CANADA'S GREEN PLAN
LE PLAN VERT DU CANADA

GREEN ON THE GRAND

FINAL MONITORING REPORT

PREPARED FOR:

The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
Ottawa, Ontario, K1A 0E4
Contribution Agreement File No. EA-0730-E2
November, 1998

PREPARED BY:

Enermodal Engineering Limited
650 Riverbend Drive
Kitchener, Ontario, N2K 3S2
Tel:(519)743-8777: Fax:(519)743-8778
E-mail: office@enermodal.com

SCIENTIFIC AUTHORITY:

Allen Carpenter - Buildings Group
The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street
Ottawa, Ontario, K1A 0E4

February 12, 1999

CITATION

Enermodal Engineering Limited., *Green on the Grand Final Monitoring Report.* Prepared under CANMET Contribution Agreement File No. EA-0730-E2. The CANMET Energy Technology Centre, (CETC) Energy Technology Branch, Energy Sector, Department of Natural Resources Canada, Ottawa, Ontario, 1996. (76 pages)

Copies of this report may be obtained through the following:

The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario,
K1A 0E4

or

Intellectual Property and Technical Information Management
Library and Documentation Service Division, CANMET
Department of Natural Resources Canada
562 Booth Street
Ottawa, Ontario
K1A 0G1

DISCLAIMER

This report is distributed for informational purposes only and does not necessarily reflect the views of the Government of Canada nor constitute an endorsement of any commercial product or person. Neither Canada nor its ministers, officers, employees or agents make any warranty in respect to this report or assume any liability arising out of this report.

NOTE

Funding for this project was provided by the Government of Canada under the Green Plan.

Catalogue No. M91-7/445-1999E
ISBN 0-660-17732-3

EXECUTIVE SUMMARY

The Green on the Grand office building is the first C2000 project in Canada. The two-storey, 2,180 m^2 (22,000 ft^2) office building is located in Kitchener, Ontario. The building design addresses the four key requirements of a C-2000 building: energy-efficiency, minimal environmental impact, occupant health and comfort, and functional performance. Green on the Grand was designed to consume half the energy and water of an efficient new building (built to the ASHRAE 90.1 standard). With respect to environmental impact, no CFCs and minimal HCFCs were to be used to produce any of the building materials or operate any of the equipment. Construction waste was reduced by 75% through a combination of reducing material requirements, re-using waste materials on site and recycling as much as possible.

Green on the Grand was able to realise major energy and HVAC capital cost savings from a highly insulated and airtight building shell. The heating load dropped by 66%. The use of spectrally selective glazings and a reduced peak electrical load allowed the installation of a chiller less than half the size that would otherwise have been required.

Green on the Grand achieved a monitored energy cost savings of 28% relative to ASHRAE 90.1. The greatest cost savings were achieved in lighting energy. A combination of energy-efficient lighting design, daylighting controls and occupancy sensors reduced the lighting electricity use by 82% for one tenant relative to ASHRAE 90.1 lighting requirements. This was achieved by a 55% reduction in lighting density and a 60 % reduction in light ouput because of daylighting and occupancy sensors. The average lighting savings for the building relative to ASHRAE 90.1 is estimated to be 60%.

The primary reason for the lower than expected energy savings was due to the poor seasonal performance of the boiler/absorption chiller. The boiler had a seasonal efficiency of 48% and the chiller had a seasonal COP of 0.51: both significantly below the manufacturer's steady-state ratings. Efficiency curves for off-rating point and part load performances are required to allow designers to properly assess and select equipment.

Displacement ventilation performs well, effectively removing pollutants and providing fresh air to the space. A C-2000 building provides a comfortable and pleasing environment for the occupants. Over 75% of the tenants were satisfied with the general environment, lighting and quality of the fresh air. Areas of low satisfaction were high noise transfer and temperature variations, particularly in the swing seasons.

Connected receptacle capacity is approximately equivalent to the 8.1 W/m^2 suggested in ASHRAE 90.1. However, the monitored operating schedule has a much higher loads at night and on weekends than the default in ASHRAE 90.1. The receptacle load is approximately 50% during the night and on weekends compared to daytime operation.

Green on the Grand: Canada's First C2000 Building

RÉSUMÉ

L'édifice à bureaux Green on the Grand est le premier projet C-2000 réalisé au Canada. Cet édifice de deux étages et de 2 180 m^2 (22 000 pi^2) est situé à Kitchener (Ontario). Par sa conception, l'édifice répond aux quatre exigences fondamentales imposées aux bâtiments C-2000 : efficacité énergétique, impacts environnementaux minimes, santé et confort des occupants et fonctionnalité. Green on the Grand a été conçu de manière à ne consommer que la moitié de l'énergie et de l'eau que demanderait un bâtiment neuf à bon rendement énergétique (construit selon la norme ASHRAE 90.1). Sous l'aspect environnemental, aucun CFC ne devait entrer dans la production des matériaux de construction ni être utilisé dans l'exploitation de l'équipement; toutefois, une quantité minime de HCFC était tolérée. Les déchets de construction ont été coupés de 75 % par une combinaison de différentes mesures : réduction des quantités de matériaux utilisées, réutilisation des matériaux de rebut du chantier et leur recyclage dans toute la mesure du possible.

L'isolation et l'étanchéité à l'air poussées de l'enveloppe de l'édifice ont permis de réaliser d'importantes économies d'énergie et d'immobilisations en installations CVCA. La charge de chauffage a été diminuée de 66 %. L'utilisation de vitrages à sélection spectrale et la réduction de la charge électrique de pointe ont permis l'installation d'un refroidisseur plus de moitié moins puissant que ce qui aurait été nécessaire dans un bâtiment simplement à bon rendement énergétique.

Green on the Grand a enregistré des économies d'énergie mesurées de 28 % par rapport à un bâtiment conforme à la norme ASHRAE 90.1. Les principales économies ont été réalisées sur l'éclairage. Une combinaison de luminaires à haut rendement énergétique, de commandes d'éclairage réagissant à la lumière naturelle et de détecteurs de présence ont permis de réduire, pour un locataire donné, de 82 % la consommation de courant pour l'éclairage par rapport aux exigences de la norme ASHRAE 90.1. Ces résultats sont imputables à une diminution de 55 % de la densité de puissance d'éclairage et à une réduction de 60 % de la puissance consommée grâce à l'emploi de l'éclairage naturel et des détecteurs de présence. Les économies d'éclairage moyennes de l'ensemble des locataires sont évaluées à 60 % par rapport aux exigences de l'ASHRAE 90.1.

Les économies d'énergie inférieures aux attentes sont reliées au faible rendement saisonnier de la chaudière-refroidisseur à absorption. La chaudière avait un rendement saisonnier de 48 % et le refroidisseur, un COP saisonnier de 0,51 : deux valeurs nettement inférieures aux rendements nominaux en régime permanent indiqués par le fabricant. Des courbes de rendement pour les températures autres que le point normalisé d'essai et pour des périodes

de fonctionnement à charge partielle sont nécessaires aux concepteurs pour l'évaluation et pour le choix éclairé du matériel.

La ventilation de renouvellement fonctionne bien, éliminant efficacement les polluants et fournissant de l'air frais aux locaux. Un bâtiment C-2000 offre à ses occupants un environnement confortable et agréable. Plus de 75 % des occupants sont satisfaits de l'environnement en général, de l'éclairage et de la qualité de l'air. Les sources d'insatisfaction sont une importante transmission du bruit et des fluctuations de température, en particulier pendant les transitions saisonnières.

La puissance raccordée aux prises est à peu près équivalente à la valeur de 8,1 W/m2 recommandée par la norme ASHRAE 90.1. Toutefois, l'horaire de service mesuré des installations présente une charge de nuit et de fin de semaine nettement supérieure à la valeur implicite de la norme ASHRAE. La charge raccordée aux prises pendant la nuit et la fin de semaine est d'environ 50 % de celle de jour.

Table of Contents

Table of Figures

Table of Tables

1. INTRODUCTION

The Green on the Grand office building is the first C2000 project in Canada. The two-storey, 2,180 m^2 (22,000 ft^2) office building is located in Kitchener, Ontario. The building design addresses the four key requirements of a C-2000 building: energy-efficiency, minimal environmental impact, occupant health and comfort, and functional performance. Green on the Grand was designed to consume half the energy and water of an efficient new building (built to the ASHRAE 90.1 standard). With respect to environmental impact, no CFCs and minimal HCFCs were to be used to produce any of the building materials or operate any of the equipment. Construction waste was reduced by 75% through a combination of reducing material requirements, re-using waste materials on site and recycling as much as possible. All of these reductions were achieved in a building that offers a superior indoor environment, an attractive and functional layout, and a long lifetime.

The building uses many new and innovative systems to achieve these energy efficient and environmental benefits, including

- a structural skeleton of engineered-wood products,
- wall, ceiling and foundation insulation 2 to 3 times the levels required by ASHRAE 90.1,
- high-performance windows with fibreglass frame, triple glazing, low-e coating, warm edge spacers, and argon gas fill,
- a spectrally selective glazing for high visible light transmission and low solar heat gains,
- radiant, hydronic heating and cooling ceiling panels,
- gas-fired combination boiler/absorption chiller,
- storm water retention pond that also acts as a cooling tower for the chiller,
- displacement ventilation system,
- sensible and latent heat recovery for ventilation air,
- daylighting system incorporating an electric light dimming system, and occupancy sensors,
- ultra low-flush toilets and urinals. Infrared eyes on faucets, showers and urinals,

A detailed description of the building design is documented in the CANMET report Green on the Grand: C-2000 Office Building Final Report [Enermodal, 1996].

Green on the Grand was constructed in 1995 and five tenants moved in during 1996. This report documents the construction process and the monitored performance of the building for 1997.

2. BUILDING DESCRIPTION

2.1 Design Features

Green on the Grand is a two-storey, 2180 m^2 (22,000 ft^2) speculative office building in Kitchener, Ontario. The floor plans are shown in Figure 2.1. The structural support system is made entirely from engineered wood products. A mixture of fixed and awning type punched windows represent 30% of each building façade. Cathedral ceilings are featured in the second floor interior. The interior of the second floor is daylit by eight dormer windows: two facing in each of the four cardinal directions.

The building shell is insulated to between two and three times the values required by ASHRAE 90.1. The details of the wall construction are shown in Figure 2.2. The windows are tripled glazed in an insulated fibreglass frame. The glazing system has two low e-coatings, two argon gas fills and an outside lite of spectrally selective glass to achieve high visible transmission and low SHGC.

Ensuring an airtight building was a primary goal for the design and construction phases. The design included a sealed polyethylene AB/VB on the warm side of the cellulose insulation. The barrier was sealed to window frames, door frames, floor headers, ring joists, and all other discontinuities in the building. A power/communication cabling raceway was installed inside the interior wall to ensure the integrity of the AB/VB when changes in wiring were required.

Heating and cooling is provided by a water-based radiant system. A separate energy recovery ventilation system provides fresh air with simultaneous dehumidification in summer. The radiant panels are mounted on the ceiling. The low heating and cooling loads meant that the panels had to cover only 30% of the ceiling area. In the winter, the panels are operated at about 35°C (95°F) and in the summer at about 13°C (55°F). Dehumidifying the ventilation air to below the radiator dew point prevents condensation on the radiant panels. Fan coils are located in the entranceways to provide heating and cooling in these high heat loss/gain areas. Hot and chilled water for the system is supplied by a gas-fired heater/absorption-chiller.

A pond in front of the building serves as the cooling tower. During cooling operation, pond water is circulated through a filter system, and the chiller's condenser. Water is returned to the pond by pouring it over landscaping rocks at the perimeter of the pond. A fountain in the middle of pond also increases evaporative cooling. Make-up water comes from rainfall collected off the roof. An ozonator is used as part of the disinfection system.

Figure 2.1: Green on the Grand First and Second Floor Plans

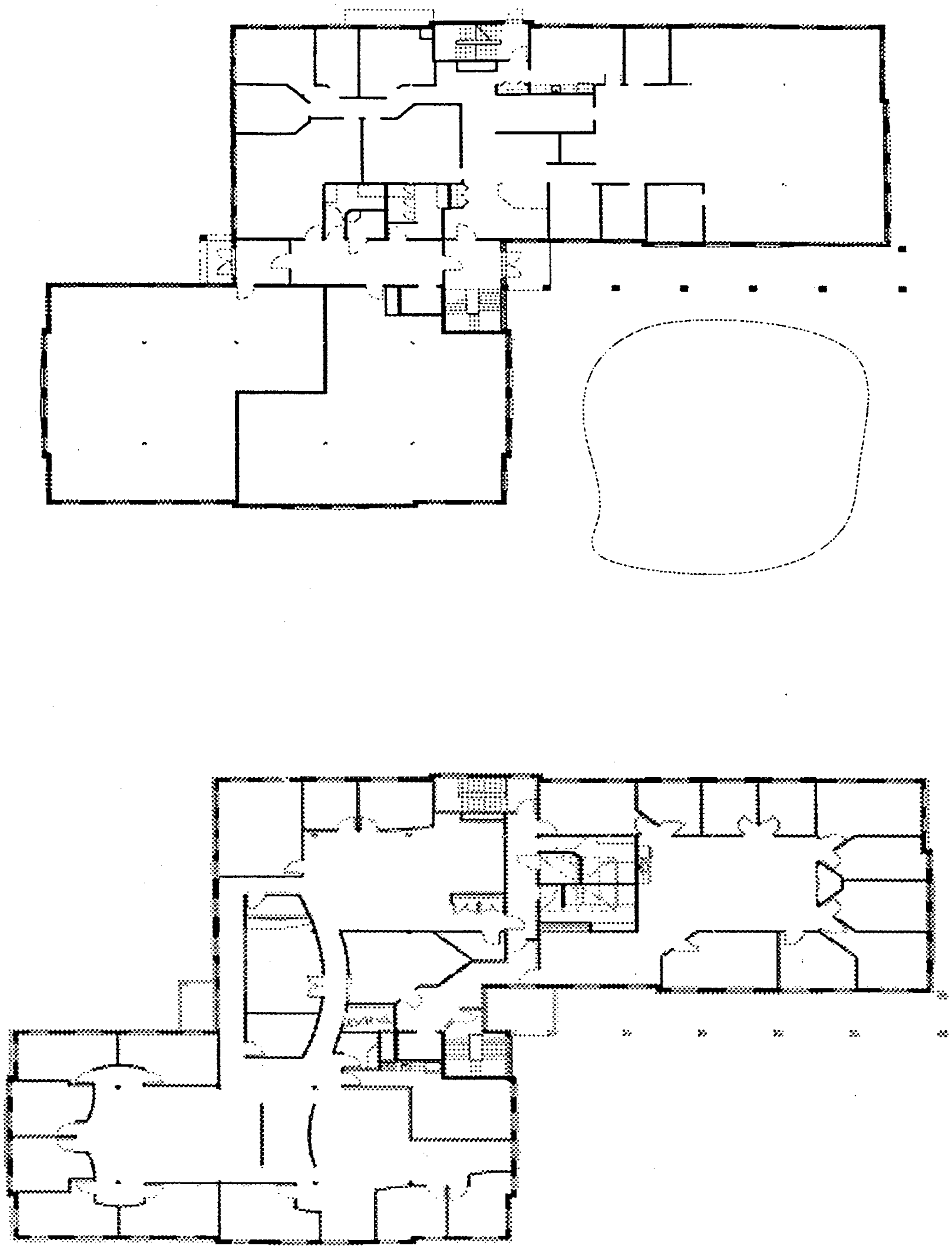
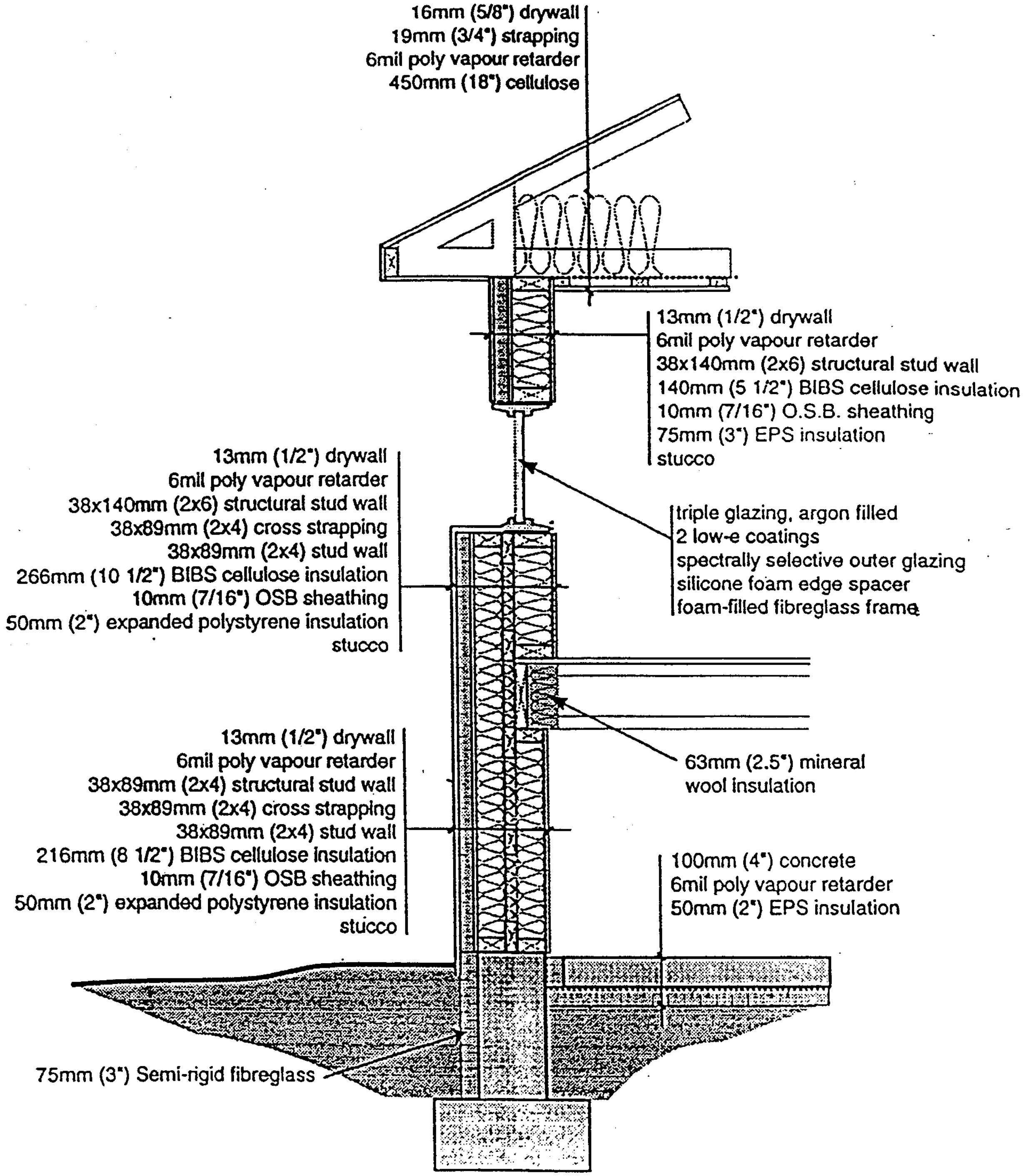


