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Consulting Engineers

REPORT

Energy Audit of Carleton Condominium Corporation # 81

Submitted to:

Ontario Hydro

Customer Energy Services Commercial
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Attention: Mr. D. Bell

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1. SUMMARY

Morrison Hershfield Limited was retained by Ontario Hydro to conduct an energy audit of Carleton Condominium Corporation # 81, located at 370 Dominion Avenue, Ottawa, Ontario. The audit was part of an Ontario Hydro project for developing strategic electrical energy programs for the commercial market sector.

The audit was conducted as a joint effort between Morrison Hershfield Limited and Maunder and Britnell Inc. in December 1989 and January 1990. The scope of work included a review of monthly electrical utility bills for 1987, 1988, and 1989, a review of available architectural, electrical, and mechanical drawings, site reviews of the various building systems, and sub-metering of the major electrical energy uses.

The results of the audit indicate that energy conservation opportunities exist in such areas as:

- garage heating and ventilating
- air sealing the elevator mechanical penthouse
- pool heating and ventilating

In general, the recommended measures involve modifications to the operation of existing systems to avoid the large building demand peaks which have occurred in the past.

2. BUILDING DESCRIPTION

2.1 Introduction

Carleton Condominium Corporation # 81 is a fourteen storey, 94 unit high-rise tower located at 370 Dominion Avenue in Ottawa, Ontario and was constructed in approximately 1974. The high-rise tower is connected to a two level indoor parking garage structure on the first and second floors, but is otherwise essentially rectangular in plan. The first floor level also incorporates an indoor swimming pool which is located within the extents of the tower.

2.2 Structural System

The main structural frame in the complex is a reinforced concrete system of cast-in-place concrete shear walls and flat slab floor construction.

A central cast-in-place elevator shaft penetrates each floor slab at the center of the tower, and terminates in an elevator mechanical penthouse which protrudes above the upper floor of the tower. At either end of the tower a cast-in-place concrete stairwell shaft runs from grade to the upper floor of the building.

2.3 Architectural

The exterior of the building is clad with precast concrete spandrel panels and horizontal strip window units at every floor level. The window units are sealed, double glazed units which account for a large portion of the surface area of the walls of the building. The precise construction of the opaque (precast) sections of the exterior walls is not documented in the drawings. The main roof of the tower is indicated to consist of 75 mm of insulation on a roofing membrane, with ballast on the insulation layer.

2.4 General Use

It is reported that none of the units in the condominium are vacant on a continual basis. However, many unit owners leave their homes for extended durations during the winter season. At the time of the audit, it was estimated that 30% of the units were unoccupied. The general population in the condominium are senior citizens who tend to desire slightly warmer indoor conditions than average. In addition, the typical day for the majority of the owners begins after 7 a.m. and ends by 10 p.m. Specific operation schedules for various building systems are explained in the following sections.

3. BUILDING SYSTEMS AND OPERATION

3.1 Mechanical

3.1.1 General

All mechanical systems in the building use electricity as the only source of primary energy. All heating, cooling and distribution systems are electric. While no natural gas is provided to the building, a medium pressure gas main exists under Dominion Street in front of the building.

3.1.2 Space Heating

All apartment suites are heated with electric baseboard heaters controlled from wall mounted thermostats. On average, suite temperatures are maintained at 22.5°C. This average temperature was measured at the outlet of several dryer exhaust fan systems and would be representative of all occupied and unoccupied suites served by the systems. No dryers were operating while the measurements were being taken. Thermostat setpoints are reported to vary between 12°C for unoccupied apartments, and 25°C in some occupied apartments. Each suite is provided with between 7 and 14 kW of heating, depending on outside wall exposure and suite size, which is in keeping with actual heat losses.

Corridors, stairwells and utility rooms (lockers, service rooms, etc) are also heated with electric baseboard heaters complete with integral thermostats. The majority of these units are either shut-off or have been set back to maintain frost free conditions only (3 to 10°C).

The main vestibule is provided with force flow electric heaters with integral thermostats. Units were found to be slightly undersized for high traffic periods.

The garages are currently provided with a total of nine 15 kW electric unit heaters with integral thermostats. Units are controlled manually at the disconnects by the building operator, generally shut down during the day at about 7 to 8 a.m. and turned on again at night between 9 to 11 p.m.

Regular checks are made by the operator during the day to ensure that temperatures remain above freezing.

The swimming pool enclosure is heated and ventilated by a built up forced air system consisting of outside air and recirculation dampers, a centrifugal supply fan and an 85 kW SCR controlled duct heater. A ducted exhaust fan completes the system. Controls are electric with a thermostat and discharge controller adjusting the supply air temperature, and a humidistat controlling the damper sequencing. With an outdoor air temperature of -17°C on one of the days of the survey, the setpoint temperature of 24°C was being maintained. Relative humidity in this space was 50% with a 34% setpoint at the humidistat. Significant condensation and frost was noted at windows and doors in both the swimming pool and the adjacent party room.

The garage sprinkler systems are heat traced at locations close to the doors, the majority of the heat traced pipe has no insulation and we were unable to determine if the heating cable does in fact work.

3.1.3 Ventilation

Each apartment suite is provided with a kitchen exhaust hood and fan, and a bathroom exhaust fan ducted directly to outside. These fans are switched by the occupants as required. Laundry dryers are ducted to eight roof mounted exhaust fans which operate 24 hours per day. Nominal capacity is 425 L/s (910 cfm) per fan. Motors are fractional horsepower.

Locker rooms, the common laundry room on the ground floor and miscellaneous other areas are provided with propeller type exhaust fans which are kept turned off.

The mechanical room, transformer, and elevator penthouses are provided with thermostatically controlled exhaust fans, intake and exhaust dampers. During the winter, the fan outlets in the mechanical and elevator rooms are blocked off by the building operator, using plywood and/or fiberglass insulation.

The air-lock vestibules between the parking garages and the building proper are designed to bring air from the corridors, through the vestibule and then exhaust to the garage. The exhaust fans have been turned off. or missing!

Garage ventilation is provided by one large propeller fan with a nominal capacity of 12.97 m^3/s (27,500 cfm) at the North west corner of the structure, serving both parking levels. Makeup air is introduced by infiltration and through the garage doors. The fan is controlled manually by the building operator to operate during the day only, when the unit heaters are off, and vice versa. It was reported that there is only minimal traffic in the garage between late evening and early morning.

The central building makeup system is a built-up unit consisting of intake louvres and dampers, filter section, electric heating coil, chilled water cooling coil and centrifugal cabinet fan. Ductwork supplies air to the corridors at each floor and to the main lobby. A 300 kW electric coil is SCR controlled by a discharge controller. The chilled water coil is controlled by a three way valve and a separate discharge controller. Nominal fan capacity is 4.86 m^3/s (10,300 cfm). Control setpoints are 20°C in winter, 22°C in summer. The unit is controlled by a timeclock which starts the unit at 7 a.m. and shuts it off at 9:45 p.m.

3.1.4 Air Conditioning

A 225 ton chiller provides 7°C chilled water for air conditioning during the summer period. Heat is rejected by a suitably sized cooling tower located on the roof adjacent to the mechanical room. The chiller and associated pumps are located in the mechanical room at the penthouse level of the building. The original chiller was oversized for the application. During a recent retrofit, a gear reducer was installed to reduce chiller capacity.

The apartment suites, guest suite, meeting/party room, and administration offices are cooled by horizontal fan coils concealed in ceiling plenums. The three bedroom suites are provided with two fan coils, the two bedroom suites with one only. Controls are electric wall mounted thermostats with fan speed control and set point adjustment. The drawings indicate that a three way diverting valve is used to adjust flows of chilled water to the fan coil units and thereby control space temperature in response to thermostat settings. However, it is reported that chilled water flow is actually controlled by two-way diverting valves. This discrepancy was not verified in the field. If the latter is the case, it may be contributing to the reported chiller problems.

No cooling is provided for the pool area.

The corridor ventilation air (makeup air) is pre-cooled to approximately 22°C by the system cooling coil during the summer. The discharge controller modulates a three way diverting valve for cooling capacity control.

Chiller controls are prepackaged by the unit manufacturer. Flow proving switches on both the chilled water and condenser circuits are provided for chiller lockout on no-flow conditions.

A condenser supply water temperature controller modulates the two speed cooling tower fan and diverting valve in sequence to maintain 29°C condensing temperatures. The starter is provided with interlocks and time delay between fan high and low speed.

3.1.5 Domestic Hot Water

Domestic hot water is provided from two concrete lined storage tanks of 3,785 L (1,000 US gal) capacity located in the mechanical room. Each tank is complete with four (4) 12 kW immersion heaters and two (2) 2-stage thermostats. The tanks appear to be insulated with 40 mm of fiberglass insulation.

A fractional horsepower recirculation pump and recirculation piping circuit ensure that hot water will be readily available to all users on demand.

Thermostat setpoints are 60°C for tank No. 1 and 57°C for tank No. 2. The recirculation pump operates 24 hours per day.

3.1.6 Pool Water Heater

The swimming pool is provided with an electric pool water heater of 24 kW capacity, thermostatically controlled to maintain a pool water temperature of 28°C which is appropriate for this application.

3.1.7 Pumping

Four major pumping systems serve the building: domestic water, sanitary and storm drainage, swimming pool and chilled water system.

The domestic water system is served by a booster pump set to maintain adequate pressures at the upper floors of the building. The booster system consists of a prepiped package designed to deliver a total of 90 US GPM at a total head of 110 ft. of water. Pumps are sized at 1/3 and 2/3 of required capacity to best match the domestic water demand throughout the day. Pressure controls start and stop the pumps as required. The controls include minimum run timers, manual pump selector switches and safety devices.

A total of three sump pump sets, all under 1 1/2 horsepower, serve the storm, elevator and pool deck drain sumps. These pumps are controlled by integral float controls.

The swimming pool circulating pump is a two horsepower unit and runs continuously for pool filtration and heating.

The chilled water system is provided with three pumps, located in the mechanical room. All units are belt driven, constant speed. Pump P-1 (10 HP) supplies chilled water to the fan coil system. Pump P-2 (10 HP) circulates condenser water between the chiller and the cooling tower. Pump P-3 (3 HP) supplies chilled water to the corridor makeup unit chilled water coil.

