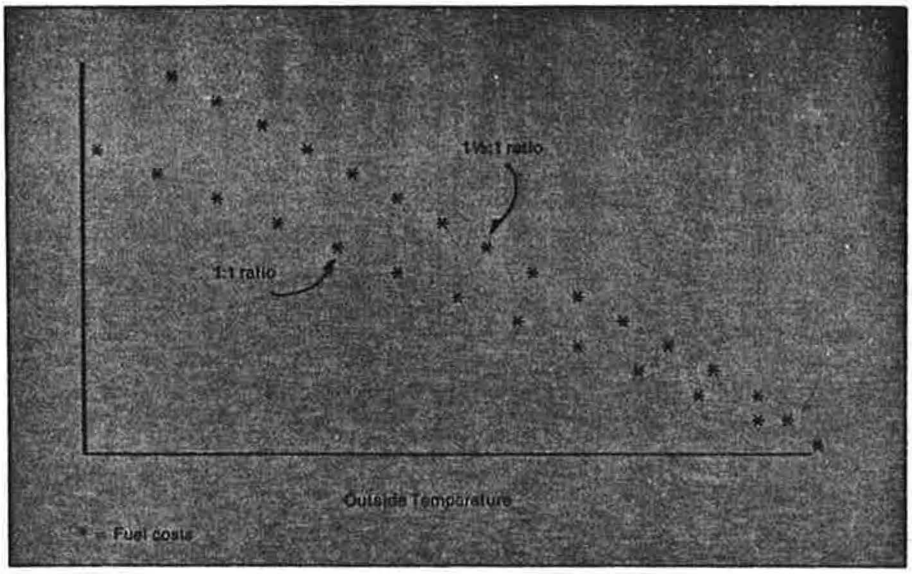


Figure 2 Boiler Water Temperature

APPENDIX

To establish the energy efficiency of a small commercial structure using the "Annual Correction" Form, proceed as follows:

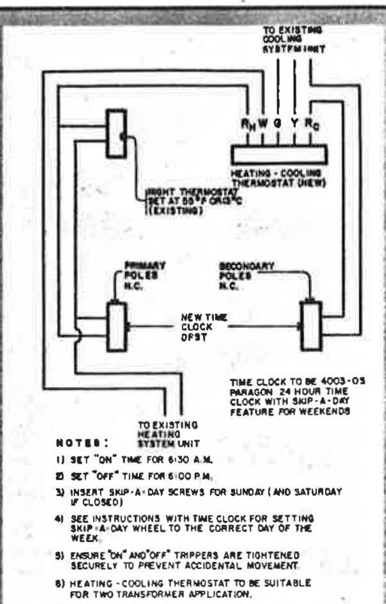
1. All areas are in square feet.
2. All energy consumption is in EkWh/sq.ft./year (equivalent kilowatt hours per square foot per year).
3. To convert fuel consumptions to EkWh apply the following factors as multipliers to the annual consumption:
   (a) Natural Gas
   1 CCF × 29.31 = EkWh
   1 Cubic Meter × 10.35 = EkWh
   (b) #1 Fuel Oil
   1 Imperial Gallon × 47.46 = EkWh
   1 U.S. Gallon × 39.55 = EkWh
   1 Litre × 10.41 = EkWh
   (c) #2 Fuel Oil
   1 Imperial Gallon × 49.03 = EkWh
   1 U.S. Gallon × 40.86 = EkWh
   1 Litre × 10.75 = EkWh
   (d) Propane
   1 Imperial Gallon × 32.24 = EkWh
   1 U.S. Gallon × 26.87 = EkWh
   1 Litre × 7.07 = EkWh
   (e) Steam
   Consult your utility
   Note: 1 Btuh × 0.0002931 EkWh
4. Divide the marginal unit energy cost by the above factors to obtain cost/EkWh.

STANDARD UNIT

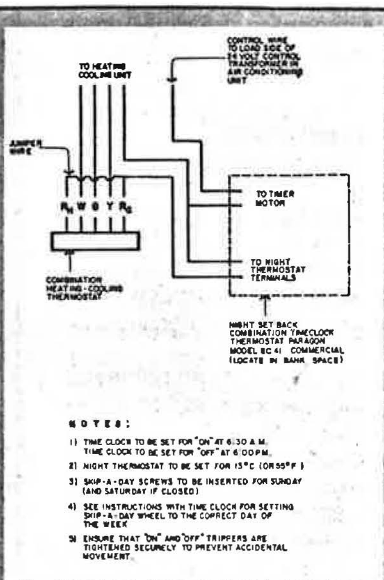
- Semi-detached (at least one party wall).
- Natural gas fired hot air system.
- 25 business hours (or 45 working hour per week.
- 10 ft. ceiling height.
- With fully enclosed vestibule.
- No roof (heated space above).
- One public entrance to outside air.
- 3000 square feet total area.