Figure 2.2: Wall Cross-Section

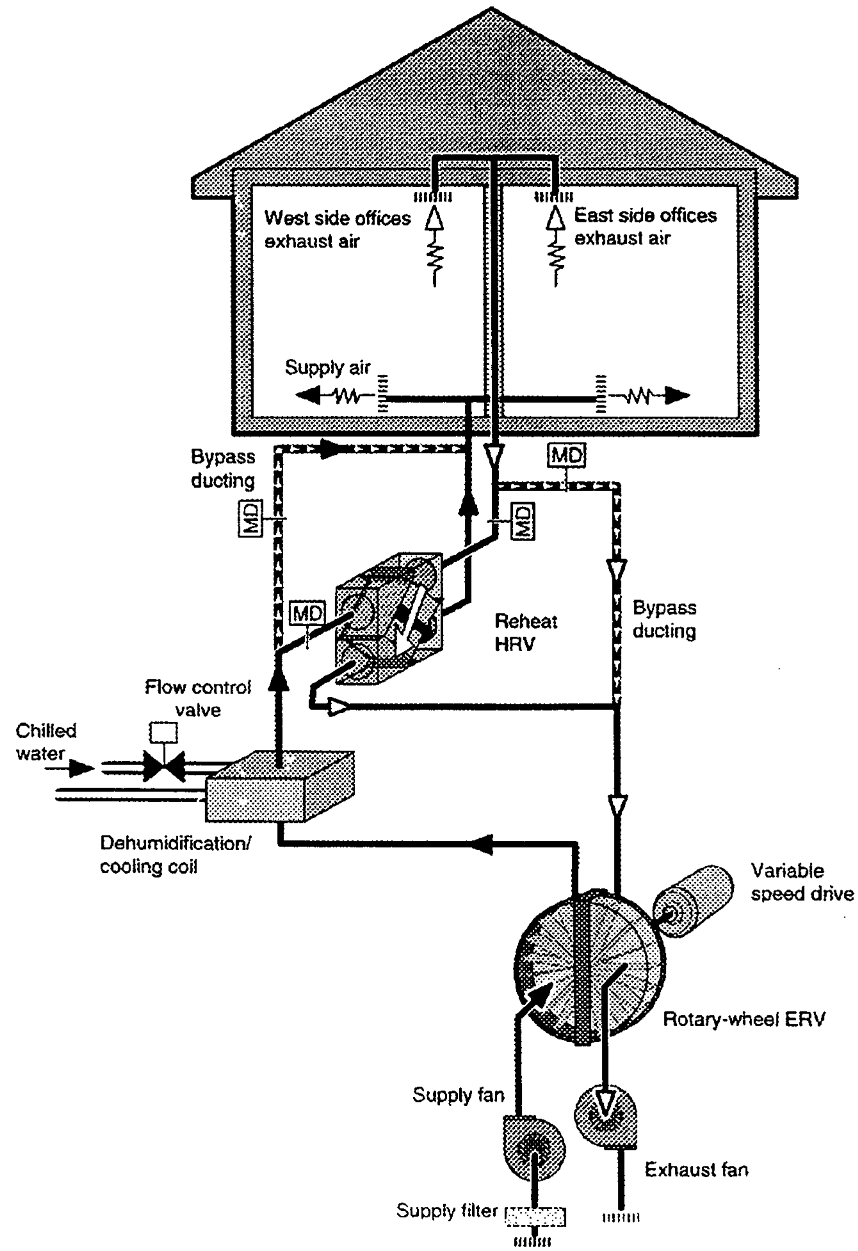


The ventilation system is the only air-based system in the building (see Figure 2.3). The two-speed ventilation system is designed to provide a continuous flow of constant temperature air to the building (14°C). The heat recovery units and a heating/cooling coil can be continuously modulated to maintain the desired temperature and humidity of the air. Ventilation distribution is by displacement ventilation; fresh air enters the space near floor level at a low velocity and stale air is exhausted at the ceiling.

The fan and pump power is minimal for Green on the Grand because of the use of radiators and the use of high-efficiency pumps, fans and motors. During normal operation, the building was designed for a fan and pump power of 3.4 kW or 1.5 W/m^2, rising to 6.7 kW (3.1 W/m^2) under peak heating or cooling loads.

Lighting is provided through energy-efficient T8 fluorescent lamps with electronic ballasts. All perimeter offices and the central areas on the second story use a light dimming system. All areas including offices, stairwells, and hallways, have occupancy sensors to turn lights on only when people are present.

Figure 2.3: Air Handling System Schematic



2.2 Construction Process

Building construction began in the spring of 1995 and the first tenants moved in in early 1996. The building was fully leased and occupied by November 1996. Almost all of the construction went as per the design. As with any building, when everyday realities of construction occur, some modifications to the design are inevitable. There were many reasons for modifications:

- changes were required by the plans examiners,
- originally specified items were too costly or required unrealistically long lead times,
- site conditions would not allow the specifications to be met,
- shortcomings in the original design, and
- workmanship was not always able to match the level of quality requested.

2.2.1 Building Shell

The building shell was built essentially as designed. Wall, foundation and slab-on-grade insulation levels were all as per the specifications. Inspections during construction confirmed that the insulation was well installed with no gaps or voids. Some minor areas were not insulated to the levels of the initial design. For example, no insulation break was installed between the floor-slab and the foundation wall. Mineral wool insulation was not installed at the second floor ring joist because of the difficulty in cutting around the I-beam floor joists. In some areas, it was not possible to install the cellulose insulation including multi-post corners, very narrow cavities and the two vertical wall sections under the end dormer windows. In these locations, blown urethane was used to overcome insulating and air-sealing difficulties. The sloped sections of roof called for RSI-10.6 mineral wool batt insulation which would have required three batts to be installed. It was only possible to install two batts with a reasonable labour effort and still maintain an air-gap above the insulation. This resulted in an RSI-7.0 in the sloped ceiling sections.

The specification called for a continuous, sealed polyethylene air barrier/vapour barrier (AB/VB) immediately behind the drywall for all exterior walls and ceilings. During construction, it became obvious that even trades claiming to have R-2000 training were not familiar with the installation and sealing requirements for an AB/VB in a commercial building. Meetings with contractors prior to commencement of the work laid out the requirement for how joints, window frames, doorframes and other discontinuities were to be sealed. Almost daily supervision of the trades was required during installation of the AB/VB to ensure proper installation and to resolve difficulties as they occurred.

Continuity of the AB/VB was accomplished as per the specifications for most areas. Creative solutions at problem locations such as the ring joist, the chimney, ceiling tie-rods, light fixtures, and other discontinuities were required

2.2.2 Mechanical Systems

The heating/cooling system was a combination of a packaged boiler/chiller and custom design work to connect this unit to terminal equipment. The ventilation system was a custom designed and fabricated air handling unit. A building automation system controlled the operation of the systems. Because of the custom design of the air handler and the necessity of ordering the boiler and chiller from Japan, there was a long lead time to get this equipment.

The design specifications called for high-efficiency equipment. It turned out to be difficult to get high-efficiency pump motors. Incentive programs and other means to encourage development of high-efficiency motors have been directed at base-mounted motors. Pumps are generally face-mounted. To adapt a base-mounted motor to a pump is expensive. The contractor was encouraged to supply high efficiency motors wherever possible.

During commissioning it was found that the condenser pump was not providing sufficient water flow. A larger pump needed to be installed increasing the power draw.

On average, the pumps as installed at Green on the Grand operate at about 57% efficiency and the motors at about 72% efficiency for a combined efficiency of about 41%.

It took over one year to commission the building automation system. The controls contractor had difficulty understanding the HVAC system operation and adapting their controls to non-standard applications.

2.2.3 Lighting Systems

The window size and design were selected to minimize energy use and maximize daylighting performance. The glazing system incorporates an outside lite of spectrally selective glass to achieve high visible transmission and low SHGC. Windows covering 30% of the wall area were sized to provide adequate daylighting for the perimeter offices. The interior of the second floor is daylit by the eight dormer windows; two facing each of the four cardinal directions.

Green on the Grand was built as a speculative office building for multiple tenant occupancy. Each tenant had his or her own interior designer. Energy-efficiency guidelines were prepared to achieve adequate lighting with a lighting power density of 9.3 W/m^2 and tenants were encouraged to comply. Table 2.1 summarises the design of the tenant spaces. The average installed lighting density is 12 W/m^2. Although higher than design guidelines, this still represents a 35% reduction of the ASHRAE 90.1 requirement of 18.5 W/m^2.

All spaces have efficient light fixtures with T8 lamps and electronic dimmable ballasts. Most tenants have suspended indirect/direct light fixtures to provide uniform light without glare. Two tenants use ceiling-mounted parabolic fixtures. Occupancy sensors control all electric lights - one in each room. All lighting in perimeter offices (except a few on the north side) and the second floor interior are controlled by a modulating dimming system. One sensor was used for each bank of offices with the same window orientation within the same tenant space.

Table 2.1: Tenant Lighting Design

Tenant	Typical Lighting Fixture	Installed Lighting Density (W/m^2)	Average Nighttime Light Level (Lux)	Window Shading Treatment	Typical Daylighting Blockage by Shades (%)
A	Suspended Indirect/Direct	8.2	350	White Venetian	15 %
B	Suspended Indirect/Direct	12.0	400	Fabric roller blind	20 %
C	T-bar	11.4	600	Dark Venetian	40 %
D	Suspended Indirect/Direct	13.8	600	Fabric Roller blind	30 %
E	T-bar	14.4	900	Vertical fabric Venetian	75 %

There are some significant differences in the lighting and daylighting design of the spaces. Tenants A and B are on the second floor so they benefit from daylighting of interior spaces. In Tenant A space, fixture choices and spacing were based on achieving 350 lux illumination. Although Tenant B has the same overhead fluorescent fixture load as Tenant A, they supplemented this lighting with fluorescent task lighting, halogen spot lighting and incandescent accent lighting. Tenant B has fabric blinds, which allow some daylight in, but reduce the glare from beam radiation. Both of these tenants tend to position the blinds off the window for maximum daylight admittance.

Tenant E has the highest installed lighting density; almost twice the value installed by Tenant A. The light levels varied throughout the space with readings as high as 1400 lux. This tenant opted for recessed parabolic fixtures in a T-bar ceiling. In addition, they used compact fluorescents for accent lighting. They have vertical blinds on the windows that are almost always closed.

3. EXPECTED PERFORMANCE

3.1 Energy Usage

Computer simulations were performed to assess the energy efficiency of the building design. Three simulations were performed: the reference building (ASHRAE 90.1), the proposed C-2000 building, and the as-built C-2000 building. The simulations use the same building dimensions, schedules, occupancy, control settings and weather conditions. The only differences are the changes in the building shell and mechanical systems.

The results of the simulations (using Toronto airport weather data) are summarized in Table 3.1. Gas consumption has been converted to an equivalent kilowatt-hour value. The as-built Green on the Grand design represented a 42% reduction in annual energy cost relative to a similar building designed to the ASHRAE 90.1 standard. The energy savings is less because the Green on the Grand cooling system is natural gas fired at a lower COP than an electric chiller in the ASHRAE 90.1 reference.

Table 3.1: Predicted Annual Energy Consumption (ekWh)
– Based on ASHRAE 90.1 Default Schedules

Component		ASHRAE 90.1	As-Designed	As-Built
Space Heating	(gas)	140,598	52,122	47,397
Cooling	(gas)	n/a	42,486	62,652
	(electric)	28,689	n/a	n/a
Water Heating	(gas)	6,941	4,021	4,021
Lighting	- tenant	87,691	28,719	37,266
	- common	9,743	3,191	4,141
	- exterior	2,474	1,237	2,924
Receptacles	- tenant	38,394	38,394	38,394
Pumps & Fans	- fans	31,098	8,529	11,242
	- pumps	n/a	7,208	17,280
	- misc. load	16,072	8,837	6,696
Total Energy Use	- ekWh	361,700	194,744	232,013
	- ekWh/m^2	165	89	106
Total Cost	($)	$18,385	$8,025	$10,656
	% Savings		57%	42%

* Building floor area 2190m^2

3.2 Water Consumption

The estimated values for annual water consumption are shown in Table 3.2. Annual purchased water consumption is estimated at 9.5 cubic metres per person: a 72% reduction over conventional office buildings. With two exceptions, the water conserving technologies were installed as per the initial design. The first change was a water softener was added to building because of the extremely hard water in the Kitchener area. Only the hot water was softened at Green on the Grand, as opposed to conventional practice of softening hot and cold water. Water softeners use a considerable amount of water during their backwash cycle. The second change was the city boulevard property and a small sitting area were sodded with conventional grass. An automatic water system irrigates these areas a few hours a week. The water for this irrigation comes from an on-site well. This well also provides make-up water for the cooling pond. Estimates of well water are included in Table 3.2.

Table 3.2: Estimated Annual Water Use (m^3/person)

Function	Typical Office Building	Green on the Grand (from city/from well)	% Savings in Purchased Water
Toilets/Urinals	10	4.5 / 0	55 %
Sinks/Washing	5	2.5 / 0	50 %
Showers	2	1 / 0	50 %
Cooling Tower	10	0 / 2	100 %
Landscaping	2	0 /1	100 %
Water Softening	4.5	1.5 / 0	67%
Total	33.5	9.5 / 3	72 %

4. MONITORING SYSTEM

4.1 Monitoring Schematics

Monitoring was provided by both a computer-based data logging system and by manual reading of utility meters and meters installed in conjunction with the monitoring system. The objective of the monitoring was to determine measurements of:

- ambient conditions,
- indoor comfort conditions,
- representative office comfort conditions,
- individual tenant electrical loads,
- ventilation effectiveness,
- ventilation system efficiency,
- daylighting system efficiency, and
- heater/chiller performance.

These requirements were the basis for producing the instrumentation selection criteria and requirements for locations where instruments would be installed. Appendix A shows the instrumentation for each of the major systems measured.

Five instruments were installed to measure weather parameters. These were:

- solar radiation,
- windspeed,
- ambient temperature,
- rainfall, and
- relative humidity.

Four space temperatures, one relative humidity and one tenant electricity consumption, were used to characterize the indoor conditions in the building.

To gain a better understanding of the comfort conditions for the individual employee, a representative office was instrumented. The measurements included:

- room temperature,
- room relative humidity,
- room mean radiant temperature,
- lighting level at desk height,
- lighting power
- ventilation air supply temperature, and
- CO_2 level.

4.2 Boiler/Chiller Instrumentation

A natural gas boiler/chiller is the heating and cooling plant. The plant delivers heating or cooling through a two pipe system, but not both simultaneously. The building side of the system has primary and secondary loops. The primary loop is maintained at approximately 50°C in heating mode and 5°C in cooling mode as dictated by the boiler/chiller controls. The secondary loop is maintained at 35°C and 13°C in winter and summer as dictated by the heating or cooling requirements. The building automation system bleeds water from the primary loop to the secondary loop as required to maintain the building loop at the proper delivery temperature.

Monitoring was set up to measure:

- runtime in each operating mode (heating, cooling, high-fire, low-fire),
- heat delivered to the space by the primary loop from the boiler,
- cooling delivered to the space by the primary loop connected directly to the evaporator,
- heat rejected to the pond by the condenser water loop, and
- electricity consumed

4.3 Air Handler Instrumentation

Possibly the most complex piece of equipment in the entire project is the air handler. It contains:

- a rotary energy recovery wheel,
- a heating and cooling/dehumidification coil,
- a fixed plate heat exchanger,
- two speed ventilation supply and exhaust fans, and
- fully modulating controls to operate all of this equipment together based on outdoor conditions, building conditions, season, and time of day.

Monitoring was also complex due to the nature of the information required. Supply and exhaust airflows were calculated based on a correlation between heat wheel pressure drop and air flow.

To understand the performance of the air handler, the following parameters were measured:

- total electricity consumed,
- maximum temperature rise (drop) available across the entire unit,
- temperature rise (drop) in the supply air,
- supply air relative humidity,

- outdoor air temperature,
- exhaust air temperature,
- exhaust air relative humidity,
- exhaust air CO_2,
- supply side airflow, and
- exhaust side airflow,

Individual component performance was also measured based on:

- rotary wheel speed,
- supply air temperature rise across the rotary wheel,
- supply air humidity rise (drop) across the rotary wheel,
- water flow rate through the heating/cooling coil, and
- water temperature rise (drop) across the heating/cooling coil.

4.4 Short-Term Performance Testing

Building air tightness is an all too often overlooked factor in commercial construction. The airtightness of the envelope was tested using a standard residential blower door on Saturday November 2, 1996. It was a mild sunny day and the winds were calm. The building was sealed according to CGSB 149.10 blower door testing requirements. The air handler was turned off and all intentional openings sealed. In the case of Green on the Grand, this meant that the supply air and exhaust air dampers for the air handler were tightly closed, the flue for the boiler/chiller was sealed and the mechanical room supply air duct was sealed. All tenants in the building co-operated by ensuring all operable windows were locked in the closed position, all perimeter office doors within the suites were open and all suite doors leading to common areas were open. The residential type blower door was installed in the single door leading out the back of the building. Eleven readings were taken in the range 70 to 25 Pascals pressure difference across the building shell. To double-check the calibration additional readings were taken when the flow orifice was changed.