3.2 Electrical

3.2.1 General

The building is a fully electric complex with individual heating in the resident areas and central ducted air systems with duct heating coils for the common areas.

3.2.2 Distribution

The distribution system is fed from transformers located on the ground floor that supply 120/208V, 3 phase 4 wire and 600 V, 3 phase secondary power to the building distribution system. Some 347 volt, 3 phase power is reported to exist but was not observed during the site visit or on the drawings. The 600 V system supply feeds the buildings motive power, general areas heating, hot water, swimming pool, garage, etc. This service is sized at 1,200 A.

Hydro says we have 347V Wye

The 120/208 V distribution system supply feeds the individual condominiums and the general area lighting and small power needs. The distribution is taken up through the building with bus duct feeder and distribution panels on every other floor. The circuit breakers in these panels feed circuit breaker panels in each condominium.

3.2.3 Lighting and Miscellaneous Power

The lighting in the general areas is primarily fluorescent, the exception being the swimming pool, the main entrance and the mechanical rooms.

Corridor lighting is provided by wall mounted units; the condominium corporation having upgraded these to 13 Watt (W) "PL" lamps.

The main entrance hall lighting is 75 W tungsten with timer and dimmer control, the pool lighting is 150 W PAR lamps with 150 W metal halide over the pool; 80% of these units are disconnected.

Garage lighting is 100% fluorescent. Coverage and illumination levels are marginal with respect to Ontario Building Code (OBC) requirements.

Lighting within the suites is 99% tungsten.

3.2.4 Heating and Ventilating

The electrical components of the heating and ventilating equipment and systems are described in section 3.1.

3.2.5 Apartment Suite Miscellaneous Power

In addition to the baseboard heating described previously, each unit is equipped with a full size refrigerator, a 9 to 12 kW range, a dishwasher, a washing machine and a clothes dryer. Many suites also have microwave ovens. and some have freezers.

3.3 Building Envelope System

As has been mentioned previously, specific information concerning the building envelope system is not available from the drawings and specifications for the complex.

However, our review of the architectural drawings for the building indicates that, as expected for construction of this vintage, there is no specific intent to control air leakage through the building envelope. The interior finishes of painted gypsum board will be generally effective in resisting air flow and some air leakage control at joints, penetrations, and connections of the interior finishes may be inherent to the construction. However, these are not the result of specific detail attention to the provision of airtightness in the original design.

At the top of the building, it is fortunate that the construction incorporates cast-in-place flat slabs for roof decks at both the main roof level and the mechanical penthouse. These slabs are inherently excellent barriers to the uncontrolled movement of air through the building envelope. In general, these elements of the envelope provide continuous airtightness except at penetrations (such as roof drains) and connections to other elements.

The review of typical conditions of air movement through the envelope during site visits indicated that the exterior wall static pressure differential regime in the winter season tends to be dominated by that induced by stack effect (temperature differential) in the tower. At the base of the tower, a negative pressure differential of approximately 30 Pa (with respect to the exterior) was measured, while at the top of the tower, a positive pressure differential of the same magnitude (with respect to the exterior) was measured. These readings imply that, in the presence of discontinuities in the building envelope, infiltration will tend to occur over the bottom half of the envelope and exfiltration over the top half of the envelope. On the top floor of the building, some air flow was observed from the elevator penthouse stairwell into the corridor. Since the pressure differential across the envelope at this height in the building is definitely positive (with respect to outside) this observation indicates that a mechanical depressurization of the corridor may exist. The precise identification of the cause of this internal air flow circuit was beyond the scope of this audit. I pointed this out to MVD.

Smoke pencil testing in various areas within the complex indicated that, in general, envelope deficiencies contributing to uncontrolled air leakage can not be identified in isolated locations, with the exception of the elevator mechanical penthouse. This situation is common amongst buildings of this construction type, where air movement through the building envelope occurs in a diffuse pattern throughout the complex and is concentrated only at the unsealed cap of an elevator shaft which connects every floor level. The movement of air within the complex will always follow the path of least resistance, which in this case is represented by the elevator shaft acting as a stack in the center of the building. The predominant air flow circuit in the building will therefore involve air movement into the elevator shaft at lower floors, and air movement to the exterior at the top of the shaft. Measurements taken on site indicated that the flow of air in this circuit can be estimated as 0.63 m^3/s (1325 cfm) under average winter outdoor conditions, and 0.76 m^3/s (1600 cfm) on a design day. In addition, the measurements indicate that the air flowing out of the building at the top of the elevator shaft averages 17°C. This implies that the costs associated with heating a volume of 0.63 m^3/s of outdoor air to 17°C are lost due to the uncontrolled air leakage through the building envelope on a continuous basis throughout the winter. Some additional air leakage will occur at kitchen and bathroom exhausts, connecting the units to the exterior. These air flow circuits will contribute to energy losses in the building, however little can be done to reduce leakage through these areas. The systems can not be completely capped (sealed) as they are required by the Ontario Building Code, to provide minimum ventilation requirements. Motorized dampers could be installed on each system to seal the stacks when the system is not in use, but the cost of this type of retrofit work is typically prohibitive.

It should be noted that the elimination of the concentrated air leakage at the top of the elevator shaft involves a relatively small air sealing project, but the rehabilitation required to eliminate all the diffuse air leakage throughout the building envelope would necessitate a very costly and comprehensive envelope retrofit.

4. ENERGY ANALYSIS

4.1 General

Total electrical energy consumption of the complex was metered by Ontario Hydro over a one month period from December 8, 1989 to January 8, 1990. Data was collected at 15 minute intervals throughout the entire period, on five recording demand meters.

Submetering was provided for the corridor makeup air unit, two water heaters and the pool heating and ventilating unit for the entire month, in the following manner; meter # 1 was connected to the main building service; meter # 2 was connected to the corridor heating coil; meter # 3 was connected to the pool area heating coil; and meters # 4 and # 5 were connected to the domestic hot water heater #1 and #2.

An additional meter was installed to the 208V service supplying floors 3 and 4 from December 12, 1989 to January 8, 1990.

Analysis of the data indicates that the winter energy use patterns in the building are relatively constant with little variations in consumption between weekdays and weekends. A strong weather dependent component was found, as would be expected for an electrically heated building. Refer to figures 1A to 1E inclusive.

Daily load fluctuations are extremely predictable with 2 major peaks occurring. The first peak typically occurs from about 7 a.m. to 10 a.m. in the morning, the second from 7 p.m. to 10 p.m. in the evening. The morning and evening peaks are similar with the morning peak usually slightly higher than the evening peak but only marginally so. Changing temperatures through the day as well as different loads imposed by the residents contribute to the relative differences between the morning and evening peaks. Any peak demand reduction measures must therefore address loads occurring both mornings and evenings. Refer to Figures 2A and 2B for typical daily load profiles.

It should be noted that approximately 30% of the apartment units are vacant from mid December to mid March. Slightly lower vacancies are reported for the summer months.

4.2 Building Electrical Peak and Demand

A peak demand of slightly more than 1000 kW was recorded for the building at 9:45 a.m. on Thursday December 21, 1989. Outdoor temperature had averaged approximately -21.7°C over the preceding two hour span.

A review of the electrical metering indicates that the largest use of power during this peak was directly related to the apartment suites. Figure 2B shows the building load profile for December 21, 1989, as measured at the main service meter, which would include all submetered loads and unmetered loads. A cross reference with the individual meter readings clearly show the total load of all the general building services and the suites to be at maximum demand. The recorded demand at the specific time shows:

Water Heater # 1	=	44 kW
Water Heater # 2	=	44 kW
Primary Ventilation Heater	=	155 kW
Swimming Pool Area Heater	=	37.5 kW
Pool Water Heater (estimated)	=	24 kW

Individual Suites - 3rd and 4th floor reading

=	118 kW/16 units		
=	7.37 kW/unit average x 94	=	693 kW
	Total	=	997.5 kW

The remaining hydro demand can be assumed as the remaining building systems i.e. lighting, motors, etc. Note that metering errors, unmetered loads and the estimated apartment loads may lead to minor errors in estimating building load distribution.

As illustrated in Figure 3, fully 69% (693 kW) of all electricity used in the building is used for space heating, lighting and appliances in the suites. Some of this load can not be eliminated or reduced, being fully under resident control. However, based on the air leakage rates estimated from field measurements, 5% (34 kW) of this load is directly attributable to uncontrolled leakage through the building envelope. The measured and projected apartment loads include heating, lighting and appliances.

Of the remaining 31% of electricity used in the building, 30% is attributed to central building systems:

- 15% corridor ventilation
- 9% water heaters
- 4% pool heating and ventilation
- 2% pool water heaters.

Some 135 kW of unit heaters in the parking garages are manually controlled and were turned off when the building peak occurred. It should be noted that when the unit heaters are turned on in the evenings a large increase in demand occurs when all the 135 kW connected unit heater load comes on-line. After the temperatures in the garage stabilizes, the loads are reduced to a fraction of the initial "cold start" load.

A review of the main service load monitoring indicates a general peak period lasting from 7:00 a.m. to 10:00 a.m. with a superimposed higher peak with a duration of approximately 15 minutes.

This is substantiated by the individual recordings for the various other sources of energy usage most of which peak during this period.

The graphic recordings indicate a second but lower peak between the hours of 7 p.m. and 10 p.m. for a period of 20 minutes.

The recorded peaks are explained by the operation and occupancy of the building. There are four major contributors to the morning peak:

.1 Tenant services

.2 Water heaters

.3 Pool area heater
.4 Ventilation heater

The resident and water heater loads can be assumed to be attributable to the occupants normal daily routine of showers, heating, cooking etc.

The pool heating and ventilating system shows a morning peak which is attributable to increased activity levels during the morning. Increased activity levels in the pool area will raise the rate of evaporation from the pool, thereby increasing space relative humidity. This in turn increases the pool ventilation rate and electric coil loads.

The evening peak can be attributed to three sources of demand which often overlap:

.1 Tenant services
.2 Garage heating
.3 Corridor ventilation

Recordings indicate the tenant source has an evening peak which generally varies between 8 p.m. to 9 p.m. The garage heating is manually switched on anytime between 9.30 p.m. and 11.30 p.m. The ventilation heater is turned off automatically at 10:45. When these three load components occur simultaneously, this can equate into a peak demand of approximately 900 kW for a short period, both during the morning and evening periods.