DETAIL

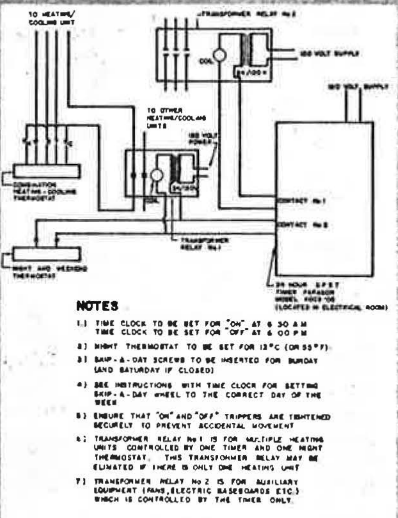
1. *Areas (in sq. ft.)*
   (a) Total area is the total of all areas served by the total of all electrical bills.
   (b) Basement area is the total area which is 100% UNDER GRADE. For other basements use fraction of the basement representing the portion of the basement walls which are below grade.
   (c) Roof area is the total roof area above the area served by the heating system under analysis.
   (d) Heating area is the total area served by the heating system (including tenant areas if applicable) less one-half of the basement area calculated above.
   (e) Roof percent is the roof area from (c) above divided by the total area served by the heating system (including tenant areas if applicable) and expressed as a percent (× 100).
2. *Electrical*
   (a) Actual consumption is the total Kwh consumed in one year, (if there is more than one account, then all account totals must be added together), divided by the total area from (1) (a) above.
   (b) A *free standing unit* is a structure which has all sides exposed to the outside. An *enclosed mall unit* is one which has *no* public entrances open to the outside air (only to heated malls, etc.).
   (c) For oil fired and propane systems, because of less associated electrical consumption, we must add a factor EkWh to our actual consumption.
   (d) If the structure has a boiler generating hot water for coils and/or perimeter systems, this factor must be added for circulating pumps, etc. For steam a factor is subtracted.
   (e) Larger areas tend to consume less electricity per sq. ft. and a factor must be added depending on the area.
   (f) This form was designed for a bank application. If working hours and business hours are substantially the same, then use (Bus. hrs-45) instead of (Bus. hrs-25).
   (g) The ceiling height to be used is the *highest* ceiling height above floor level.
3. *Total*
   Total adjusted annual consumption in EkWh/sq.ft.
4. *Total Energy*
   (a) Fuel consumption in EkWh (use multipliers above) divided by the heating area calculated in (1) (d) above.
   (b) Same as (2) (a).



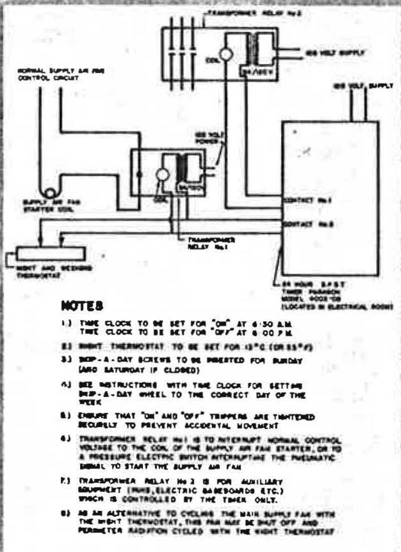
A—Night set back control for branches with separate heating and cooling thermostats.



B—Night set back control for systems with existing combinations heating-cooling thermostats and new installations.



C—Night set back for multiple heating systems and multiple auxiliary equipment for systems with combination heating/cooling thermostats and new installations.



D—Night set back control for large central station systems which normally operate with continuous fan operation.

(c) Because of the greater efficiency of oil-fired systems, we add the factor shown. Electrically heated branches consume less energy per square foot than for other fuels. The correction factor is shown. Extra energy for propane vaporizers make this fuel less efficient by the factor shown.

(d) Larger areas consume less total energy per square foot so a correction factor is added (or deleted if the area is below 3,000 sq. ft.).

(e) *Enclosed mall* units have a factor to be added because of its lower ambient temperature dependency. *Free-standing* units will experience greater losses as shown by the factor.

(f) The inefficiencies of hot water and steam systems require a factor to be deducted.

(g) The extra inefficiency resulting from the number of outside entrances.

(h) Roof area is not a large factor, however, its existence must be accounted for in our calculations.

(i) Higher ceilings require more heat and this factor is accounted for here.

5. *Waste*

(a) The "Normalized" electrical consumption is compared to our target of 15.9 kWh/sq.ft/year. The difference when multiplied by the marginal cost of the last unit of power (the average cost is a close approximation for larger bills), yields the electrical waste per square foot. However, whatever heat from electrical power consumption is eliminated must be replaced with heat from the heating system for approximately one-half of the year in small commercial buildings. This fuel is usually much cheaper than electricity. With an assumed seasonal efficiency of 50%, we must double the unit fuel cost.

Note: The marginal fuel cost must be in dollars/EkWh. (see conversion factor above).

(b) The "Normalized" total energy consumption is compared to our target level of 30.7 EkWh/sq.ft./year.

Note: Targets are actual consumptions of existing buildings. Many structures may yield results which are lower than targets. □□