Other short-term measurements performed included

- boiler combustion efficiency,
- CO_2 concentration (as an indicator of ventilation effectiveness),
- Light level (as an indicator of suitability of lighting and daylighting), and
- Vertical temperature distribution (as an indicator of temperature stratification).

4.5 Completeness of Monitored Data

Monthly manual readings of electricity, natural gas and water consumption began in March 1996 and continued for two years to March 1998. The 1997 year is considered the most representative of long-term building performance because the building was fully occupied and most of the building systems were commissioned.

The installation of the detailed monitoring system began in early 1997. The first usable data was collected in the Spring of 1997 and focussed on the boiler/chiller. The monitoring system was fully installed and commissioned by September 1997 and data collection continued until March of 1998. Over this period, the monitoring system underwent some changes. The initial monitoring system included a roof-mounted anemometer for measuring wind speed. On several occasions the data acquisition board (DAQ) became damaged and had to be repaired. It was determined that the damage coincided with lightning storms. To solve this problem, the roof-mounted anemometer was disconnected and the DAQ was replaced with a more robust model. The new DAQ equipment had lower voltage measurement thresholds than the original equipment and voltage dividers had to be installed on some of the sensors to drop their output range to match the new DAQ equipment.

Early data analysis revealed that relative humidity sensors in the air handler did not agree with each other. During periods when the cooling coil was inactive, the humidity content of the air before and after the coil was measured to be significantly different. The humidity sensors were found to be prone to drift and sometimes reported relative humidity values that were less than 0%. The "to building" supply air humidity sensor was replaced; however the replacement was prone to drift. Additional temperature sensors were added on November 25, 1997. The additional sensors allowed for the accurate assessment of sensible performance, without relying on the relative humidity sensors.

4.6 Weather Data

The 1997 weather file for the Toronto International Airport was obtained from Environment Canada. This was compared to the average weather data contained in a Canadian Weather for Energy Calculations (CWEC) weather file.

Table 4.1 shows that the two weather files are similar: there was a 3% decrease in heating degree-days and a 6% increase in cooling degree-days during 1997.

Table 4.1: 1997 and CWEC Degree-Days

	HDD (Base 18°C)	CDD(Base 18°C)
1997	3,969	245
CWEC	4,089	232

The yearly average temperature for 1997 was 0.3°C warmer than the CWEC file. Figure 4.1 shows slightly warmer temperatures for the months of June, February and December 1997 than the CWEC average year. Figure 4.2 shows the horizontal solar radiation for 1997 and the CWEC weather file. Again the 1997 values are very close to the CWEC values. It is concluded that 1997 weather is typical of long-term weather. As a result, CWEC data was used for modelling to directly compare monitored performance to predicted performance.

Figure 4.1: 1997 and CWEC Monthly Average Temperature

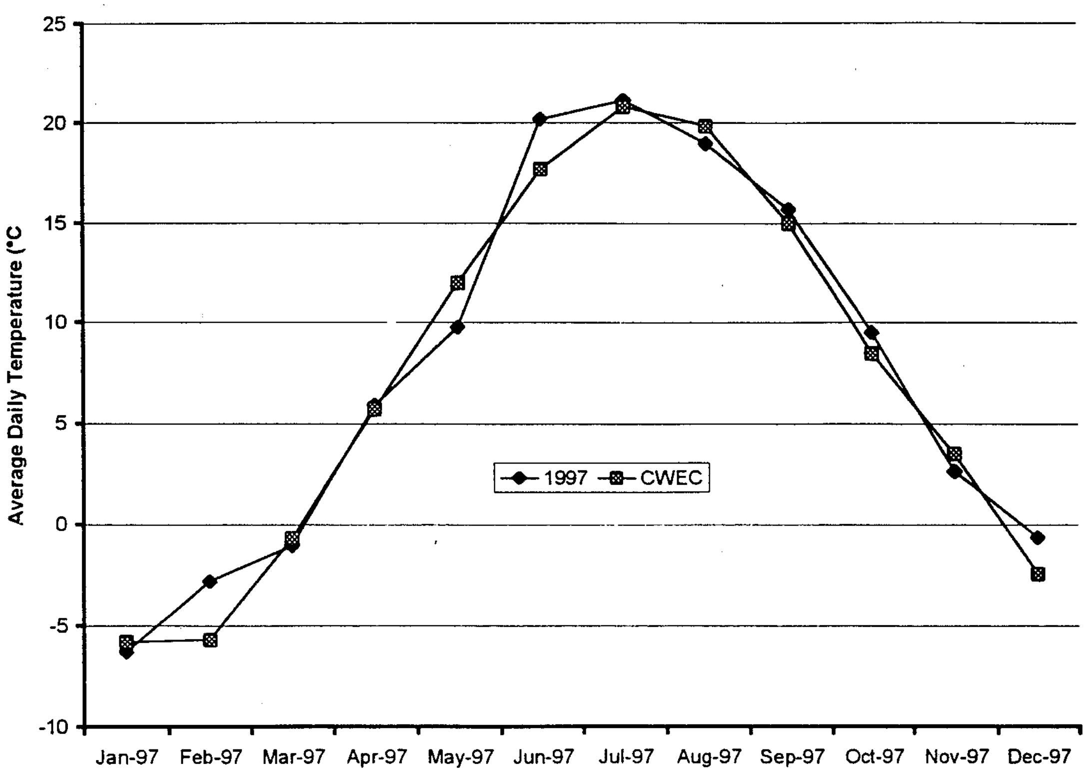
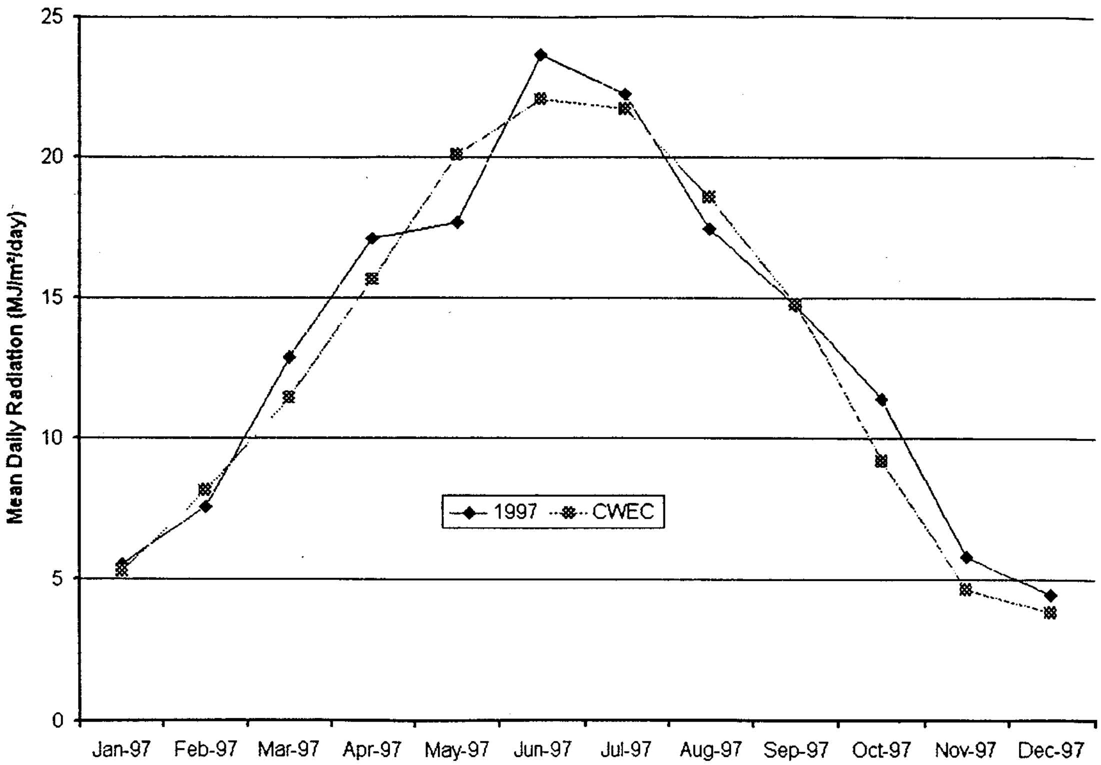


Figure 4.2: 1997 and CWEC Global Horizontal Solar Radiation



5. PERFORMANCE RESULTS

5.1 Building and Equipment Operation

The first tenants took occupancy in early 1996. The building was fully leased and occupied by November 1996. As with any new system, there were some initial "teething" problems to overcome. Several months were required to completely commission the building automation system (BAS). The BAS was primarily used to provide control of the multiple functions within the air handler, control of building water loop temperature for the radiant panels, and scheduling of equipment operation.

Initially the coil in the air handler was not able to cool ventilation air sufficiently to avoid condensation on the radiant panels. Loop temperatures had to be raised reducing cooling capacity and allowing temperatures in some areas to rise to uncomfortable levels. The coil was found to have low water flow due to unacceptably high piping losses and reversed piping connections so that the water flow was not in a counterflow pattern. Moving a pump and reconstruction of some piping connections increased water flow. Reversing the piping connections rectified the flow pattern problem. After the changes, the air temperature exiting the coil could be maintained at 12°C (54°F) and the system operated as designed.

Some operational changes were required to provide consistent comfort throughout the building under variable conditions. For short periods during the swing months some tenants needed heating. whereas at different times other tenants required cooling. To resolve this problem, the system was manually switched from heating in the morning to cooling in the afternoon (a relay is being added to perform this function automatically in the swing months). Additionally, two interior meeting rooms tended to overheat when occupied. This concern was resolved by separating the heating/cooling and ventilation functions. Small booster fans installed behind the supply air grilles in the two meeting rooms increased cooling capacity using additional conditioned ventilation air during occupied periods. Also, the delivered air temperature for the ventilation system was lowered to 12°C (54°F). A computer room also overheated and it was necessary to install a small dedicated air conditioner.

The ASHRAE 90.1 standard defines a typical office as requiring the building HVAC system to be run the equivalent of 92 hours a week with equipment turned off and temperatures set back during unoccupied hours. The lighting (and internal electric loads) are assumed to be on the equivalent of 53 hours per week. With five tenants with different schedules, Green on the Grand was occupied about 120 hours a week. Tenants demanded full ventilation capacity from 5 a.m. to 1 a.m. and low speed ventilation the remaining 4 hours. Temperature setback was not feasible, and occupants tended not to turn off computers and photocopiers over-night.

5.2 Building Envelope

The goal was to have an airtight building envelope. There are several standards that define building airtightness. The R-2000 airtightness standard for residential construction requires an airtightness level of less than 1.5 air changes per hour at 50 Pascals (ACH_{50}). The value measured at Green on the Grand is half this value at 0.7 ACH_{50}.

Commercial building air tightness is typically expressed in terms of flow per unit area at a 75 Pascal pressure difference. The Standard of the National Architectural Metal Manufacturers for curtain walls calls for the leakage to not be more than 0.3 L/s/m² at a pressure difference of 75 Pa ($L/s/m^2_{75}$). The C-2000 requirements are 3 times more stringent than these requirements at 0.1 $L/s/m^2_{75}$. The measured value at Green on the Grand is five times this value at 0.5 $L/s/m^2_{75}$. The values quoted in the two standards are based on sample wall sections placed in a test chamber. These tests do not account for the air leakage around building junctions or interfaces (e.g., wall/window, wall/floor): - usually the areas of highest air leakage. Full-building air-leakage test results on conventional buildings are required before a comment can be made on the acceptability of the Green on the Grand value.

5.3 Total Building Energy Use

The annual energy consumption for 1997 is presented in Table 5.1. The simulations presented in Section 3 were re-done using the actual building operation schedules (for HVAC operation and receptacle loads) instead of the default ASHRAE 90.1 schedules. With the more representative operating schedules, the building was expected to achieve a 36% energy savings relative to an ASHRAE 90.1 building.

The actual monitored savings were slightly less than predicted at 28% of ASHRAE 90.1, primarily because of higher gas use for space heating and cooling. Nevertheless, the annual energy bill is only $8.20 per square metre (76 cents per square foot): typically half that of existing office buildings. The energy intensity is 196 ekWh/m^2 with natural gas as the cooling energy source. The energy intensity would have been under 150 ekWh/m^2 if the cooling had been provided by electricity.

Table 5.1: Simulated and Monitored Annual Energy Consumption (ekWh) – based on Actual Operating Schedules

Component		ASHRAE 90.1 (simulated)	As-Operated (simulated)	Monitored
Space Heating	(gas)	184,128	64,113	78,807
Cooling	(gas)	n/a	71,918	160,900
	(electric)	45,129	n/a	n/a
Water Heating	(gas)	6,941	4,021	4,119
Lighting	- tenant	87,691	37,266	36,557
	- common	9,743	4,141	4,870
	- exterior	2,474	2,924	1,533
Receptacles	- tenant	84,626	76,789	83,303
Pumps & Fans	- fans	43,369	20,586	25,765
	- pumps	n/a	31,588	25,787
	- misc. load	16,072	8,386	8,305
Total Energy Use	- ekWh - kWh/m^2	480,173 219	321,732 147	429,946 196
Total Cost	($)	$24,740	$15,867	$17,860
	% Savings		36%	28%

Monitoring shows that space heating is 23% higher than the "As-Operated" simulation. The primary reason for this is that the boiler seasonal efficiency is well below the manufacturers rated steady-state value of 83% (see Section 5.4.1).

Cooling gas use was the largest component of excessive energy consumption when compared to the "As-Operated" building. Some of the added consumption can be attributed to additional internal gains such as the receptacle loads. However, monitoring of the chiller showed that it was operating at a seasonal COP well below expectations (see Section 5.4.2). The manufacturer's specifications are a steady-state COP of 0.9 to 0.95. Short term testing of the system shows that actual COP including cycling losses, varied between 0.41 and 0.61. Several factors appear to be contributing to the lower than expected performance. These include higher than design condenser (pond) water temperatures due to the additional heat rejected, lower than design evaporator temperatures possibly due to control calibration, and a large number of short firing cycles. The poor performance in both heating and cooling indicate that the equipment may suffer from poor part-load performance.

Receptacle loads were an area of significant additional energy consumption over the initial design values (see Section 3). Monitoring showed that receptacle loads remain significantly above the ASHRAE default schedule at night. Network servers, personal computers, fax machines, printers, photocopiers, refrigerators, water coolers, and other electrical equipment do not get turned off at night resulting in significant energy consumption when little was expected.

Building lighting energy use was approximately the amount expected according to the "As-Operated" simulation. The energy-efficient lighting systems and occupancy/daylighting controls appear to be effective in reducing electricity use.

5.4 Heating/Cooling System Performance

5.4.1 Boiler Performance

The packaged boiler-chiller, was properly sized for the cooling load but oversized for heating in high-fire. In low-fire mode, the boiler output is reduced to 40% of the rated 360 MBH (106 kW) - enough to heat the building.

Monitoring of the system began immediately upon installation. The gas meter was read on a monthly basis. After the first few months, it was clear that gas use was higher than expected. Investigations began into the potential causes. Numerous checks were made to determine the cause of the problem.

Steady-state (or thermal) boiler efficiency was determined from measurements of flow rate and water temperature rise. A flue gas analysis was used to measure combustion efficiency. Combustion efficiency was found to be approximately 83%. The heat delivered to the water under steady-state conditions (thermal efficiency) was measured at 77% (i.e., jacket losses of approximately 6%). The manufacturer quotes a slightly higher thermal efficiency of 83%.

The measured flue temperature during the "off" cycle was over 50°C. This suggests that a significant amount of heat is stored in the casing of the boiler and lost up the flue during the off cycle. An event counter showed that the boiler had an average of 64 eight-minute "ON" cycles daily.

Figure 5.1 shows the gas energy consumed, the heat delivered, and the monthly thermal efficiency for the months of October 1997 through March 1998. It shows increased efficiency as the heat delivered to the building increases. The monthly thermal efficiency, however, peaks at approximately 55% and averages 48% over the heating season: well below the steady-state value of 77%. Thus, there appears to be significant heat stored in the piping and casing that is either lost up the flue or to the mechanical room during off cycles.