4.3 Energy Consumption

Total metered electrical consumption during the period of December 8, 1989 to January 8, 1990 was approximately 494,500 kWh, which would have incurred approximately $22,500 in electrical consumption charges. Figure 4, which illustrates the breakdown of the various load components, was obtained from submetering data collected over the month. The apartment floor data, measured for only 16 suites and 25 days, was corrected to provide estimates of total apartment consumption over the period. Also note that the "apartment" component of the consumption figures includes consumption directly attributable to air leakage as discussed elsewhere in this report. In the monitoring period, this air leakage portion of the "Apartment" load has been estimated to be 13,600 kWh or approximately 4% of the total apartment consumption. Consumption was distributed as follows:

Apartments:	369,035 kWh	75%
Corridor Ventilation:	44,425 kWh	9%
Water Heaters:	19,306 kWh	4%
Pool Ventilation:	19,306 kWh	4%
Other:	23,341 kWh	5%

The ratios of the consumption loads are similar to that of the demand except that the apartment component is larger due to continuous operation, and the ventilation component smaller due to restricted hours of operation. This consumption pattern would be typical of December for this building where a large number of residents are absent for a brief period at Christmas. Figure 1C shows the markedly reduced loads occurring at that time. High energy consumption compared to previous years can mainly be attributed to the record breaking cold weather experienced in 1989.

4.4 Electrical Bill Analysis for 1988 - 1989

The following information was collected during the site survey and information obtained from Hydro. During the period covered approximately 30% of the suites were unoccupied and the heating in those suites was set at 10°C to 16°C.

Carleton Condominium Corporation No. 81 spent $147,412.05 for electricity for the 12 month period from December 12, 1988 to November 9, 1989, which averages $12,284.33 per month.

There is a significant variance in the energy consumption from summer to winter months. Summer consumption is as low as 151,200 kWh per month, and demand 170 kW. Winter consumption reached its peak of 415,800 kWh in January, 1989 where 550 kW demand was recorded.

It should be noted that a peak of over 1000 kW was reached during the colder than average month of December in 1989.

4.5 Electrical Billing Rates

Ottawa Hydro monthly rates for 1988-89 were as follows:

.1	**Demand Charges**	**$/kW**
	First 50 kW	Nil
	50 kW and over	$3.90
.2	**Energy Charges**	
	First 250 kWh	6.23¢
	Next 12,250 kWh	5.98¢
	Remainder	4.33¢

There are no discounts allowed on this account.

Review of the 1987-88 and 1989 invoices from the Ottawa Hydro Electric Commission indicate no power factor penalties have been levied. Hydro has confirmed that no power factor charges are levied against this building. However, the billing structure in effect applies a slight penalty due to the manner in which the demand costs are calculated, as illustrated below. The billing shows that in 1988, the months of June, July, August and September have higher kVA values when calculated than kW for demand charge purposes. The demand charges are calculated at 90% of kVA or total kW whichever is greater, as shown below:

June reading	=	170 kW or 210 kVA
Penalty	=	(210 x .9) - 170
	=	19 x $3.90
	=	$ 74.10
July reading	=	175 kW or 215 kVA
Penalty	=	(215 x .9) - 175
	=	18 x $3.90
	=	70.20
Aug. reading	=	180 kW or 220 kVA
Penalty	=	(220 x .9) - 180
	=	18 x $3.90
	=	70.20
Sept reading	=	170 kW or 220 kVA
Penalty	=	(200 x .9) - 170
	=	10 x $3.9 = 39.00
Total for the four periods	=	$253.00

Therefore the billings for this period include a hidden "power factor" charge of $253.00 within the reported demand charges.

This was not in draft.

A Reserve Fund Study dated March, 1989 (prepared by J.L. Richards and Associates Limited) identifies the same method of calculating demand charges. Differing costs appear to be a function of varying load conditions in the building but could not be confirmed. All data used in this report was taken directly from Hydro invoices.

I supplied Doug Bellmitt photocopy of raw data obtained by Richards from Hydro

4.6 Heating and Cooling Loads

Heating and cooling loads were calculated for the building. From the available building drawings and our site investigation, a computer simulation of the building was done. The software model is based on ASHRAE calculation procedures.

Summer heat gains are estimated to be 482 kW (137 tons) at peak design conditions. The building peak would normally be expected at 5 p.m. in the month of July. The chiller electrical demand would be approximately 150 kW, assuming 1.1 kW per ton of cooling. The cooling load profiles derived from the simulation show the typical fluctuations in cooling loads from which total energy consumption for the year can be estimated:

	kWh	kW
May	14,446	69
June	23,430	96
July	64,790	150
August	14,446	69
September	7,200	35
Total Annual	**124,312 kWh**	**419 kW**

Total annual cooling costs are therefore in the order of $5660 in energy charges and $1720 in demand charges.

Design heat losses were calculated using the same simulation model. Peak heating loads on the winter design day would be 1340 kW (4,577,400 Btu/hr.)

which appears to be consistent with the observed loads in the study period which did not include a day with design conditions. Using the simplified degree day method the annual energy use for heating was found to be 2,139,724 kWh/year (7.3 x 10^9 Btu/year). This corresponds to approximately $97,500 per year in energy costs and $7225 per year in demand charges. These energy costs are not abnormal for a building of this type and vintage heated with electricity.

5. ENERGY CONSERVATION MEASURES

5.1 General

The objective of this section is to identify cost effective energy conservation opportunities which could be implemented to reduce the overall energy cost. The analysis presented is based on information collected during site surveys and discussions with the condominium operations manager and Ontario Hydro personnel.

Our review indicated a limited number of areas which could be addressed as part of an energy management program:

- garage heating and ventilation
- air sealing the elevator shaft cap
- corridor ventilation and suite exhaust
- pool heating and ventilation
- pool water heating
- domestic water heating

The various approaches to reduce energy consumption and demand are discussed in Section 5.2 of this report. Section 5.3 summarizes and prioritizes our recommendations.

Common area lighting does not have the potential for energy conservation. The corridors have already been converted to high efficiency "PL" type lamps (Gold Star) and lighting in other areas has been reduced to absolute minimum levels.

There would not appear to be any measures that could be implemented relative to the resident services for demand control. The installation of individual metering to each suite would possibly reduce energy consumption by virtue of individual occupants being aware of and managing their own energy consumption. Assuming that the rate structure was maintained as is and that the individual meters were sub-meters for internal purposes only, cost savings would also be realized. However, additional accounting time would be required to properly bill the residents based on the submeter readings. The cost to install the meters is estimated to be $800 per unit. However, we could not estimate what savings would be realized since they would be a function of the individual residents habits and energy consciousness.

5.2 Conservation Opportunity Descriptions

5.2.1 Heating

.1 All unnecessary heaters in common areas the building are currently turned off or set to maintain frost free conditions only, and little energy conservation or demand reduction potential exists for these systems. Apartment heating is controlled by the owners and tenants and cannot be changed. The only systems which can be controlled are the pool space heating and garage heating. Refer to 5.2.4 for the pool systems.

.2 The pool heating/ventilating unit thermostat setpoint is currently maintained at 24.5°C for user comfort. During unoccupied periods the setpoint temperature could be reduced by 4.5°C. In addition to reducing envelope losses and ventilation loads, pool evaporation would be reduced, resulting in less energy being used for pool heating and enclosure dehumidification. If setback temperature occurred from 10 p.m. to 6 a.m., approximately 2,225 kWh of energy at a cost of $100.00 would be saved per year. Cost of a setback thermostat with remote temperature sensor would be $250 installed. Simple payback would be approximately 30 months.

.3 Parking garage heaters are generally turned off early in the morning by the building operator and turned on late in the evening. The unit heaters operate for about 8 hours/day. Thermostats are set to maintain frost free conditions only (approximately 5°C) during those operating hours. A review of the metering data indicates that the heaters almost always contribute to the evening peak, and regularly contribute to the morning peak. Several alternatives to reduce peak demand are possible.

(a) Provide a central timeclock and contactors as required to permit unit heater operation through the day, except during electrical peak periods. Timers would generally lock out the heaters from 6 a.m. to 11 p.m. to ensure that all the heaters did not come on when the corridor ventilation unit was still operating. New thermostats would permit more accurate control, closer to the lowest acceptable temperature and will therefore reduce energy costs.

(b) As above, except provide two timing circuits to control unit heaters. The first time clock would prevent all unit heaters except select units near the garage doors from operating between the hours of 6 a.m. and 11 p.m. This would avoid operating concurrently with tenant and other daytime loads. The second timeclock would prevent the selected unit heaters from operating between 6.30 a.m. and 12 a.m., 3 p.m. and 11 p.m. This schedule should maintain frost free conditions near the garage doors without creating new peaks. If all heaters operate during the 12 to 3 p.m. period, a new peak would be created when all the heaters turned on at noon. Operating select heaters during the midday period would reduce the risk of frost damage due to slightly reduced night time operating hours. Note that with multi-channel timeclocks only additional contactors would be required to implement this option over the previous.

(c) Load shedding could also be implemented to permit operation all day except when pre-determined "acceptable" peaks are approached. This has the benefit of providing more even temperatures throughout the day and reduced demand when the units re-energize after being shut off by the load management program. We would recommend that low limit controls be provided to override the load shedding program to avoid freezing pipes under extreme conditions, at the risk of creating a new electrical peak.

Estimated annual savings costs and paybacks can be estimated:

Garage

Examination of the load profiles indicate that the unit heaters contribute to the morning and/or evening peaks on a regular basis. As these units have been shut off for most of the day, all heaters come on at the same time, i.e. creating a 135 kW peak in the evening. Most mornings, a similar peak occurs as the unit heaters are generally still "On" at part load when the makeup air unit is turned on. If time clock controls are provided to lock out unit heaters during all or part of the day, the building peak will generally be shifted to the evening and the unit heaters will be contributing to that new daily peak. Again from the main service load profiles, the average contribution to the morning peak appears to be in the order of 80 kW due to garage door openings, etc. and 135 kW to the evening peak. Note that if the corridor ventilation loads are reduced, the daytime loads will be levelled considerably. Any operation of the garage unit heaters during the day would contribute to new daytime peaks, therefore, running all the heaters all day is not recommended. For the months with mean temperatures below 3°C the savings can be calculated:

Morning Peak	=	5 months x 80 kW x $4.10/kW
	=	$1,640 per year
Evening Peak	=	2 x 135 x 4.10
	=	$2,767 per year

This is mainly a demand reducing measure. As the garage must maintain average temperatures above freezing, the average energy consumption and operating hours would not be expected to change significantly.

Estimated capital costs for timers, relays, contractors and wiring are approximately $3,500. The payback for this work can be calculated as shown below including the maximum 50% incentive by Ontario Hydro.

SIMPLE PAYBACK (morning) $= \frac{\$3,500 - \$1,750}{\$1,640}$

= 1.1 years

OR

SIMPLE PAYBACK (evening) $= \frac{\$3,500 - \$1,750}{\$2,767}$

= 0.65 years

< 1.5 years (see p 30)

Even in the worst case, paybacks are acceptable and we recommend that the time clocks for unit heater control be installed.

The minimum cost to install load shedding equipment for this application is estimated to be in the order of $9000. Energy savings would be similar to the previously calculated savings using timeclocks as discussed above.

Payback would be at least:

SIMPLE PAYBACK = $\frac{\$9000 \text{ (minimum)}}{\$2767 \text{ (maximum)}}$ = 3.3 years (or greater)

Including an Ontario Hydro incentive, estimated as $4,500, would reduce the payback to 1.6 years.

(Y) For the load shedding option, controlling the pool and domestic water heaters in addition to the unit heaters would reduce demand by a further 65 kW, for additional savings of approximately $250 per month or $2995 per year maximum. Savings are the result of de-energizing the pool heater and half the domestic water heaters. The additional wiring and equipment costs would add $4000 to the load shedding equipment cost; and the estimated Hydro incentive would be 50% of capital costs:

SIMPLE PAYBACK = $\frac{\$13{,}000 \text{ (minimum)} - \$6500}{\$1640 + 2995}$

= 1.4 years

Refer to sections 5.2.4 and 5.2.5 for further information.

5.2.2 Ventilation

.1 The corridor makeup air (ventilating) unit is a major contributor to both electrical demand and consumption over the year. At winter design conditions the unit contributes approximately $12,650 to the building electrical bills. Of this approximately $2,200 is due to demand charges, the rest to consumption. Operating in parallel with this system is the dryer exhaust system, rejecting heated air at approximately 22°C, and running 24 hours per day. Two approaches can be considered to reduce energy consumption and peak demand.

5221 (a) Converting the ventilation unit to a gas fired makeup air unit:

(N) The gas conversion would require running a gas pipe up the exterior face of the building adjacent to the north exit stairs and across the roof to the mechanical room. A packaged rooftop indirect gas fired unit would then be ducted through the main intake louvres to supply the space. The natural gas cost, at $5.00/MCF would be in the order of $3,725 per year. Fan power consumption would be similar to existing conditions. "No"

Assuming that the gas company would provide the street connection and meter, the estimated cost of construction would be approximately $44,000. insurance

SIMPLE PAYBACK $= \frac{\text{Cost}}{\text{Net Savings}}$

$= \frac{44{,}000}{(12{,}650 - 3{,}725)}$

$=$ 4.9 years

Electrical consumption would be reduced by 230,000 kWh and demand by an average of about 60 kW over a 9 month season. Peak demand savings would be in the order of 97 kW, based on average December conditions.

(b) Converting the ventilation unit to a heat recovery unit:

(Y) This alternative recovers waste heat. The existing dryer system currently exhausts approximately 2453 L/s of air at 22°C everyday throughout the year. By reducing operating hours on this system and reclaiming the otherwise wasted heat, energy savings can be realized. "yes"

The dryer exhaust system removes air previously heated by the space heating units in the suites. On a design winter day this corresponds to about 145 kW and 250,000 kWh/year of electrical energy. Reducing the operating hours to coincide with the makeup air system operation would reduce system operation by 8 1/2 hours and save $4,000 per year in electrical costs for heating alone. Some cooling energy savings would also be generated.

Exhaust air would be transported by ducts running across the roof to an air-to-air heat exchanger to preheat the makeup air in winter, and precool the makeup air during the summer. A heat pipe based system supplying 2606 L/s and exhausting 2453 L/s would save approximately $6,350 per year in combined energy and demand costs. Total kW reduction would be in the order of 112 kW in January, a total of 671 kW over the year, representing approximately $2,750 in demand charges. The heat recovery system would be designed to pre-cool entering air in summer, whenever the total energy of the exhaust stream was less than that of the outside air. Under other conditions, controls would modify system performance to reject the exhaust air without heat recovery.

For a built-up heat recovery package, using heat pipe technology and evaporative cooling, and including for power wiring, fans, starters and ductwork, installation costs are estimated to be approximately $44,000. Timeclocks for the exhaust fans and make-up air unit control would cost approximately $1,600. Assuming a maximum Ontario Hydro incentive of $300 per kW and considering winter load reductions only:

$$\text{SIMPLE PAYBACK} = \frac{\$44{,}000 + \$1{,}600 - (75 \times 300)}{\$6{,}350 + \$4{,}000}$$

$$= \frac{\$23{,}100}{\$10{,}350}$$

$$= 2.2 \text{ years}$$

522.1 The cost calculation assumes that the average kW savings over a 9 month season for ventilation air is (671 kW/9 month) = 75 kW, generally a $22,500 Ontario Hydro Incentive.

We would recommend that heat recovery be installed in preference to converting to gas. The heat recovery package would reduce overall energy consumption by utilizing "free heat" instead of simply displacing the source of energy. During hours where the timeclocks locked out the corridor ventilation unit and dryer exhaust fans, the use of dryers would have to be restricted. "yes"

522.2 Garage exhaust fan operation currently results in approximately $1,890 per year in electrical and demand charges. We would recommend as part of the retrofit work that the exhaust fan and dampers be provided with a carbon monoxide detection system to automatically control the exhaust fan. This could save in the order of $1,500 per year in energy. No credit can be taken for demand reduction since safety requirements necessitate that the exhaust fan be capable of operating at any time. A typical six point solid state C.O. detection system with one controller would cost approximately $6,000 installed. "yes" (Y)

$$\text{SIMPLE PAYBACK} = \frac{\$6,000}{\$1,500} = 4 \text{ years}$$

In addition to reducing energy costs, other benefits are obtained: warmer garage and less risk of freezing pipes in the garage. Small demand reductions would be realized, but are not considered.This option should be implemented to help reduce the potential for frost damage to the structure and piping; the energy benefits will pay for the investment.

(Y) 522.3 The elevator room intake and exhaust, the mechanical room intake and exhaust and the makeup air unit intake are equipped with dampers in very poor condition. Each should be replaced with new low leakage units.

When the corridor make-up air system is shut down by the timeclock, the stack effect in the building can result in infiltration of outside air at the base of the building and exfiltration of heated air at the top of the building. The leaking dampers provide an air path to the outside, facilitating exfiltration.

The mechanical and elevator rooms are each provided with thermostatically controlled intake dampers and exhaust fans which are provided with gravity backdraft dampers. These dampers are in poor condition due to deterioration over the years. In addition, the gravity dampers do not close well. Damper leakage is estimated to be approximately 247 L/s on a winter design day. New low leakage motorized dampers would reduce this by about 224 L/s. Calculating savings based on an average winter day at -11°C, we estimate that damper leakage wastes approximately 21,300 kWh/year and contributes an average 7.4 kW to demand. Replacing these dampers would save, on an annual basis, $112 in demand, and $885 per year in energy.

Capital costs for new low leakage dampers, two new damper motors, miscellaneous sheet metal and wiring would be approximately $2,700. Assuming full Ontario Hydro incentives of $300 per avoided kW then:

$$\text{SIMPLE PAYBACK} = \frac{\$2{,}700 - (7.4 \times 300)}{\$1{,}000} = 0.5 \text{ years}$$

or 2.7 years prior to application of incentives? ∴ eligible?

Note that the generator room dampers are in very poor condition and require refurbishing. Benefits of refurbishing the dampers would include reduced risk of freezing in the room, better comfort for the suite above it, and proper generator ventilation. However, the associated energy savings would be minimal.

5.2.3 Air Leakage

(Y)

The lack of adequate air leakage control in the building envelope of this complex, particularly at the elevator mechanical penthouse is a contributor to both electrical demand and consumption over the year. Throughout a typical winter season where temperatures over a four month period average -11°C, and drop to -25°C on two occasions, the uncontrolled movement of air out of the elevator mechanical penthouse contributes approximately $2500 to the building electrical bills. Of this, approximately $2,200 is due to consumption, and the remaining $300 demand charges. This corresponds to a total of approximately 68 kW of demand per year. Additional charges due to uncontrolled air leakage may occur in the cooling season, but can not be accurately estimated.

Through an effective air sealing program, the flow of indoor air out of the elevator penthouse can be eliminated. This sealing would cost approximately $1500 to implement, and would result in yearly savings of $2300 as a result of the reduced space heating load achieved by eliminating the air leakage flow.

The payback for this conservation measure is calculated as:

SIMPLE PAYBACK = $1500 / $2300

= 0.65 years

Note that Ontario Hydro incentives are not available for measures with paybacks less than 1.5 years.

5.2.4 Pool Systems

.1 The pool area's two main systems consist of a 85 kW electric duct heater and fan to provide ventilation and space heating, and a 24 kW electric pool heater.

5241

Pool water heat losses are mainly attributable to evaporation of water and replacement with cold makeup from the city mains. Assuming constant space temperatures and winter water temperatures of 3°C, the estimated pool water losses are approximately 17 kW, or 150,000 kWh/year. Costs would be about $6,800 in energy cost and $800 in demand costs.