Figure 5.1: Green on the Grand Boiler/Chiller Heating Performance

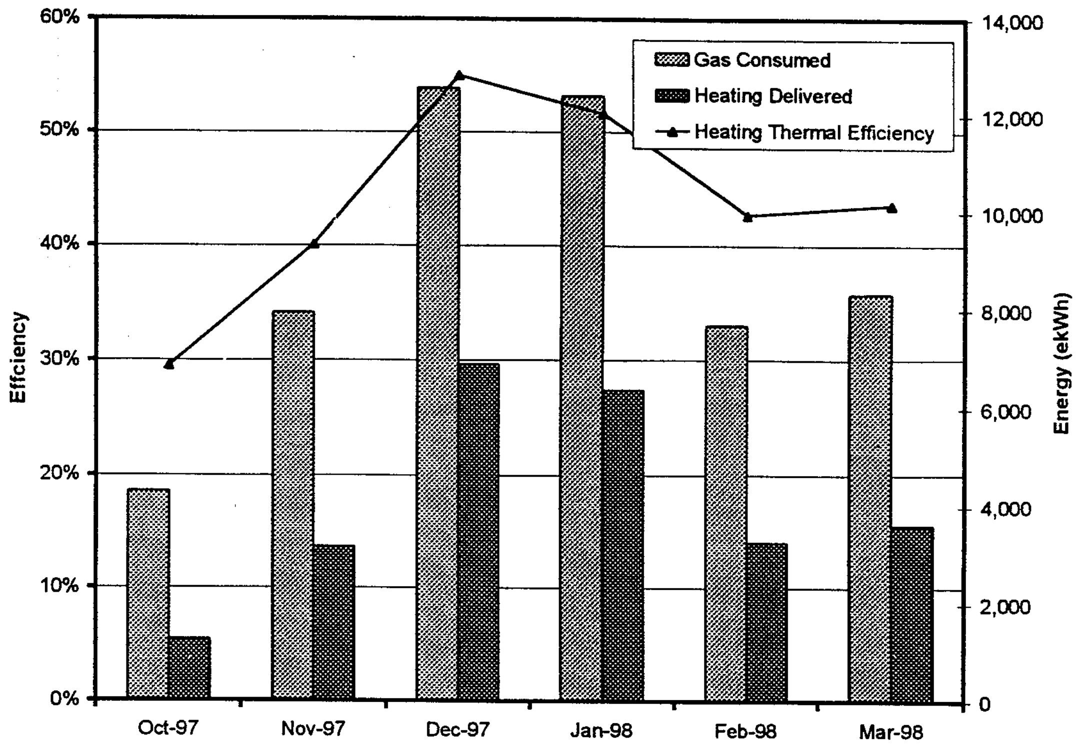
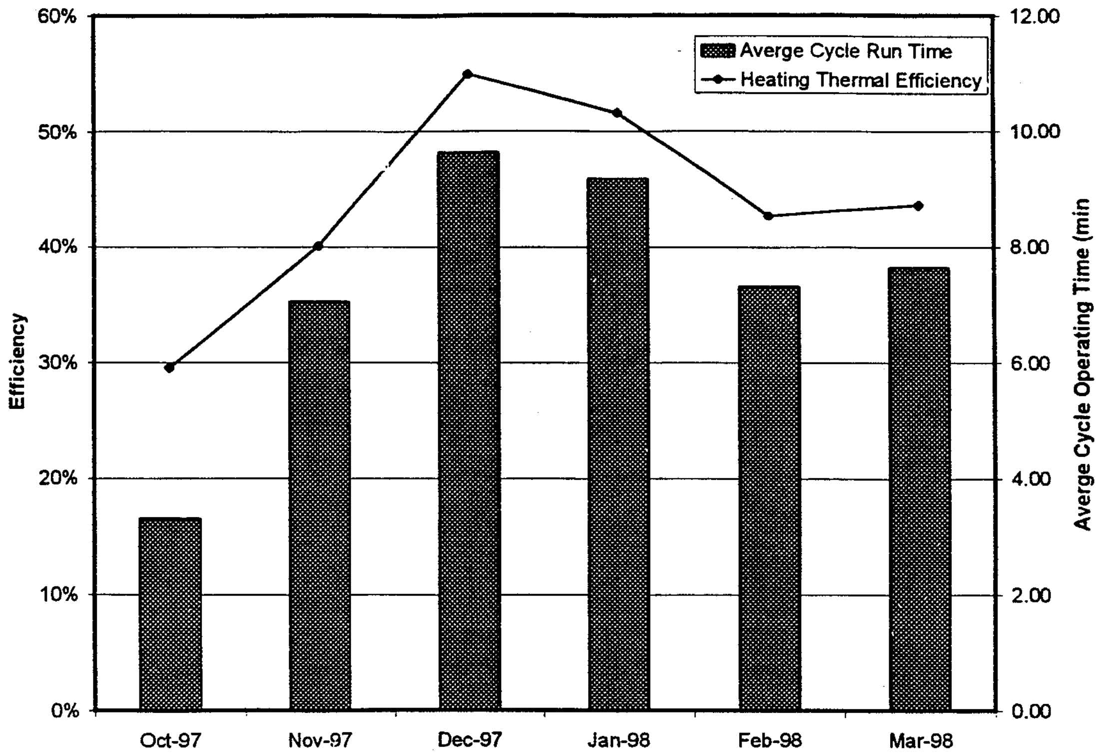


Figure 5.2 shows the monthly thermal efficiency of the boiler and the average cycle time for the months of October 1997 through March 1998. As the average cycle time increases so does the boiler efficiency. What is notable is that all the average cycle times are below 10 minutes. This would indicate that, even in low-fire, the boiler is oversized for the building.

Figure 5.2: Boiler Thermal Efficiency vs. Average Cycle Run Time



5.4.2 Chiller Performance

The manufacturer's specification for the chiller is a COP of 0.95 at a cooling water inlet temperature of 29.4°C and a chilled water outlet temperature of 7°C. These temperatures represent the optimum operating point of the chiller because they strike a balance between a high COP and low wear and tear on the unit. Higher COPs are possible, but the chiller becomes too efficient and can crystalize the unit. Thawing the water system represents expensive maintenance. As was the case when in heating mode, the boiler/chiller gas consumption was higher than expected.

Effect of Cooling and Chilled Water Temperatures

The monitored operating data indicates that the chiller doesn't always operate at the ideal temperatures specified by the manufacturer. Figure 5.3 summarizes the relationship between the COP and the cooling water inlet temperature according to the manufacturer's specifications. Curves are plotted for chilled water outlet temperatures of 5, 7 and 9°C. The ideal operating temperature is indicated by the 'star' symbol. The COP at the ideal operating temperatures is 0.95. The COP drops to 0.86 for a chilled water outlet temperature of 7°C and a cooling water inlet temperature of 32°C. The COP drops further to 0.80 for a chilled water outlet temperature of 5°C and a cooling water inlet temperature of 32°C. A curve fitted through the data points for a chilled water outlet temperature of 5°C is extrapolated for cooling water inlet temperatures up to 38°C.

Figure 5.4 shows that the performance of the chiller over a typical day. The chilled water outlet temperature ranges between roughly 9°C and 3°C with an average of 5°C while the chiller is operating. On this particular day, the pond temperature was at or below 29°C so that the cooling water temperature could be maintained at 29°C. Cooling water temperatures in the mid to high 30s were, however, recorded during prolonged hot spells in June and July. Ironically, the higher pond temperatures are a result of the poorer than expected chiller performance (and higher than expected cooling loads). At an average chilled water outlet temperature of 5°C and an average cooling water inlet temperature of 34°C, a steady-state COP of 0.7 is expected.

Effect of Chiller Cycle Times

The manufacturer's COP values are for steady-state operating conditions. As shown in Figure 5.4, however, the chiller does not run continuously but cycles over a 10 to 20 minute period. Every time a cycle starts, the chiller must heat up the absorbant to the temperature necessary to drive the water vapour out of the lithium bromide solution. The time required to do this is indicated by the lag between the initial firing of the chiller and the peak in the chilled water outlet temperature. This reduces the COP because energy is being put in to run the chiller, but no energy is being removed because there is no cooling. At the other end of the cycle, the COP is reduced because the low-fire burner is on and energy is input to run the chiller, but only a small amount of cooling is provided. As the cycle times get shorter, the inefficiencies on either end of the cycle have a large impact on cycle efficiency and the COP for the cycle is reduced.

The actual COP including cycling losses ranged from 0.41 to 0.61 with an average of 0.51.

Figure 5.3: COP vs. Cooling Water Temp.
Chiller/Heater Cooling Performance

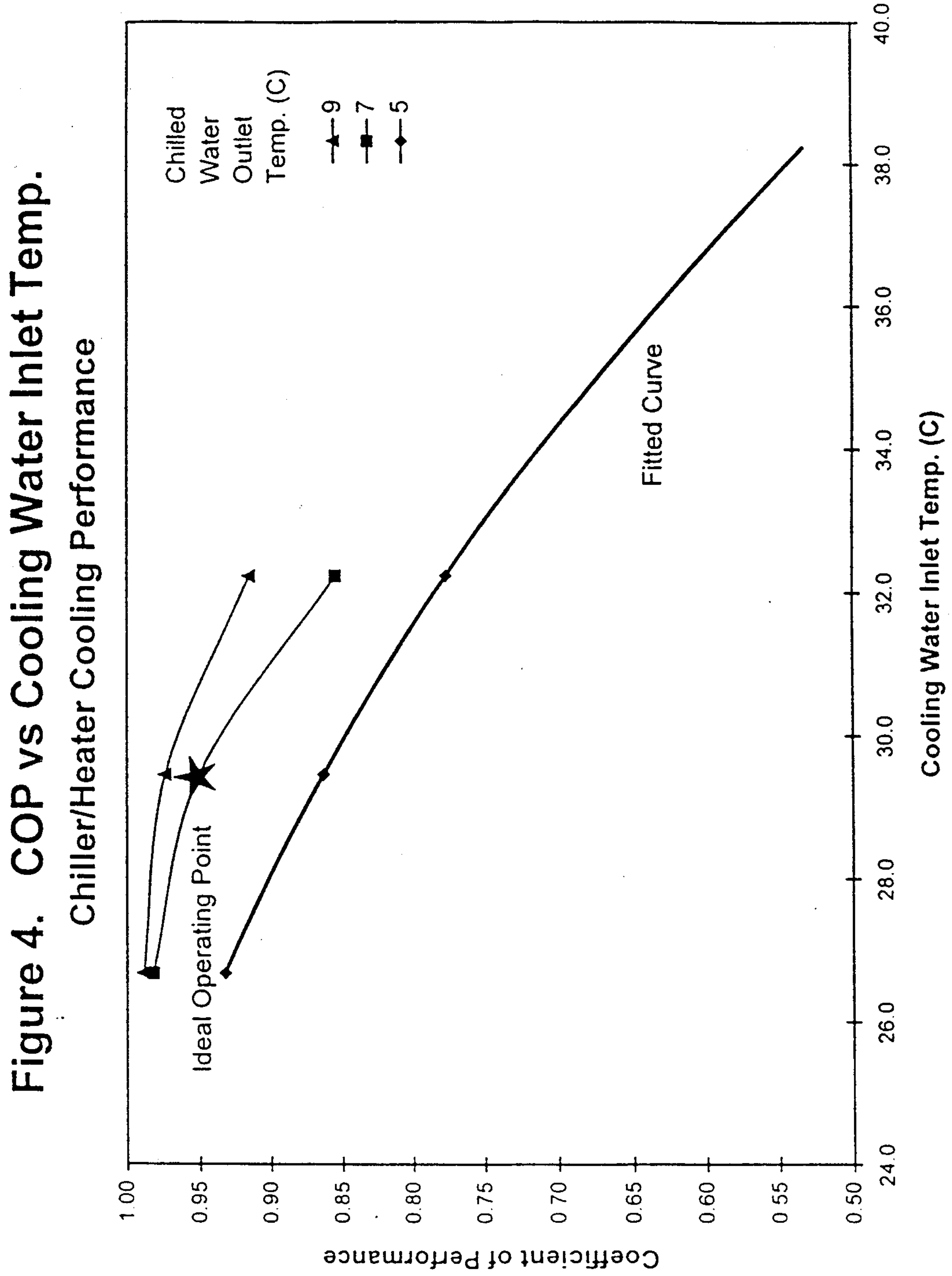
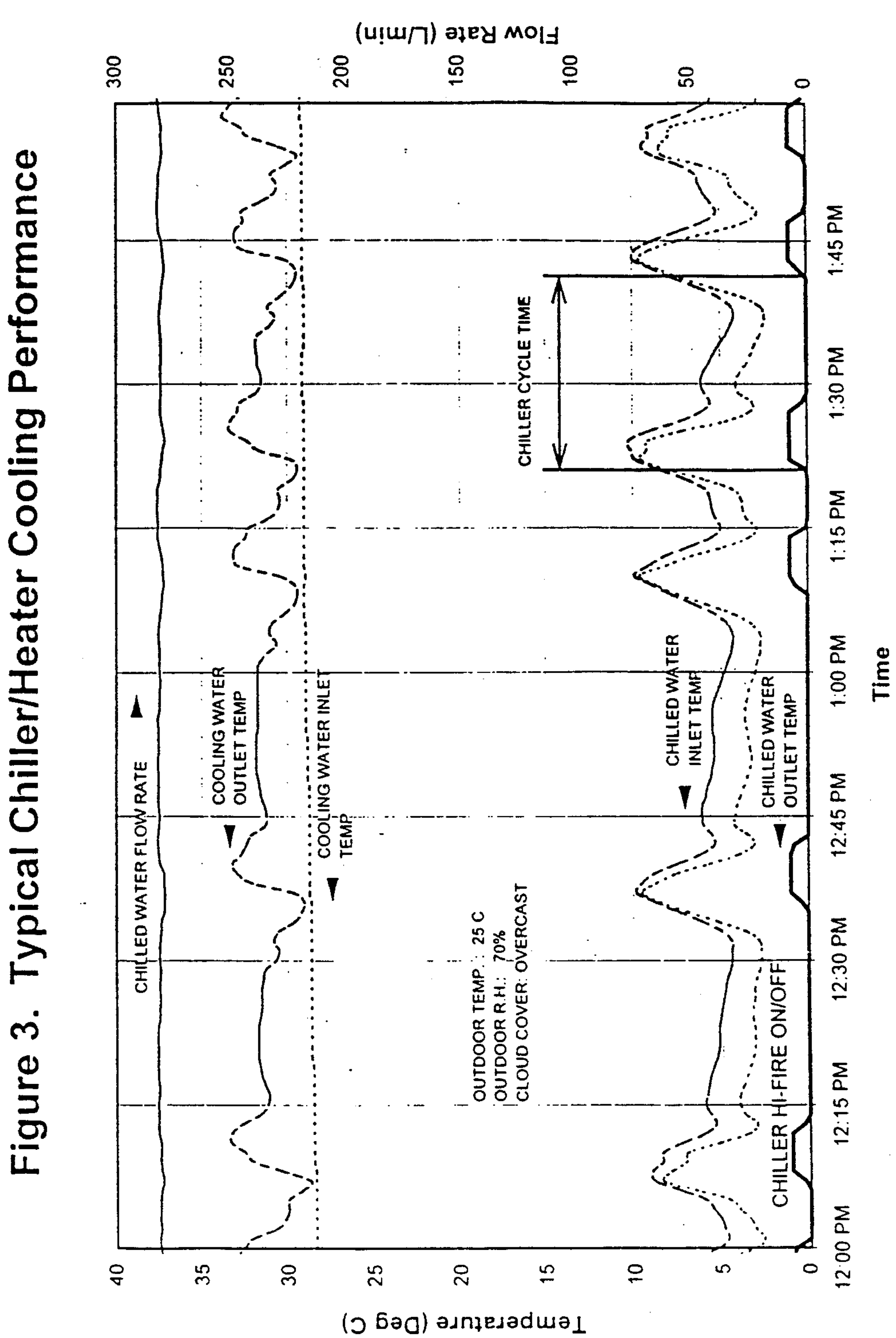


Figure 5.4: Typical Chiller/Heater Cooling Performance



5.4.3 Cooling Pond

A landscape pond in front of the building serves as the cooling tower for the chiller. The pond water is circulated through the chiller condenser and then returned to the pond. Heat rejection from the pond is primarily through evaporation. Make-up water is provided by rainfall collected off the roof. The pond has a surface area of 120 square metres and a maximum depth (when full) of just under one metre.

Because of the lower than expected COP of the chiller, almost twice as much heat had to be rejected by the pond. On hot sunny days, this caused the pond to become too warm for proper chiller operation (above 35°C). Two modifications were made to overcome this problem. First, a spray fountain was added to the pond to increase evaporative heat loss. Second, if the pond temperature went above 32°C, make-up water from the well (or city mains) was added. Because of the higher rate of heat rejection (and evaporation), much of this make-up water was needed to fill the pond anyway. The impact on water consumption is discussed in Section 5.9.

The purpose of the ozonator is to treat the water to prevent growth of algae. Ozonators have been successfully used in many swimming pools. In this application, the ozonator was not completely effective and chemicals (chlorine) were required. There was concern that the high iron content in the well water might be absorbing the ozone. For the 1997 cooling season, softened and iron-filtered water (from the city) provided much of the make-up water.

5.5 Ventilation System Performance

5.5.1 Heat Recovery

The ventilation system supplies 13°C fresh air to the building throughout the heating season. As described in Section 2.2.2, two heat recovery systems are used. Fresh air passes through the energy recovery wheel, then a heating coil and finally a conventional plate heat exchanger. The energy recovery wheel is capable of recovering both sensible and latent heat energy from the exhausted air, however, due to unreliable humidity measurements, only the sensible performance is measured.

Figure 5.5 shows the sensible heat supplied to the ventilation air by the heating coil (heat supplied by boiler), plate heat exchanger and rotary wheel heat exchanger. This represents the heat energy required to raise the ventilation air to 13°C from the outdoor air temperature. The boiler only supplied an average of 6% of the required heating energy. The remaining 94% of the ventilation heat was recovered from the exhaust air.

Figure 5.6 shows that the sensible effectiveness of the heat wheel is approximately 70% at maximum speed. The wheel speed varies in order to deliver a constant delivered air temperature or to avoid frost forming on the heat exchanger. Whenever the wheel speed is below 100%, there is enough recovered heat to meet the desired delivered air temperature of 13°C or there is a concern that moisture from the exhaust air stream will freeze on the wheel.

Figure 5.5: Heat Supplied to Ventilation Air

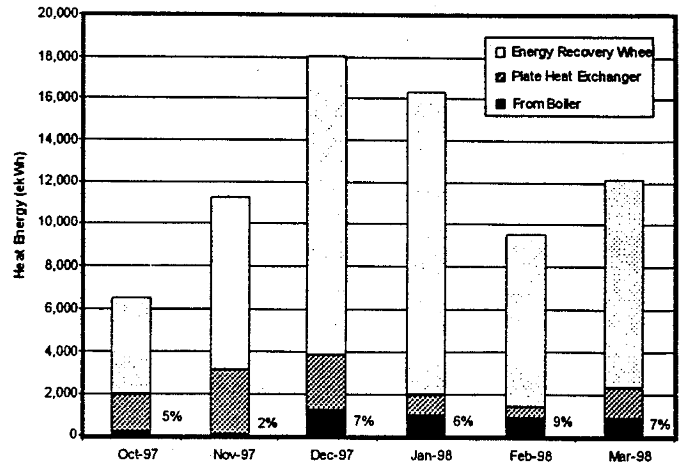
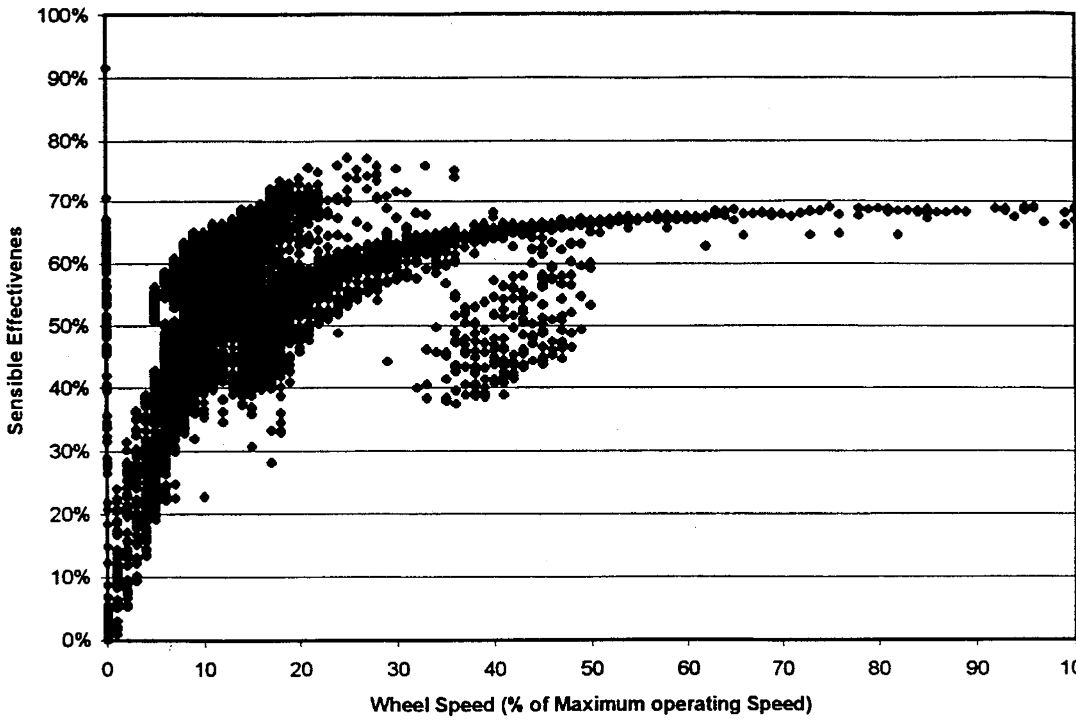


Figure 5.6: Sensible Performance of Energy Recovery Wheel



5.5.2 Fans

High efficiency fans and motors deliver air to the building at a rate of 1600 L/s in high-speed and 1100 L/s in low-speed operation. On average, the system consumed 2.1 Watts of electricity for each L/s of flow rate.