(Y)

OR

5.2.4.3

The simplest demand limiting options would be providing a timeclock to lock out the pool water heater during the peak periods. For a cost of under $500 the building peak load could be avoided. Caution would have to be exercised to avoid creating a new peak when the pool heater was re-energized at full load. Simple payback based on eliminating the demand charges only, without Hydro incentives, would be in the order of: "YES"

$$\text{SIMPLE PAYBACK} = \frac{\$500}{\$800}$$

$$= 0.6 \text{ years}$$

Refer to section 5.2.1 for a discussion of load shedding potential. (page 22)

524.2 To avoid electrical costs entirely, the pool heater could be converted to a high efficiency gas boiler. A "pulse" type condensing boiler with seasonal efficiencies of over 90% would cost approximately $13,000 to install, including gas piping, PVC inlet and exhaust piping, coring of the terrace roof slab. The cost of natural gas would be $2,850 per year. Net energy cost savings would be $4,750/year. "NO"

(N)

$$\text{SIMPLE PAYBACK} = \frac{\$13{,}000}{\$4{,}750}$$

$$= 2.7 \text{ years}$$

Electrical savings and demand reduction obtained by shifting the load to a non- renewable resource may not be considered desirable.

524.3 A third approach would consider both major pool systems: the water heater as well as the heating and ventilating unit. The heating and ventilating system consumes approximately 289,110 kWh/year of electricity, at a cost of $13,000 excluding the demand costs, according to the results of several computer simulations. Installation of a refrigerated air dryer would permit a reduction in outside air quantities presently required to control space humidity. Several equipment models available work on the principle of cooling the air from the pool enclosure to condense out the water vapour, rejecting the condenser heat to the air stream to reheat the air stream and preheat pool water and/or domestic hot water. Excess heat is rejected to the outdoors by the ventilation system. Outside air quantities are reduced by a factor of up to 10 which reduces the electrical heating requirements. A small electric reheat coil is provided to makeup for insufficient system capacity under some conditions.

(Y) "YES"

Energy costs for operating the new air dryer's compressor, the net increase in fan power and reheat are estimated to be $7,700 per year at typical ventilation rates.

Net savings for the pool air dryer are the total energy costs of the existing pool heater and ventilation system less the operating costs of the new system.

Savings = $20,200 - $7,700 = $12,500 per year including demand savings.

Estimated capital costs for providing and installing the air dryer, removing and modifying existing air handling systems, making good the drywall ceilings and partitions removed to allow installation of the dryer would be approximately $46,500.

Demand reductions in the coldest months based on existing (inadequate) ventilation rates would be approximately 35 to 40 kW. As ventilation rates are increased when warmer more humid air is brought in for pool ventilation, the energy demand would be expected to remain in the same order of magnitude. If maximum incentives of \$300 per kW were applied:

$$\text{SIMPLE PAYBACK} = \frac{\$46{,}500 - (35 \times 300)}{\$12{,}500} = 2.9 \text{ years}$$

524.4 An inexpensive but labour intensive and restrictive measure would be to provide a pool blanket. A custom blanket with permanent storage would cost in the order of \$750 installed. By essentially eliminating evaporation of pool water, the pool heat losses would be reduced in direct proportion to the time the pool was kept covered. Assuming that the building superintendent kept the pool covered from 10 p.m. to 7 a.m., pool water heating costs would be reduced by:

$$\text{Savings} = \frac{9 \times \$6{,}800}{24} = \$2{,}550/\text{year}$$

For the existing heating and ventilating system remaining unchanged, similar savings in ventilation costs would be expected.

Total capital costs would include the cost of the pool blanket, repairs and modifications to the heating and ventilating unit and controls. A budget estimate of \$2,500 should be adequate for these items. No Ontario Hydro incentives would be expected for financing this recommendation.

$$\text{SIMPLE PAYBACK} = \frac{\$750 + \$2{,}500}{\$2{,}550 + 2{,}550} = 0.64 \text{ years (8 months)}$$

Note that installing and using the pool blanket may not be acceptable to the residents.

5.2.5 Domestic Hot Water

Domestic hot water requires an average 1145 kWh per day of electricity, and typically contributes 80 kW to the morning peak and 60 kW to the earlier part evening peak during the winter. Assuming constant water usage profiles, and annual average water temperature of 5°C we can calculate average annual consumption and demand costs.

Cost of Energy = 1145 kWh/day x 365 days x $0.0455/kWh
= $19,015 per year

Demand Costs = $\frac{(60 + 80\text{ kW})}{2}$ x 12 months x $4.10
= $3,444

Total Costs = $22,462 per year

(Y)

.1 Providing water conserving shower heads is known to reduce hot water costs by up to 28%. Using a more conservative figure of 20% the potential energy savings are estimated to be (0.2 x $19,000) = $3,800 per year. This represents 83,500 kWh of reduced consumption. Reductions in demand would save $690 per year and reduce the peak by 14 kW.

"YES"

We estimate that the cost of installing new shower heads throughout the building would be $4,800 if done by a contractor ($2,400 for the materials only). Assuming contractor installation of the heads; and Ontario Hydro rebate of $10 per shower head:

two showers per unit
2 x 95 = 190
+ Guest + 2 x pool = 3
193

$$\text{SIMPLE PAYBACK} = \frac{\$\,4{,}800 - (97 \times 10)}{\$\,3{,}800 + \$690} = 0.85 \text{ years}$$

+ 1 for superintendent

The 97 shower heads include the 94 units, one guest suite, and the two pool changing rooms.

(N)

525.2 The possibility of increasing the storage water temperature was examined. Under this scenario, by raising the storage temperature, the depletion rate of the tank can be reduced and effective water storage capacity increased. This could have permitted locking out the water heaters for critical demand periods. To prevent scalding, fail safe mixing valves located in the penthouse mechanical room would then mix the hot and cold water to the normal temperature of 140°F.

This possibility is not practical as water demand is relatively high for long periods of time during both the morning and evening peaks. For example, by increasing the stored water temperature to 190°F, the depletion rate can only be reduced by 30%. This would permit a maximum storage capacity of 25 minutes before the water temperature in the storage system began to fall, which would be unacceptable to the residents.

We would recommend, however, that the heater controls and balancing be reviewed. Tank No. 1, for example, appears to be operating 48 kW of heat with ON/OFF control only, while Tank No. 2 seems to be working with 2 stages of control. These tanks are both equipped with 2 thermostats, 2 stages each which should theoretically provide 4 stages of control per tank. Correcting these hardware problems will reduce demand. A diffuser assembly on the tank water inlet would improve stratification in the tank and also help reduce peak demand. Demand savings could not be estimated because the contribution of the water heaters to the building peak varies on a daily basis. Improving the controls would allow the heating elements to independently cycle on and off to more accurately follow the load, rather than having them all turn on and off simultaneously as they are now doing.

.3 Providing a natural draft (conventional) domestic water boiler with vent, combustion air intake louvres, piping, pump and controls would cost approximately $20,500. Net savings would be in the order of $12,000 per year.

$$\text{SIMPLE PAYBACK} = \frac{\$20,000}{\$12,000} = 1.7 \text{ years}$$

525 .4 Instead of a natural draft boiler, more efficient "pulse" type condensing boilers, with circulating pumps, piping, heat exchanger and all accessories could be installed at the cost of $29,250. Net savings of $14,600 per year could be realized. "YES"

Y

$$\text{SIMPLE PAYBACK} = \frac{\$29{,}250}{\$14{,}600}$$

$$= 2.0 \text{ years}$$

.5 Chiller heat recovery was briefly examined and found not to be a viable energy management option. Maximum expected savings would be in the order of $2000 per year and capital costs after maximum incentives, in the order of $15,000 to $20,000, excluding engineering fees. Paybacks would be unacceptable. This option is not viable due to a number of limiting factors:

- short cooling season with a significant proportion of part load operation;
- hot water demand not coinciding with the highest cooling loads; and
- high capital costs for a plate heat exchanger, pumps, piping, insulation, valves and controls.

5.3 Summary of Energy Conservation Opportunities

The following table summarizes the energy conservation measures examined in Section 5.2. The table is cross referenced to the appropriate sections. Recommended measures are identified, but caution should be exercised as some measures are mutually exclusive. Cost estimates are based on "stand alone" implementation of the recommended measures; in some cases the total costs could be lower because of shared costs when similar measures are implemented. An example would be the load shedding recommendations where the new equipment costs are shared between garage unit heaters, pool water heaters and domestic water heaters.

Description	Item	Savings $	Cost $	Payback (years)	Recommended
Low leakage dampers	5.2.2.3	1000	500	0.5	Yes
Pool water heater time clock	5.2.4.1	800	500	0.6	Yes
Pool blanket and repairs	5.2.4.4	5100	3250	0.64	No
Air Sealing Elevator Mechanical Penthouse	5.2.3	2300	1500	0.65	Yes
Water conserving shower heads	5.2.5.1	4490	3830	0.85	Yes
Timers garage unit heaters	5.2.1.3	1640	1750	1.1	Yes
Load Shedding garage unit heaters, pool heaters, domestic water heaters	5.2.1.3	4635	6500	1.4	Yes
Domestic water boiler	5.2.5.3	12000	20500	1.7	No
Pulse type water boiler	5.2.5.4	14600	29250	2.0	Yes
Ventilation heat recovery	5.2.2.1(b)	10350	23100	2.2	Yes
Pool temperature setback	5.2.1.2	100	250	2.5	No
Pulse boiler, pool heater	5.2.4.2	4750	13000	2.7	No
Refrigerated air dryer and heat recovery for pool ventilation and heating	5.2.4.3	12500	36000	2.9	Yes
Ventilation gas conversion with timeclock on exhaust	5.2.2.3	12925	45600	3.5	No
C.O. control of garage exhaust fan	5.2.2.2	1500	6000	4.0	Yes
Ventilation gas conversion	5.2.2.1(a)	8925	44000	4.9	No
Raise water temperature, provide mixing valve	5.2.5.2	-	-	-	No

Priorities for implementation would be dependent on available financing, and the Condominium Corporation long term goals. For example, installing the pool blanket (5.2.4.4) would reduce the savings of installing an air dryer and would require more reheat to heat the pool enclosure at night. A trade off would have to be made, at the cost of extra work for the building operator and perhaps inconvenience for the residents.

MORRISON HERSHFIELD LIMITED

FIGURES

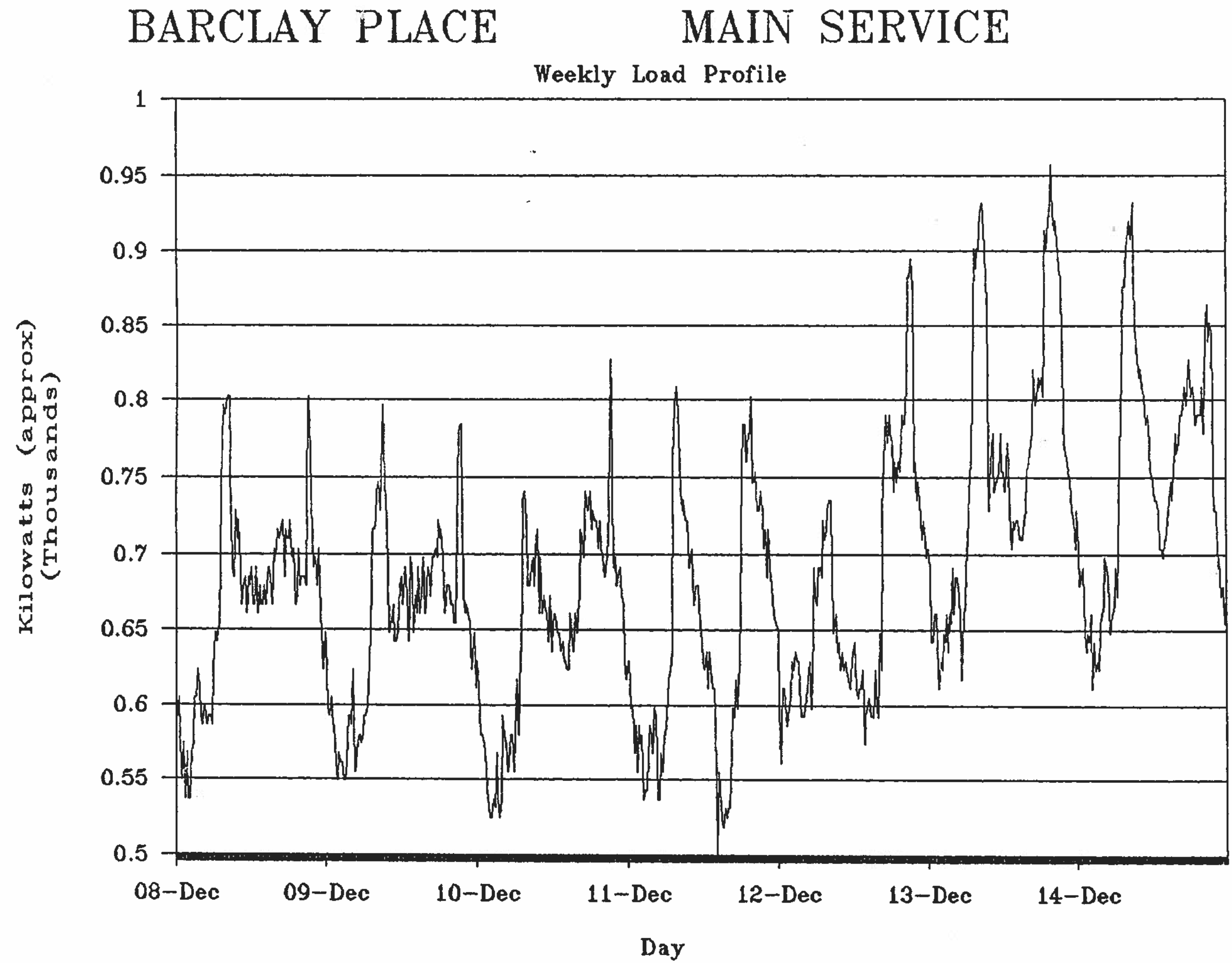
BARCLAY PLACE
MAIN SERVICE
Weekly Load Profile
Kilowatts (approx)
(Thousands)
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
08-Dec
09-Dec
10-Dec
11-Dec
12-Dec
13-Dec
14-Dec
Day

FIGURE 1A

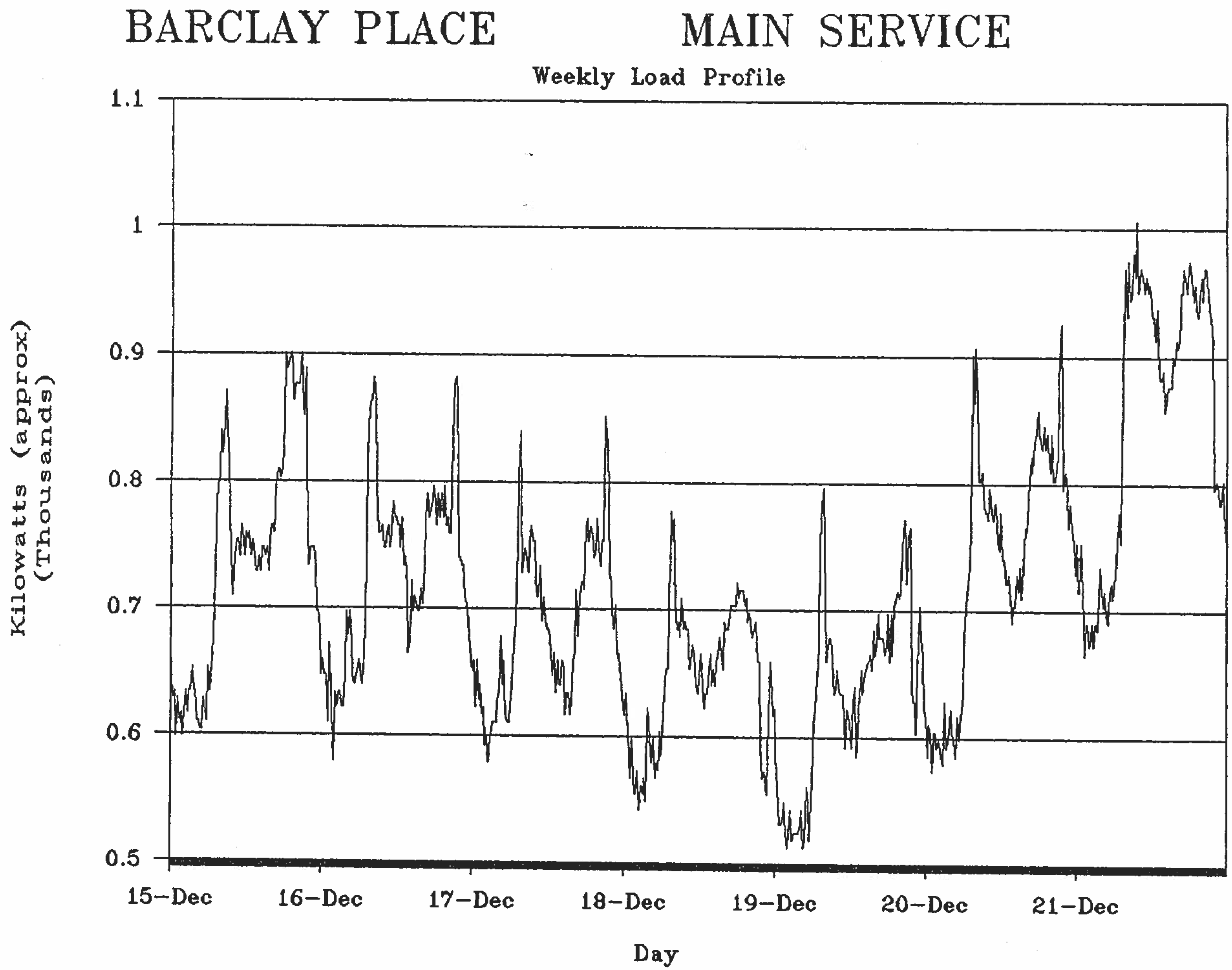
BARCLAY PLACE MAIN SERVICE
Weekly Load Profile
Kilowatts (approx)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
15-Dec
16-Dec
17-Dec
18-Dec
19-Dec
20-Dec
21-Dec
Day