5.6 Occupant Comfort and Satisfaction

5.6.1 Occupant Comfort

The radiant heating/cooling and displacement ventilation systems were selected to improve thermal comfort and indoor air quality. Some people, however, expressed concern over possible cold drafts, inadequate air mixing, and temperature stratification. Several measurements were made to assess occupant health and comfort.

Figures 5.7 and 5.8 show air and panel temperatures on a typical January day. Figure 5.7 shows the air temperature stratification in a typical office for two time periods: heat off and heat on. With the heat off, the floor temperature is 20°C (68°F) and the ceiling temperature is 23.5°C (74°F); a stratification of 1.5°C per metre (0.8°F per foot). This level of temperature stratification is not significantly more than with other heating system types. When hot water is circulated through the panel, it rises to 35°C (95°F) and the air temperature at the ceiling level rises, but the air temperatures at the occupied heights remain almost unchanged. It would seem that radiant heating does not adversely affect temperature stratification.

Figure 5.8 shows the air temperature distribution at various points in the room. The temperature plots show the effect of displacement ventilation. The cool air entering the room affects the air temperature horizontally for approximately one metre, but has almost no effect on the vertical distribution of air temperature. Directly in front of the fresh air vent, the air temperature is 16°C, four degrees cooler than in the middle of the room. Thus, it appears that the ventilation air is travelling horizontally and then slowly rising towards the ceiling exhaust. Carbon dioxide measurements in a typical office confirm this phenomena. The carbon dioxide measurement at the floor level is 350 ppm (outdoor air value). The CO_2 concentration gradually increases with height to a maximum of 800 ppm at the ceiling. A measurement of CO_2 concentration on the opposite side of the room at 1.2 metres height was only 450 ppm, far below the recommended maximum CO_2 values (800 to 1000ppm).

Figure 5.7: Typical Office Room Stratification

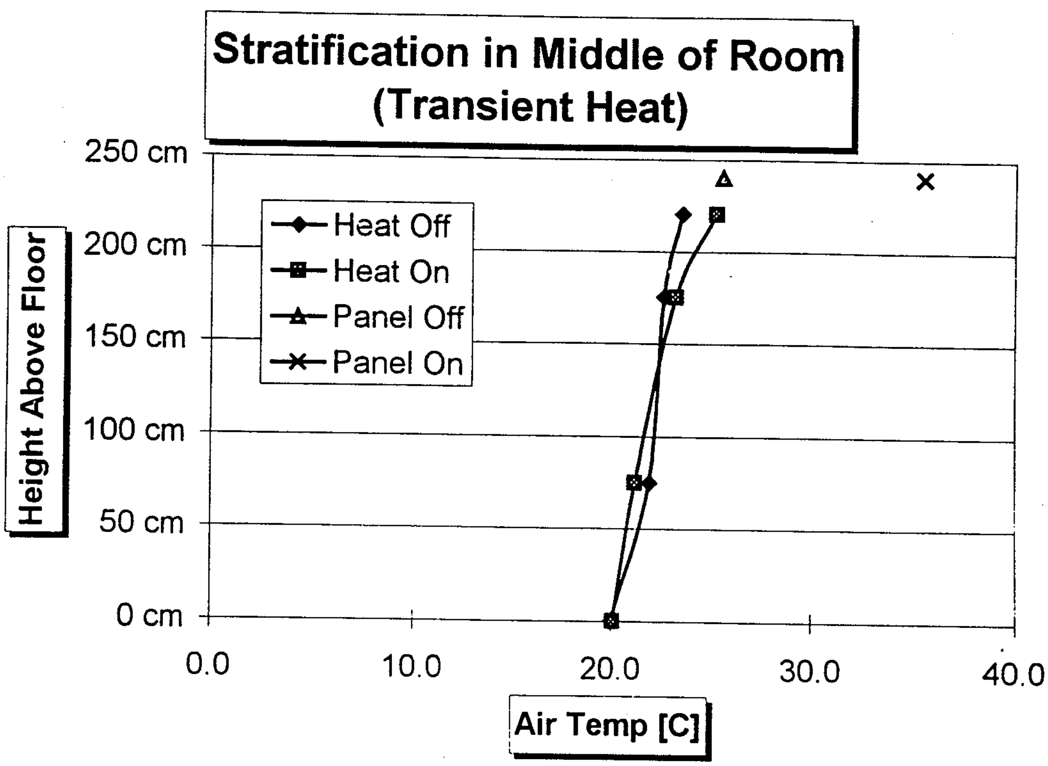
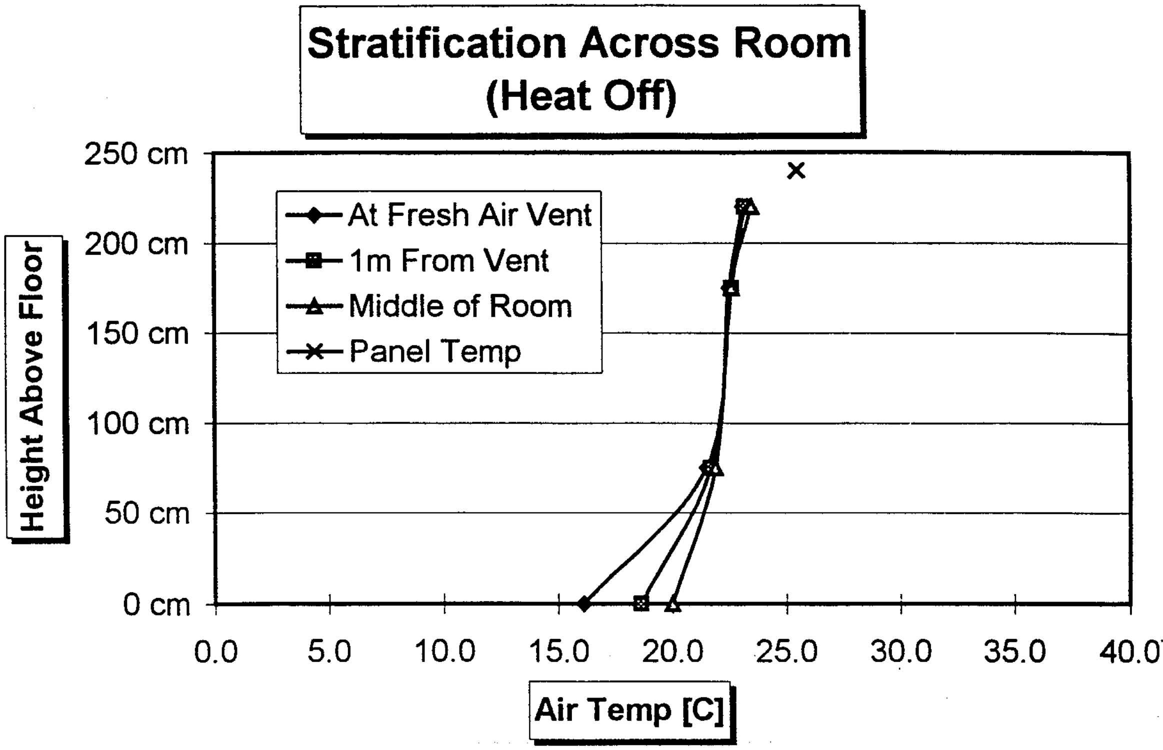


Figure 5.8: Horizontal and Vertical Room Temperature Distribution



Temperature data was also logged for a representative office. The mean radiant and room air temperature as well as the radiant panel surface temperature were measured throughout the monitoring period. Typical forced air systems, while controlling the room air temperature, do not control mean radiant temperatures well. Thus, during cooling operation, the air temperature is kept cool, while mean radiant temperatures can be warm. Conversely, during heating operation, the mean radiant temperature is often much cooler than the air temperature giving the perception of drafts from windows. The results of this is that occupants often set the thermostat either higher or lower than the desired room temperature in order to maintain comfort conditions in the space.

The combination of radiant heating/cooling and the excellent envelope characteristics of Green on the Grand maintain the mean radiant temperature and the room air temperature to within 1°C of each other. Average air and mean radiant temperature for the representative office was 22°C during both heating and cooling seasons. In other words, the warm radiant panels compensate for the cool windows and exterior walls to maintain a constant mean radiant temperature in the winter (and vice-versa in summer).

5.6.2 Occupant Satisfaction

An occupant survey was performed using the questions and methodology defined in the IEA Task 21 POE survey requirements [Atif et al, 1997]. The tenants were asked 27 questions about their satisfaction with the work place. Approximately 70% of the tenants completed the survey. Table 5.2 summarizes the results of the survey, listed in order of tenant satisfaction. Over 80% of the tenants were satisfied with the general environment and lighting in their office. General office noise and concern with temperature were the areas of least satisfaction. The low satisfaction with the temperature may have been partly a result of conducting the survey during the swing months (end of March 1998). The dissatisfaction with noise levels is likely a result of the hard surfaces of the radiant panels and the linoleum flooring and the lack of masking noise from an air heating system.

Table 5.2: Tenant Satisfaction with Green on the Grand

	Satisfied	Indifferent	Dissatisfied
General Environment	82	11	6
Lighting	81	4	15
Lots of Space	78	15	6
Window Size	77	12	10
Odour	75	17	8
View	61	26	12
Privacy	53	35	12
Ventilation	50	4	46
Noise Level	49	2	49
Temperature	33	6	61

5.7 Lighting and Daylighting System Performance

5.7.1 Operational Performance

The daylighting system and occupancy sensors operated reliably over the monitoring period. Tenants raised no objections to lights being controlled by occupancy sensors. The daylight sensors provided an additional benefit beyond daylight savings. In several offices, the tenant found the light level too high. By adjusting the dip switches on the daylight sensor, the lights could be permanently dimmed to the desired light level. There was some problem with a single daylight sensor controlling numerous rooms with different lighting requirements. For example, if the blinds in the room with the sensor were open, the lights would dim. The tenant in an adjacent office might need to control glare by closing the blinds and would not have enough light. The solution would have been to have additional sensors where conflicting use patterns could cause a problem (albeit at a higher cost).

Table 5.3 lists the average daily electricity use for lighting and receptacles (plug loads) on a per unit floor area basis. The total electricity use for all tenants and the lighting/receptacle breakdown for Tenant A is from monitored data. The tenant breakdowns for Tenants B through E are estimated from the installed lighting capacity and their operation of the window shades.

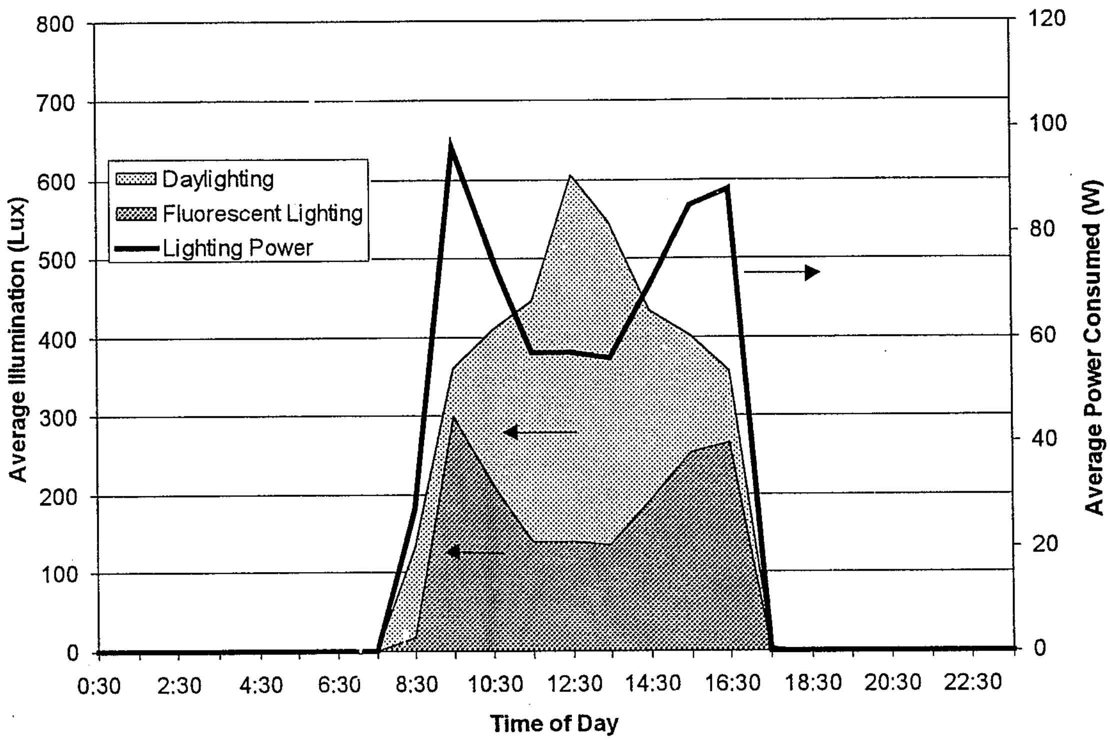
When performing computer simulations according to ASHRAE 90.1, the lighting density must be 18.5 W/m^2 (or less) and it is assumed that the lights are on full for the equivalent of 53 hours per week. This corresponds to annual lighting use of 51 kWh per square metre of floor area. Tenant A uses only 9.4 kWh/m^2 - an 82% reduction. Lighting energy accounts for 30% of Tenant A's electricity use. This reduction is made up of two parts: installed lighting capacity that is only 45% of ASHRAE 90.1, and fewer operating hours at full output. Assuming that the ASHRAE lighting schedule is similar to Tenant A's schedule, the use of occupancy sensors and daylighting controls reduces lighting energy use to only 40% of ASHRAE 90.1 full load electricity use.

It is difficult to estimate the split in savings between occupancy sensors and the daylighting system. Figure 5.9 shows the light level and lighting energy use for the monitored office on a typical fall day. The office tenant arrived at 8 AM and left at about 5 PM. The lighting power is at the maximum early in the morning and late in the afternoon and provides approximately 350 lux. As the sun comes up, the light level increases to 500 lux and the lighting power decreases. For this day, daylighting provided an additional 150 lux and reduced lighting energy by 23%. The split in light levels between daylight and electric lights was determined by measuring the lighting output of the lamps verses the electricity use. The control allows the lights to dim to about 20% of their peak illumination, however, at the minimum setting the light consumes 35% of the peak electricity use.

Table 5.3: Tenant Annual Electricity Use (values in italics are estimates)

Tenant	Lighting Energy (kWh per m^2)	Receptacle Energy (kWh per m^2)	Total Tenant Electrical Energy (kWh per m^2)
A	9.4	22.2	31.6
B	*18.2*	*43.7*	61.9
C	*22.0*	*34.9*	56.9
D	*20.9*	*66.8*	87.7
E	*27.8*	*62.4*	90.2

Figure 5.9: Lighting in Typical Office – Tues. Jan 13, 1998

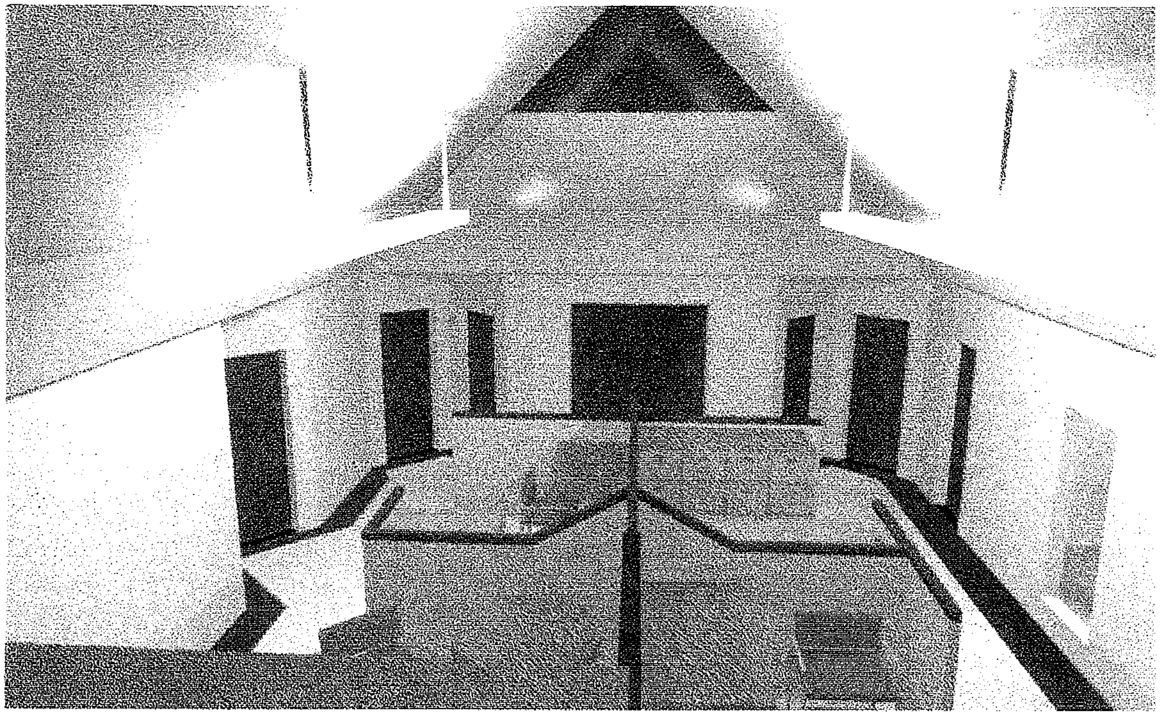


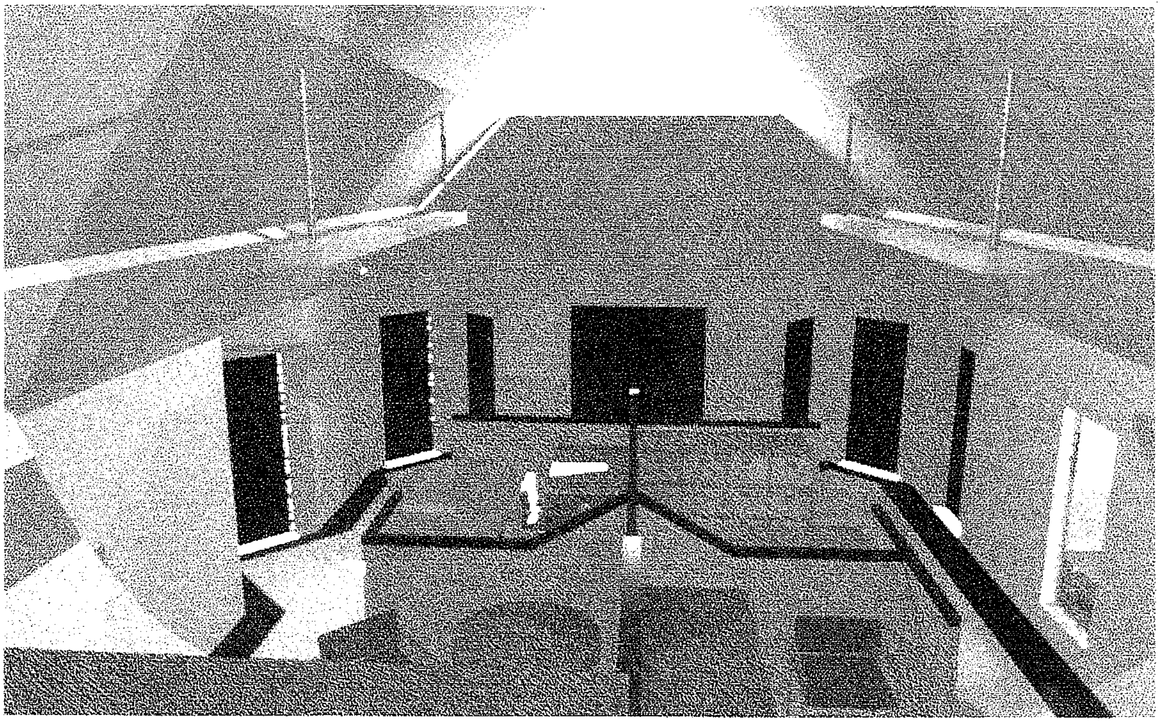
5.7.2 Daylight Simulations

Computer simulation using the ADELINE 1.0 computer program was performed to study the daylight distribution and the daylight-linked lighting system performance in two office spaces on the second floor of the building. Figure 5.11 shows the ADELINE output for the interior office space on the second floor under daytime and nighttime conditions. Figure 5.10 is a photograph of the same space. The computer rendering is very similar to the photograph of the actual space indicating its value as a design tool. The on-site measured illuminance and electric lighting energy consumption were compared with simulation results and the energy savings potential of replacing electric lighting with daylighting was evaluated. The accuracy of the ADELINE computer program in simulating the energy savings from the use of daylight-linked control system was studied in a related report [Galasiu and Atif, 1997].

Figure 5.10: Photograph of Second Floor Interior Office

Figure 5.11: ADELINE Renderings of the Second Floor Interior Office (Night & Day)





5.8 Other Electrical Loads

Receptacle loads were an area of significant additional energy consumption. The connected receptacle capacity is very close to the 8.1 W/m^2 suggested in ASHRAE 90.1 as typical for offices and the 8.9 W/m^2 that Komor [1997] monitored in other office buildings. The increase in energy use is because the receptacle loads remain significantly above the ASHRAE default schedule at night. Network servers, personal computers, fax machines, printers, photocopiers, refrigerators, water coolers, and so on do not get turned off at night resulting in significant energy consumption when little was expected.

Figures 5.12 and 5.13 compare normalized receptacle and lighting loads for Tenant A against the ASHRAE schedule (the solid line) for weekdays and weekends respectively. The monitored results are hourly values averaged over a six month period. Figure 5.12 shows that lighting follows the ASHRAE schedule reasonably well on weekdays, though the evening hours run slightly longer. The long dashes show the night-time receptacle loads are 50% of the daytime values rather than zero. Figure 5.13 shows that weekend electricity use is significantly higher for both lighting and receptacles.

Figure 5.12: Tenant Weekday Electricity Use (Normalized to Peak Value)

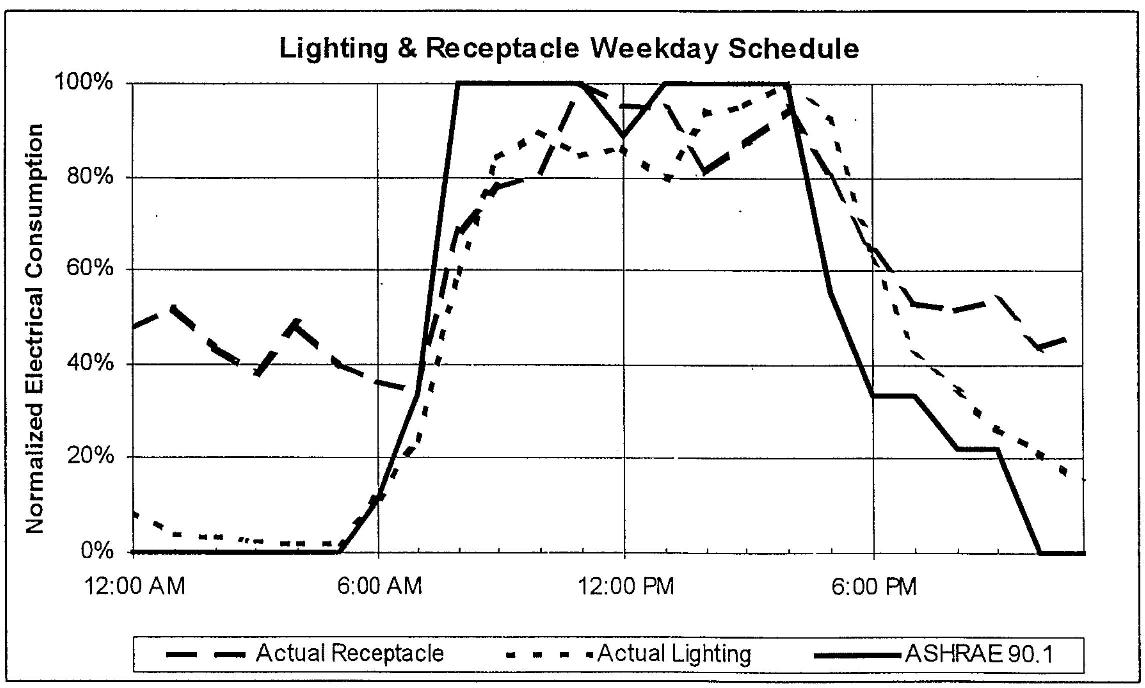
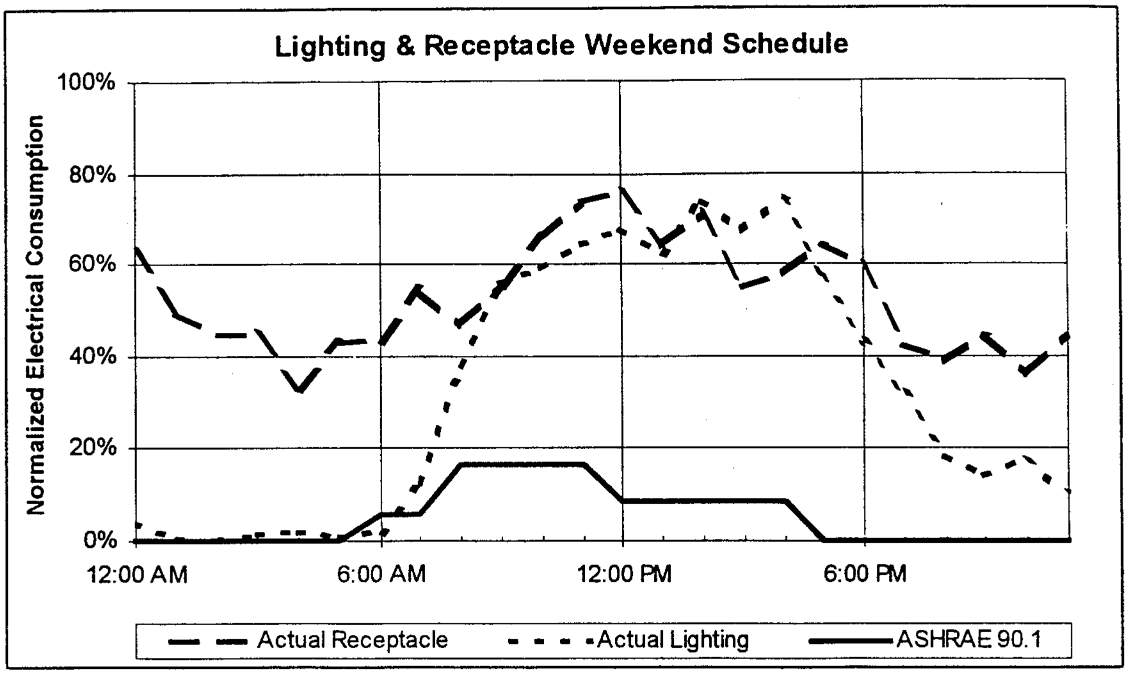


Figure 5.13: Tenant Weekend Electricity Use (Normalized to Peak Weekday Value)



5.9 Water Consumption

Over the two-year monitoring period, annual purchased water consumption was 9 m^3 per person or 25 litres per person per day (based on an occupancy of 75 people). This value is very close to the predicted value of 9.5 m^3 per person (see Section 3.2). Well water consumption was an additional 9 m^3 per person: much higher than the predicted value of 3 m^3 per person.

There is a definite seasonal trend in purchased water usage. Winter water consumption is only 15 litres per person per day, whereas summer water use rises to 44 litres per person per day. The winter value is indicative of water consumption related to people: toilets, sinks, drinking etc.

The increase in the summer water usage is for the cooling pond and landscape watering. Water usage associated with the cooling pond (city and well water) is 13 m^3 per person per year of which half is from the city. Future modifications call for installing an iron filter on the well water supply so that all pond water can come from the well.

6. CONCLUSIONS

Green on the Grand was able to realise major energy and HVAC capital cost savings from a highly insulated and airtight building shell. The heating load dropped by 66%. The use of spectrally selective glazings and a reduced peak electrical load (45 kW monitored vs. 100 kW ASHRAE 90.1) allowed the installation of a chiller less than half the size that would otherwise have been required.

Green on the Grand achieved a monitored energy cost savings of 28% relative to ASHRAE 90.1. The greatest savings were achieved with the lighting system. A combination of energy-efficient lighting design, daylighting controls and occupancy sensors reduced the lighting electricity use by 82% for one tenant relative to ASHRAE 90.1 lighting requirements. This reduction was achieved by a 55% reduction in lighting density and a 60 % reduction in light ouput because of daylighting and occupancy sensors. The average lighting savings for the building relative to ASHRAE 90.1 is estimated to be 60%.

The lower than expected energy savings was a result of the poor seasonal performance of the boiler/absorption chiller. The boiler had a seasonal efficiency of 48% and the chiller had a seasonal COP of 0.51: both significantly below the manufacturer's steady-state ratings. Efficiency curves for off-rating point and part load performances are required to allow designers to properly assess and select equipment.

Displacement ventilation performs well, effectively removing pollutants and providing fresh air to the space. The building provides a comfortable and pleasing environment for the occupants, although noise transfer was an area of low satisfaction.

Connected receptacle capacity is approximately equivalent to the 8.1 W/m^2 required by ASHRAE 90.1 but the operating schedule needs to have a much higher load at night and on weekends. The receptacle load is approximately 50% during the night and on weekends compared to daytime operation.

7. REFERENCES

ASHRAE/IES 90.1-1989 – ASHRAE Standard – Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings.

Atif, M., Love, J., and Littlefair, P., 1997. Daylighting Monitoring Protocols and Procedures for Buildings, report of IEA Task 21: Daylighting in Buildings.

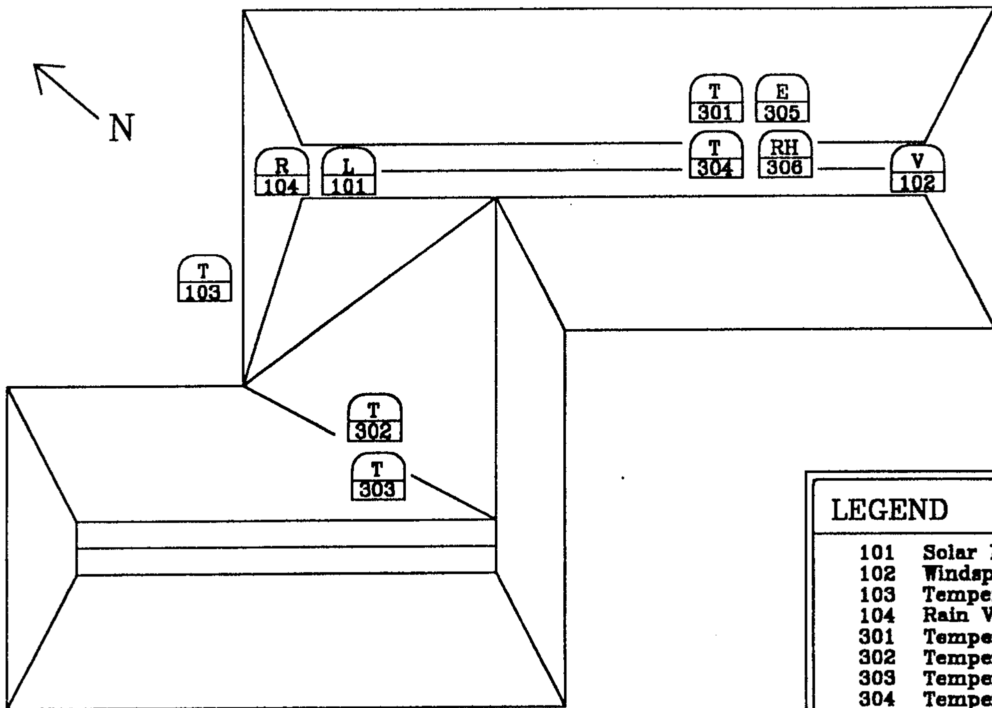
Enermodal, 1996. Green on the Grand: C-2000 Office Building Final Report. Report prepared for CANMET, Natural Resources Canada.

Galasiu, A. and Atif, M., 1998. Daylighting Performance of Canada's First C2000 Office Building: Computer Simulation of a Continuous Dimming Lighting Control System, report prepared for Natural Resources Canada by National Research Council of Canada, Report No. A-3578.1.

Komor, Paul, 1997. Space Cooling Demands From Office Plug Loads. ASHRAE Journal, December 1997.