FIGURE 1B

BARCLAY PLACE MAIN SERVICE

Weekly Load Profile

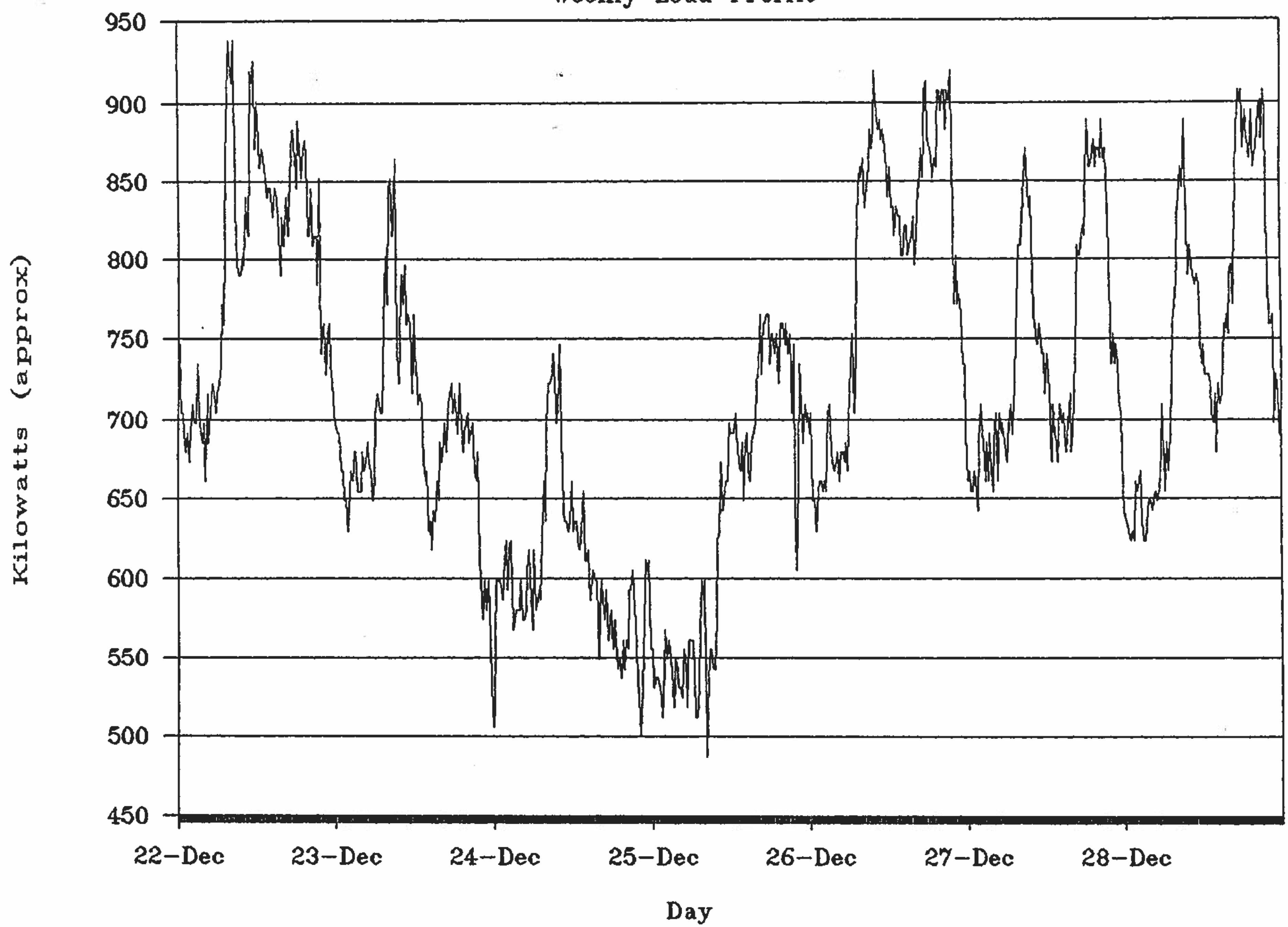

FIGURE 1C

BARCLAY PLACE MAIN SERVICE

Weekly Load Profile

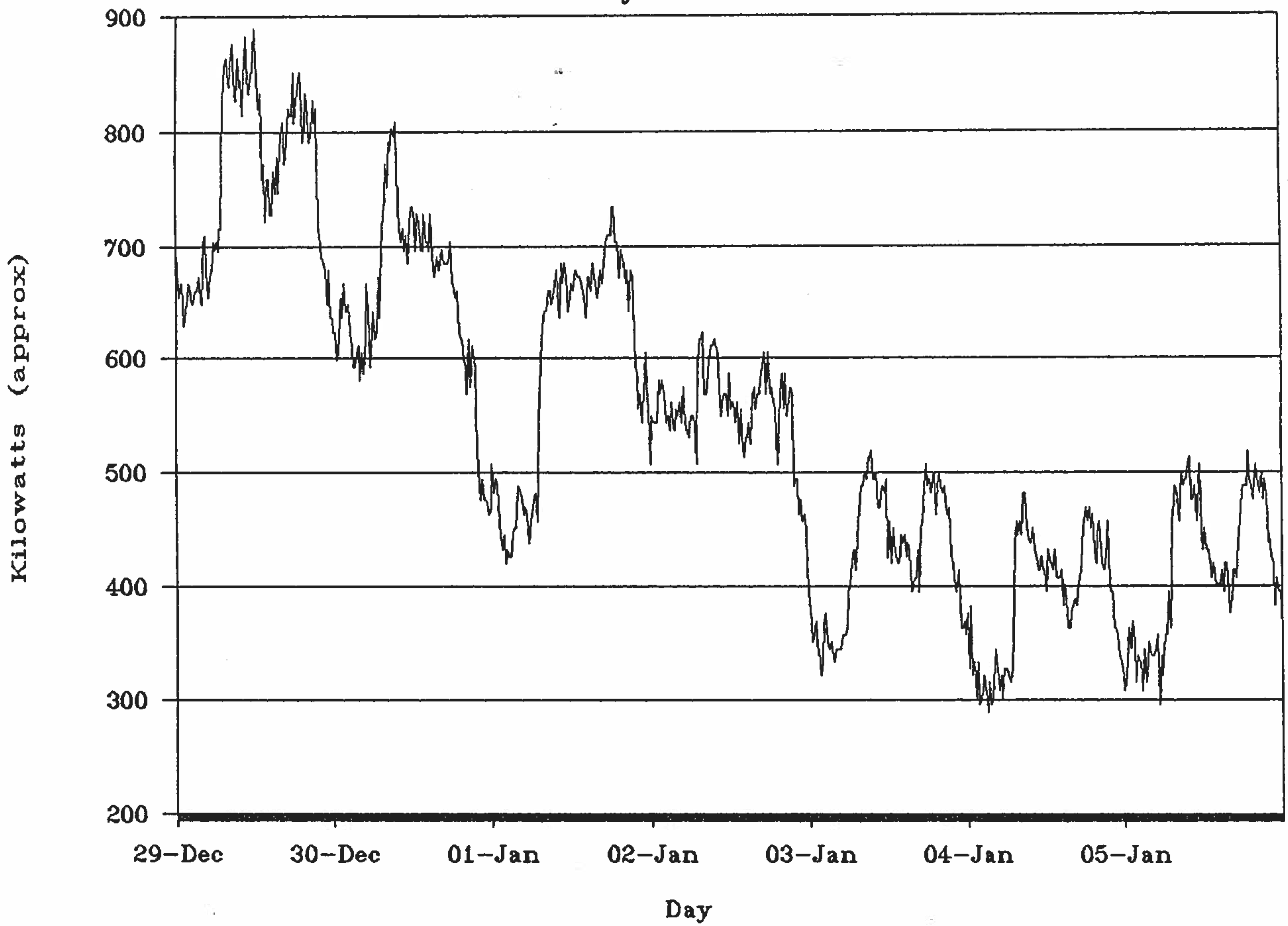

FIGURE 1D

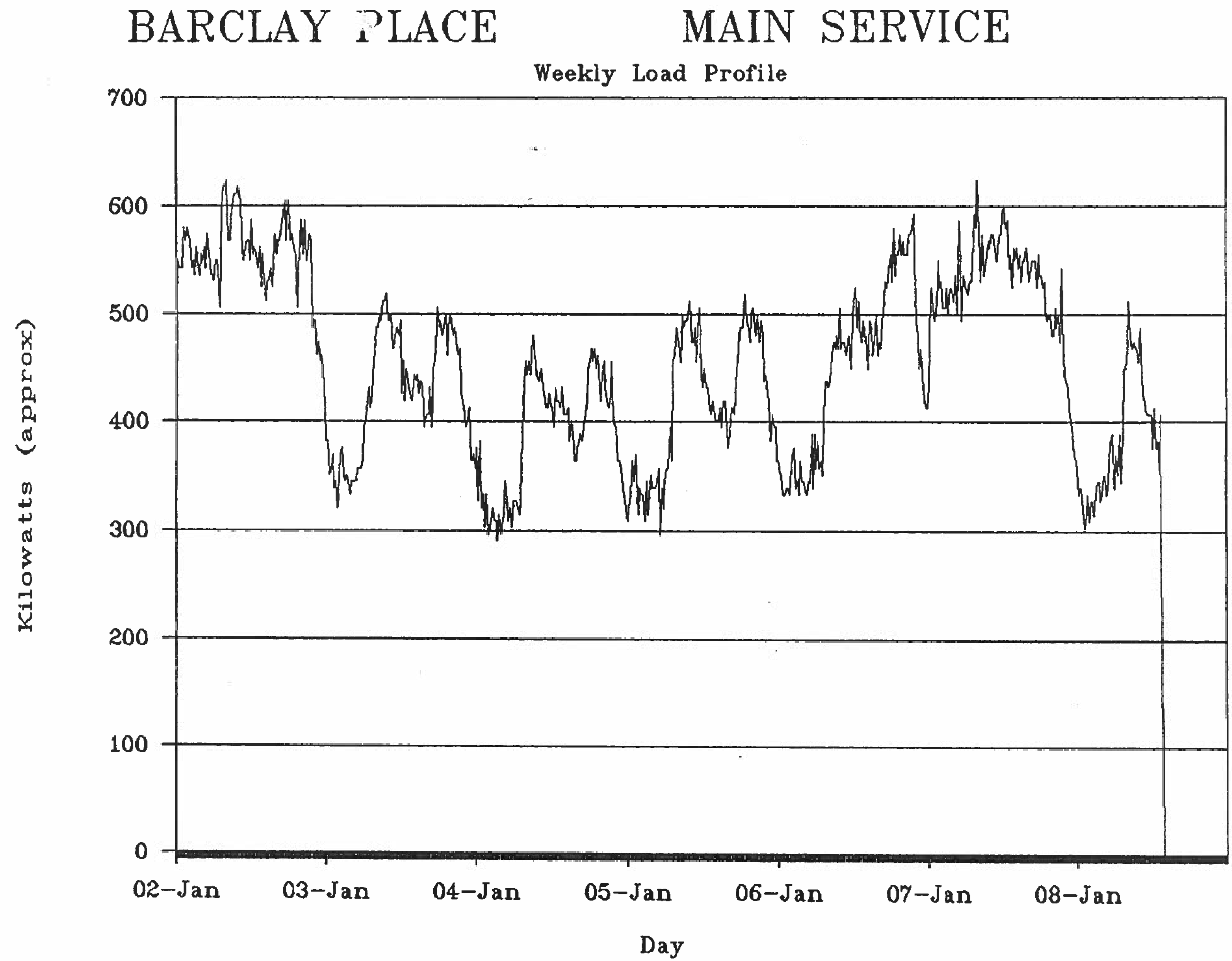
BARCLAY PLACE MAIN SERVICE
Weekly Load Profile
Kilowatts (approx)
700
600
500
400
300
200
100
0
02-Jan
03-Jan
04-Jan
05-Jan
06-Jan
07-Jan
08-Jan
Day