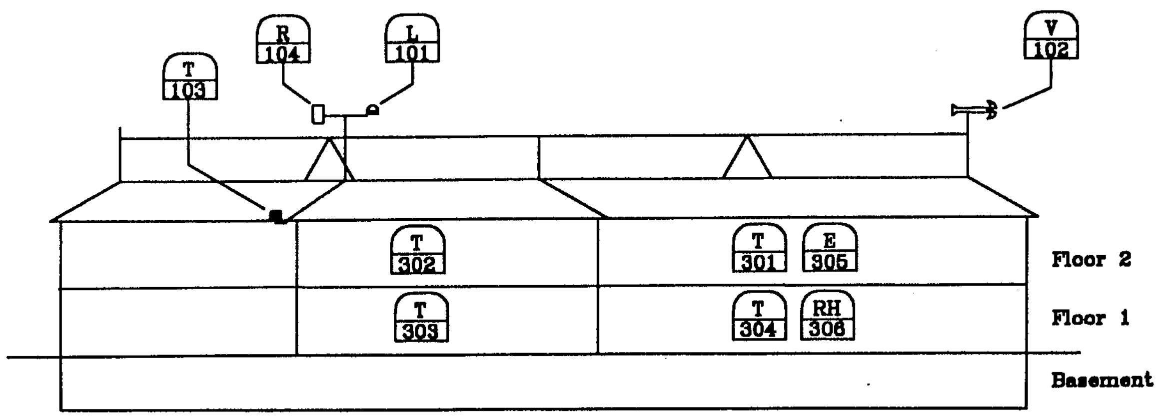
Appendix A. Monitoring System Schematics

OUTDOOR AND TENANT INSTRUMENTATION SCHEMATIC

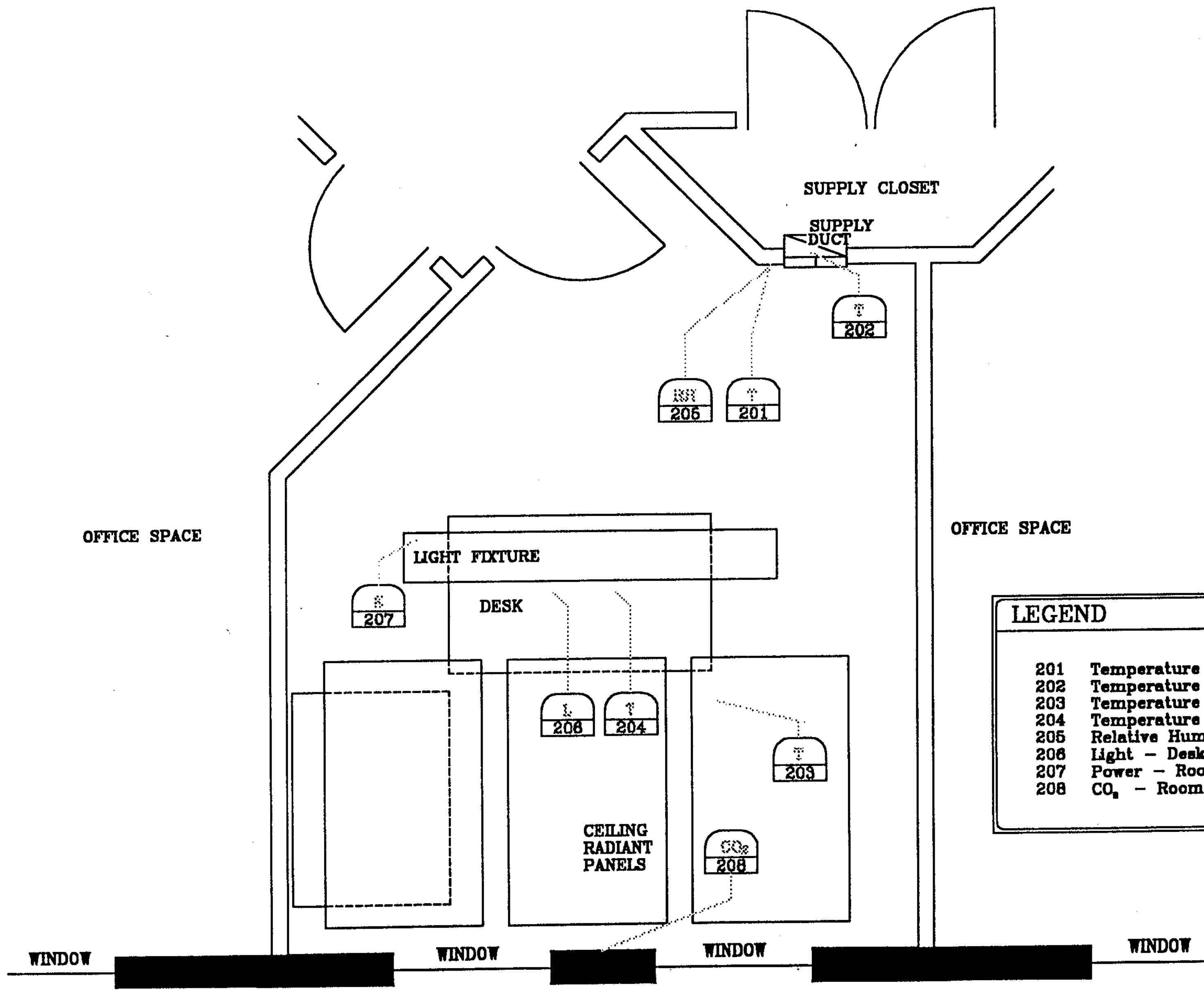


LEGEND

101	Solar Radiation — Horizontal Outdoor
102	Windspeed — Outdoor
103	Temperature — Ambient Outdoor
104	Rain Volume
301	Temperature — Enermodal Averge
302	Temperature — Hybrid Average
303	Temperature — Sommerfeld Average
304	Temperature — MTE Average
305	Power — Enermodal Lighting
306	Relative Humidity — Enermodal Average



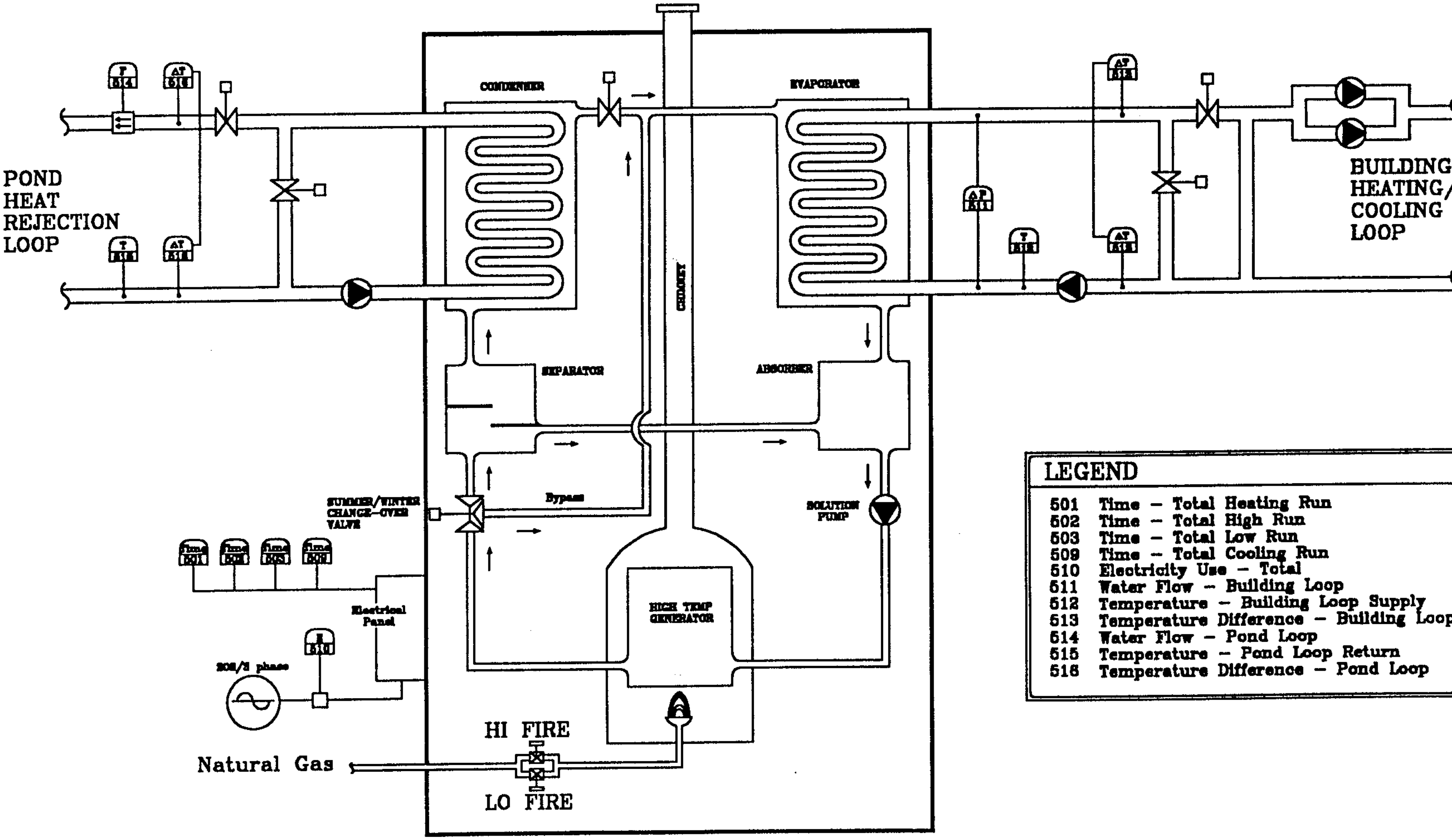
REPRESENTATIVE OFFICE INSTRUMENTATION SCHEMATIC



LEGEND

201	Temperature – Room Average
202	Temperature – Ventilation Air Supply
203	Temperature – Radiant Panel Surface
204	Temperature – Mean Radiant
205	Relative Humidity – Room Average
206	Light – Desk Level
207	Power – Room Light Fixture
208	CO_2 – Room Average

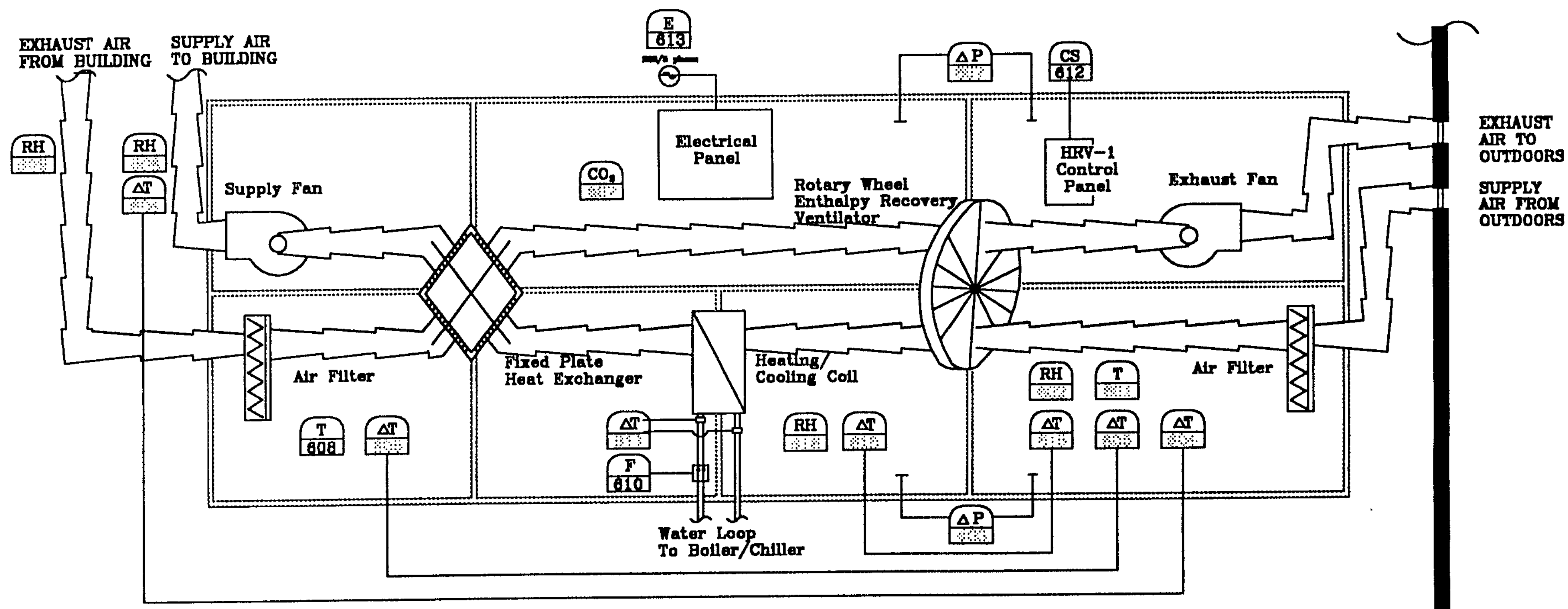
BOILER/CHILLER INSTRUMENTATION SCHEMATIC



LEGEND

501	Time -- Total Heating Run
502	Time -- Total High Run
503	Time -- Total Low Run
509	Time -- Total Cooling Run
510	Electricity Use -- Total
511	Water Flow -- Building Loop
512	Temperature -- Building Loop Supply
513	Temperature Difference -- Building Loop
514	Water Flow -- Pond Loop
515	Temperature -- Pond Loop Return
516	Temperature Difference -- Pond Loop

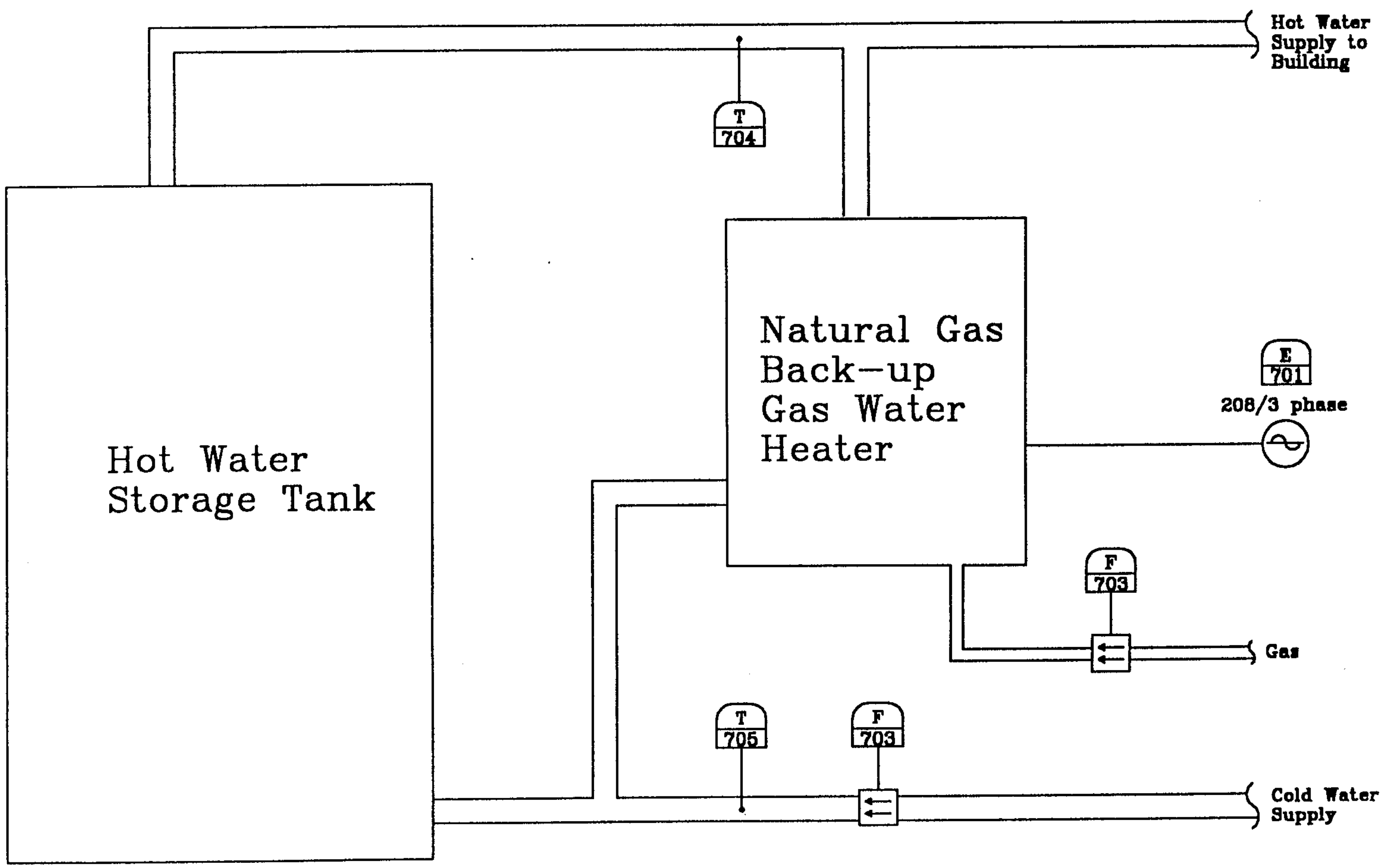
AIR HANDLING SYSTEM INSTRUMENTATION SCHEMATIC



LEGEND

307	CO_2 Level – Exhaust Air From Building
601	Temperature – Supply Air From Outdoors
602	Relative Humidity – Supply Air From Outdoors
603	Pressure Difference – Supply Airflow
604	Temperature Difference – Supply Total Rise
605	Temperature Difference – Total Available
606	Relative Humidity – Supply Air To Building
607	Pressure Difference – Exhaust Airflow
608	Temperature – Exhaust Air From Building
609	Relative Humidity – Exhaust Air From Building
610	Water Flow – Heating/Cooling Coil
611	Temperature Difference – Heating/Cooling Coil Rise
612	Control Signal – Rotary Wheel Speed
613	Electricity Use – Total
615	Temperature Difference – Supply Air Rise Through Rotary Wheel
616	Relative Humidity – Supply Air From Outdoors After Rotary Wheel

HOT WATER TANK INSTRUMENTATION SCHEMATIC



LEGEND

701 Total Electricity Use – Water Heater
702 Total Gas Use – Water Heater
703 Total Hot Water Use
704 Temperature – Hot Water Average
705 Temperature – Mains Water Average

Appendix B. Monthly Utility Consumption

Monthly Utility Consumption - Total Building

Month	Total Building Elec. (kWh)	Tenant Suite Electricity Use (kWh) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Tenant 5	Common Elec. Use (kWh)	Elevator Runtime (hrs)	Total Building Gas (m³)	Total Building Gas (eKWh)	Total City Water (m³)	Well Water (m³)
April,96	11718.0	648.0	3590.0	755.0	3865.0	0.0	2712.0	0.0	900.5	9319.7	28.3	0.0
May,96	12237.7	614.5	3358.0	774.1	4041.9	0.0	3437.4	0.0	384.7	3981.5	41.0	0.0
June,96	15709.7	856.6	3517.2	711.7	4245.5	0.0	6284.5	0.0	2170.6	22465.4	26.9	0.0
July,96	17310.8	590.1	3293.5	860.5	3860.0	0.0	8572.0	0.0	2757.6	28540.1	28.9	0.0
August,96	17900.9	498.1	3121.4	849.8	3841.9	0.0	9481.7	0.0	5279.1	54636.5	65.4	0.0
September,96	17088.8	517.5	3279.4	1005.0	3531.6	0.0	8556.6	0.0	3814.8	39482.2	72.5	0.0
October,96	15791.4	602.4	3498.9	1039.5	4404.1	739.9	5517.0		1053.4	10902.2		
November,96	14788.1	690.9	3301.9	932.8	3979.7	1104.4	4621.9		1462.8	15138.9	61.6	
December,96	12642.0	682.0	3130.0	833.0	3113.0	945.0	3841.0		2262.5	23416.4	39.5	
Sum	**135187.4**	**5700.2**	**30090.2**	**7761.5**	**34882.6**	**2789.2**	**53024.0**	**0.0**	**20086.0**	**207882.8**	**364.2**	**0.0**
Avg	**15020.8**	**633.4**	**3343.4**	**862.4**	**3875.8**	**309.9**	**5891.6**	**0.0**	**2231.8**	**23098.1**	**45.5**	**0.0**
Min	**11718.0**	**498.1**	**3121.4**	**711.7**	**3113.0**	**0.0**	**2712.0**	**0.0**	**384.7**	**3981.5**	**26.9**	**0.0**
Max	**17900.9**	**856.6**	**3590.0**	**1039.5**	**4404.1**	**1104.4**	**9481.7**	**0.0**	**5279.1**	**54636.5**	**72.5**	**0.0**
ekWh/m²	**59.0**	**21.2**	**48.2**	**56.0**	**68.2**	**11.6**	**104.4**			**90.7**	**0.2**	**0.0**