FIGURE 1E

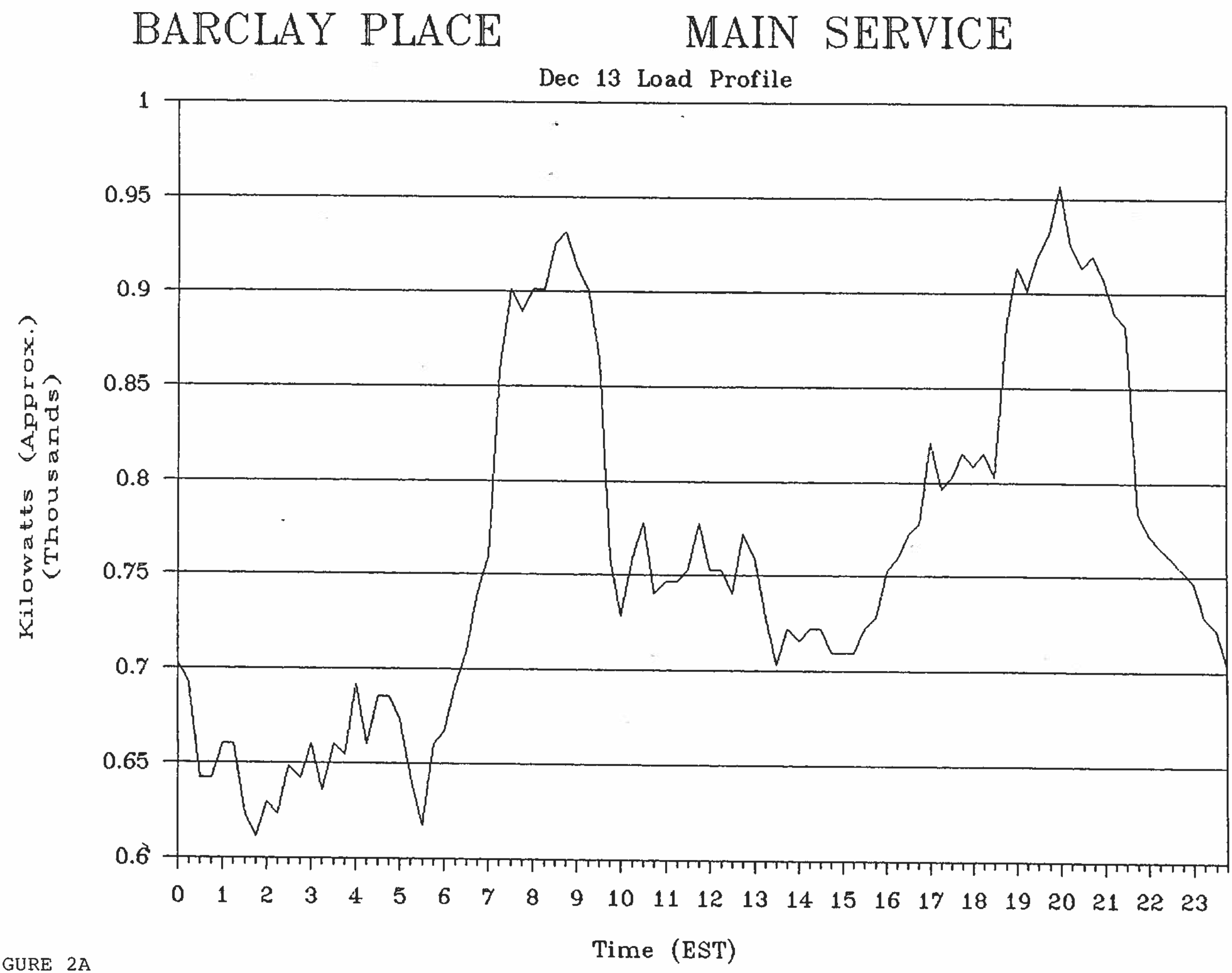
BARCLAY PLACE
MAIN SERVICE
Dec 13 Load Profile
Kilowatts (Approx.)
(Thousands)
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time (EST)

FIGURE 2A

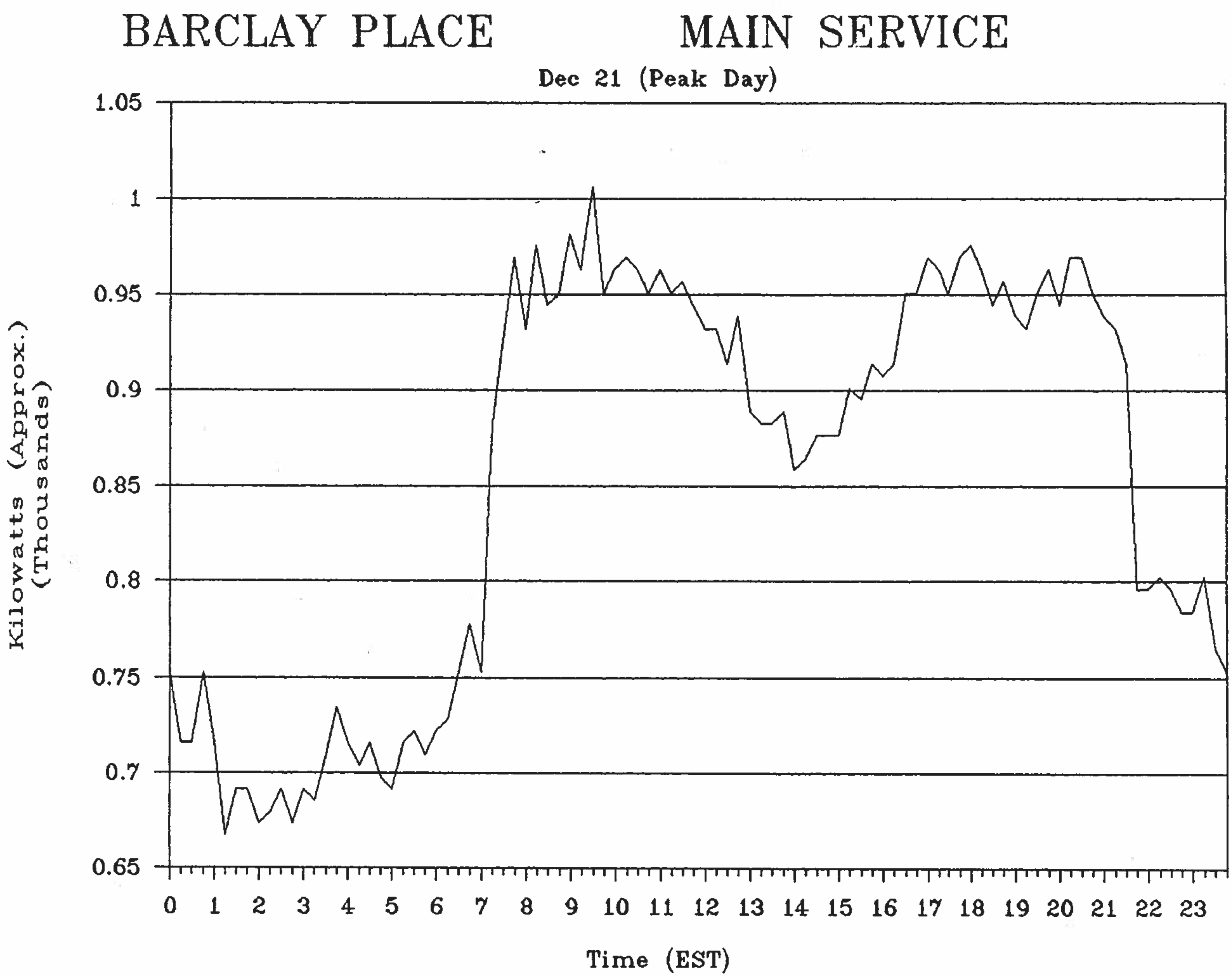
BARCLAY PLACE
MAIN SERVICE
Dec 21 (Peak Day)
Kilowatts (Approx.)
(Thousands)
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time (EST)

FIGURE 2B

ELECTRICAL DEMAND
DECEMBER 21, 1989, 9:45 A.M.

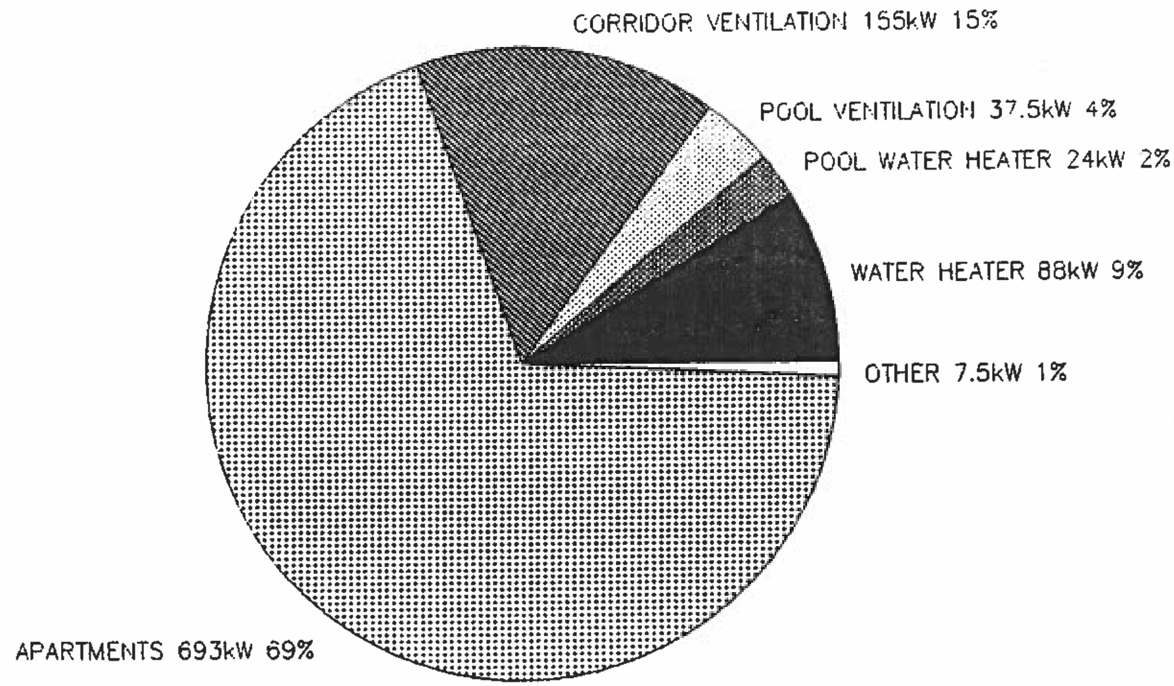

Figure 3