Monthly Utility Consumption - Total Building

Month	Total Building Elec. (kWh)	Tenant Suite Electricity Use (kWh) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Tenant 5	Common Elec. Use (kWh)	Elevator Runtime (hrs)	Total Building Gas (m³)	Total Building Gas (eKWh)	Total City Water (m³)	Well Water (m³)
January,97	13837.3	792.8	3283.2	957.2	3821.5	1030.5	3903.2		2168.0	22437.7	31.3	
February,97	13248.0	522.0	3081.0	1212.0	3464.0	1093.0	3649.0		1356.4	14038.1	35.1	
March,97	15092.6	595.6	3218.5	1192.4	5044.1	1288.7	4739.7		1379.4	14276.7	33.0	
April,97	15744.0	665.0	3112.0	1093.0	3527.5	1476.0	5339.0	2.5	1042.1	10785.0	105.7	1200.3
May,97	14938.1	704.3	3038.0	939.7	3417.3	909.7	5133.4	1.3	1215.2	12577.3	36.7	0.0
June,97	16926.0	699.0	3040.0	992.0	3705.0	1236.0	6943.0	1.4	3919.1	40561.0	300.3	0.0
July,97	18786.0	681.0	3247.8	1102.6	4208.8	1039.5	8672.8	1.2	3508.4	36310.5	111.0	81.6
August,97	17803.7	638.4	3022.5	922.3	3728.2	1003.1	7932.1	1.1	2735.0	28306.1	88.8	91.9
September,97	17138.6	780.7	3205.0	947.1	3892.5	1113.2	7400.0	0.9	1704.1	17636.6	29.9	10.9
October,97	16740.0	887.2	3548.8	1064.3	4174.7	1256.2	5693.7	0.9	992.8	10274.9	31.5	0.0
November,97	15913.3	800.0	3315.6	924.4	3702.2	1092.2	5944.4	0.9	1349.8	13969.7	25.9	0.0
December,97	15257.8	736.3	3538.8	805.0	3450.7	1108.3	5603.3	2.0	1728.2	17886.5	56.9	0.0
Sum	**191425.4**	**8502.3**	**38651.1**	**12152.1**	**46136.4**	**13646.5**	**70953.5**	**12.2**	**23098.4**	**239060.2**	**886.2**	**1384.7**
Avg	**15952.1**	**708.5**	**3220.9**	**1012.7**	**3844.7**	**1137.2**	**5912.8**	**1.4**	**1924.9**	**19921.7**	**73.8**	**153.9**
Min	**13248.0**	**522.0**	**3022.5**	**805.0**	**3417.3**	**909.7**	**3649.0**	**0.9**	**992.8**	**10274.9**	**25.9**	**0.0**
Max	**18786.0**	**887.2**	**3548.8**	**1212.0**	**5044.1**	**1476.0**	**8672.8**	**2.5**	**3919.1**	**40561.0**	**300.3**	**1200.3**
ekWh/m²	**83.5**	**31.6**	**61.9**	**87.7**	**90.2**	**56.9**	**139.7**			**104.3**	**0.4**	**0.6**

Monthly Utility Consumption - Total Building

Month	Total Building Elec. (kWh)	Tenant Suite Electricity Use (kWh)					Common Elec. Use (kWh)	Elevator Runtime (hrs)	Total Building Gas (m³)	Total Building Gas (eKWh)	Total City Water (m³)	Well Water (m³)
		Tenant 1	Tenant 2	Tenant 3	Tenant 4	Tenant 5						
January,98	15870.0	904.0	3693.0	924.0	3970.0	1147.0	4941.0	0.6	1614.1	16705.0	33.0	0.0
February,98	14982.0	843.0	4479.0	952.0	3885.0	1170.0	4536.0	0.7	1265.8	13100.3	33.9	0.0
March,98	15016.4	954.8	2431.4	895.9	3777.9	1341.3	4453.7	1.3	1068.0	11053.7	40.7	1.6
Sum	**45868.4**	**2701.8**	**10603.4**	**2771.9**	**11632.9**	**3658.3**	**13930.7**	**2.6**	**3947.9**	**40859.0**	**107.6**	**1.6**
Avg	**15289.5**	**900.6**	**3534.5**	**924.0**	**3877.6**	**1219.4**	**4643.6**	**0.9**	**1316.0**	**13619.7**	**35.9**	**0.5**
Min	**14982.0**	**843.0**	**2431.4**	**895.9**	**3777.9**	**1147.0**	**4453.7**	**0.6**	**1068.0**	**11053.7**	**33.0**	**0.0**
Max	**15870.0**	**954.8**	**4479.0**	**952.0**	**3970.0**	**1341.3**	**4941.0**	**1.3**	**1614.1**	**16705.0**	**40.7**	**1.6**
ekWh/m²	**20.0**	**10.0**	**17.0**	**20.0**	**22.7**	**15.2**	**27.4**			**17.8**	**0.0**	**0.0**

Appendix C. Monthly Monitoring Reports

Indoor Comfort Conditions - Representative Office

Date	Outdoor Ambient Temp. (°C)	Avgerage Office Temp. (°C)	Office MRT (°C)	Radiant Panel Temp. (°C)	Average Ventilation Temp. (°C)	Relative Humidity (%)	Carbon Dioxide (ppm)	Average Insolation (W/m²)	Average Light Level (lux)	Maximum Light Level (lux)	Average Lighting Power (W)	Day of Week
01-Jan-98	-4.7	21.4	21.2	24.5	18.6	3	217	174	375	883	0	Thu
02-Jan-98	2.4	21.8	21.4	22.8	19.8	7	268	167	633	2263	0	Fri
03-Jan-98	6.3	21.2	20.8	22.3	19.0	15	223	41	46	128	0	Sat
04-Jan-98	-0.8	21.2	21.0	24.1	18.8	13	221	33	37	101	0	Sun
05-Jan-98	2.6	21.4	21.4	22.1	18.6	15	366	34	352	425	96	Mon
06-Jan-98	8.6	21.7	22.0	22.3	18.8	29	393	72	322	438	86	Tue
07-Jan-98	4.5	22.0	22.4	22.4	19.1	24	415	23	308	365	92	Wed
08-Jan-98	0.7	21.7	22.0	22.6	18.8	16	361	22	297	366	83	Thu
09-Jan-98	-0.1	21.4	21.7	23.2	18.5	14	368	40	287	376	74	Fri
10-Jan-98	-2.8	21.8	21.9	24.3	19.1	8	246	217	602	2150	0	Sat
11-Jan-98	-8.3	21.5	21.6	25.8	18.7	4	232	160	300	1005	0	Sun
12-Jan-98	-5.8	22.1	22.3	25.0	19.1	6	461	126	347	596	76	Mon
13-Jan-98	-6.9	22.2	22.4	24.1	19.4	8	359	201	369	605	61	Tue
14-Jan-98	-9.4	21.9	22.2	24.9	18.9	7	402	193	378	619	73	Wed
15-Jan-98	-8.6	22.0	22.0	23.4	19.3	8	406	71	335	477	72	Thu
16-Jan-98	-8.5	21.9	21.9	23.9	19.2	8	417	126	325	444	75	Fri
17-Jan-98	-6.2	21.2	21.1	26.4	18.6	5	230	69	55	111	0	Sat
18-Jan-98	-3.9	21.1	21.0	26.4	18.4	3	229	142	146	347	0	Sun
19-Jan-98	-3.5	21.8	21.7	24.3	18.9	5	361	190	356	551	67	Mon
20-Jan-98	-5.5	22.8	22.8	24.3	19.7	5	342	351	425	680	39	Tue
21-Jan-98	-5.0	22.3	22.4	24.5	19.5	5	371	161	327	448	78	Wed
22-Jan-98	-7.6	22.4	22.5	24.9	19.5	6	394	138	324	462	77	Thu
23-Jan-98	-2.9	22.4	22.5	24.3	19.7	8	388	46	317	427	76	Fri
24-Jan-98	-2.8	22.1	22.2	25.3	19.4	4	237	106	105	206	0	Sat
25-Jan-98	-3.8	22.3	22.4	25.7	19.4	3	238	237	472	1056	0	Sun
26-Jan-98	-6.7	22.4	22.5	25.5	19.5	5	400	145	356	562	71	Mon
27-Jan-98	-3.6	22.3	22.5	25.0	19.5	7	419	130	346	560	71	Tue
28-Jan-98	-3.1	22.5	22.6	24.8	19.7	8	451	173	355	476	76	Wed
29-Jan-98	-0.8	22.2	22.2	23.4	19.5	10	408	49	258	357	71	Thu
30-Jan-98	-1.6	22.0	22.1	22.6	19.4	10	402	133	358	483	77	Fri
31-Jan-98	-2.2	21.4	21.4	25.2	18.9	4	236	169	137	260	0	Sat
Sum												
Avg	**-2.9**	**21.9**	**21.9**	**24.2**	**19.1**	**9**	**337**	**127**	**311**	**588**	**48**	
Min	**-9.4**	**21.1**	**20.8**	**22.1**	**18.4**	**3**	**217**	**22**	**37**	**101**	**0**	
Max	**8.6**	**22.8**	**22.8**	**26.4**	**19.8**	**29**	**461**	**351**	**633**	**2263**	**96**	

Indoor Comfort Conditions - Representative Office

February 1998

Date	Outdoor Ambient Temp. (°C)	Avgerage Office Temp. (°C)	Office MRT (°C)	Radiant Panel Temp. (°C)	Average Ventilation Temp. (°C)	Relative Humidity (%)	Carbon Dioxide (ppm)	Average Insolation (W/m²)	Average Light Level (lux)	Maximum Light Level (lux)	Average Lighting Power (W)	Day of Week
01-Feb-98	-1.4	22.0	22.0	25.2	19.0	3	234	350	720	1421	2	Sun
02-Feb-98	0.9	21.8	21.8	23.5	19.2	8	417	128	168	293	24	Mon
03-Feb-98	-4.2	21.9	21.9	23.2	19.3	7	373	216	302	487	36	Tue
04-Feb-98	-6.3	22.1	22.2	24.3	19.4	4	384	299	291	463	17	Wed
05-Feb-98	-4.6	22.2	22.4	24.5	19.4	4	381	366	266	534	0	Thu
06-Feb-98	-9.1	22.2	22.0	24.5	20.0	4	289	0				Fri
10-Feb-98	2.9	24.1	24.3	25.2	20.3	6	454	340	482	765	44	Tue
11-Feb-98	1.5	22.5	22.8	23.1	19.7	9	463	148	310	388	80	Wed
12-Feb-98	0.5	22.0	22.1	22.0	19.4	12	421	67	178	341	49	Thu
13-Feb-98	-3.9	22.0	22.3	24.4	19.2	8	446	146	319	399	81	Fri
14-Feb-98	-9.9	22.1	22.1	27.1	18.8	3	235	463	562	966	0	Sat
15-Feb-98	-6.0	21.7	21.9	28.6	18.7	3	233	274	196	431	0	Sun
16-Feb-98	-2.2	22.3	22.5	25.6	19.3	5	419	260	382	501	65	Mon
17-Feb-98	0.8	22.4	22.5	23.7	19.6	10	360	37	309	350	90	Tue
18-Feb-98	0.9	22.4	22.5	22.9	19.7	12	387	60	267	364	75	Wed
19-Feb-98	1.0	22.3	22.4	23.4	19.8	14	400	94	99	267	19	Thu
20-Feb-98	0.8	22.0	22.0	22.6	19.7	13	359	122	81	246	9	Fri
21-Feb-98	-0.3	21.6	21.7	25.3	19.1	8	231	143	61	109	0	Sat
22-Feb-98	-0.1	21.6	21.7	26.2	19.0	7	229	117	49	92	0	Sun
23-Feb-98	0.4	22.6	22.8	24.8	19.6	8	392	309	348	458	72	Mon
24-Feb-98	-0.7	22.6	22.8	23.9	19.8	8	399	250	308	404	70	Tue
25-Feb-98	1.4	23.2	23.3	24.7	20.1	10	373	414	428	670	48	Wed
26-Feb-98	1.8	23.2	23.4	24.3	20.1	10	394	397	445	772	51	Thu
27-Feb-98	1.4	22.8	23.1	23.2	20.1	10	438	138	320	465	73	Fri
28-Feb-98	2.7	21.9	22.0	23.7	19.4	12	247	256	374	1152	0	Sat
Sum												
Avg	**-1.3**	**22.3**	**22.4**	**24.4**	**19.5**	**8**	**358**	**216**	**303**	**514**	**38**	
Min	**-9.9**	**21.6**	**21.7**	**22.0**	**18.7**	**3**	**229**	**0**	**49**	**92**	**0**	
Max	**2.9**	**24.1**	**24.3**	**28.6**	**20.3**	**14**	**463**	**463**	**720**	**1421**	**90**	

Indoor Comfort Conditions - Representative Office

Date	Outdoor Ambient Temp. (°C)	Avgerage Office Temp. (°C)	Office MRT (°C)	Radiant Panel Temp. (°C)	Average Ventilation Temp. (°C)	Relative Humidity (%)	Carbon Dioxide (ppm)	Average Insolation (W/m²)	Average Light Level (lux)	Maximum Light Level (lux)	Average Lighting Power (W)	Day of Week
01-Mar-98	3.8	21.6	21.6	24.5	19.1	15	235	154	126	275	0	Sun
02-Mar-98	1.0	22.4	22.5	24.2	19.5	13	413	136	337	490	80	Mon
03-Mar-98	0.8	22.2	22.2	22.7	19.6	13	377	180	201	345	29	Tue
04-Mar-98	-0.6	22.5	22.6	22.6	19.8	10	422	175	352	465	76	Wed
05-Mar-98	-0.6	22.2	22.3	23.2	19.6	10	417	173	291	433	61	Thu
06-Mar-98	-1.0	22.3	22.5	24.0	19.6	9	434	156	351	461	83	Fri
07-Mar-98	0.3	21.8	21.8	25.6	19.2	6	247	234	208	555	0	Sat
08-Mar-98	0.4	21.6	21.6	26.6	19.0	7	230	79	45	100	0	Sun
09-Mar-98	3.1	21.7	21.7	23.5	19.3	17	365	100	57	129	0	Mon
10-Mar-98	-9.6	21.6	21.5	26.0	18.7	7	353	459	545	1104	0	Tue
11-Mar-98	-11.2	21.8	22.0	27.6	18.4	3	367	514	552	1013	0	Wed
12-Mar-98	-8.9	22.3	22.3	27.0	18.8	4	372	497	507	794	45	Thu
13-Mar-98	-5.1	22.1	22.1	26.5	19.0	4	358	430	396	575	43	Fri
14-Mar-98	-2.5	21.4	21.4	27.1	18.6	3	234	282	166	287	0	Sat
15-Mar-98	-7.5	22.0	22.0	27.6	18.7	3	239	602	444	765	0	Sun
16-Mar-98	-7.9	22.5	22.7	28.1	18.6	3	402	601	673	986	30	Mon
17-Mar-98	-3.1	22.9	23.0	26.5	19.5	4	423	551	594	994	36	Tue
18-Mar-98	0.3	22.3	22.4	24.1	19.6	9	434	53	158	220	48	Wed
19-Mar-98	0.2	22.1	22.2	23.0	19.6	11	417	53	113	196	41	Thu
20-Mar-98	-1.4	21.8	21.9	23.6	19.2	9	395	159	220	345	42	Fri
21-Mar-98	-3.3	21.4	21.4	24.7	18.9	5	259	159	536	810	0	Sat
22-Mar-98	-3.3	21.4	21.5	24.1	18.8	3	231	331	1016	2381	0	Sun
23-Mar-98	-4.3	22.8	22.8	25.3	19.6	4	387	592	383	771	32	Mon
24-Mar-98	-3.3	22.9	23.2	23.8	19.6	3	375	631	384	582	29	Tue
25-Mar-98	2.4	22.9	23.1	23.6	19.8	6	408	504	478	735	29	Wed
26-Mar-98	12.4	23.8	23.5	23.6	21.5	20	383	347	343	684	27	Thu
27-Mar-98	18.0	25.5	25.1	25.2	23.2	30	258	331	307	506	35	Fri
28-Mar-98	15.6	25.2	24.9	24.9	23.1	29	232	354	1011	2238	0	Sat
29-Mar-98	14.0	24.8	24.9	25.1	22.2	27	233	518	1040	1839	0	Sun
30-Mar-98	18.7	25.9	25.7	25.5	23.9	34	256	389	975	2346	0	Mon
31-Mar-98	20.0	26.5	25.9	26.1	24.6	34	262	344	189	434	0	Tue
Sum												
Avg	**1.2**	**22.7**	**22.7**	**25.0**	**19.9**	**11**	**336**	**325**	**419**	**770**	**25**	
Min	**-11.2**	**21.4**	**21.4**	**22.6**	**18.4**	**3**	**230**	**53**	**45**	**100**	**0**	
Max	**20.0**	**26.5**	**25.9**	**28.1**	**24.6**	**34**	**434**	**631**	**1040**	**2381**	**83**	

Indoor Comfort Conditions - Total Building

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C)				Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%)		Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust CO2 (ppm)	Day of Week
		Tenant 1	Tenant 2	Tenant 3	Tenant 4				Tenant 1	Tenant 4				
20-Sep-97	13.5	21.3	21.2	21.5	21.7	21.4	16.9	20.8	45	52	66	47	376	Sat
21-Sep-97	8.8	20.0	19.6	21.1	21.6	20.5	15.2	19.7	30	38	41	35	376	Sun
22-Sep-97	12.4	21.1	21.0	21.9	22.7	21.7	17.1	20.8	33	40	47	37	482	Mon
23-Sep-97	11.3	22.2	22.2	22.2	22.5	22.3	15.2	21.1	37	43	60	40	471	Tue
24-Sep-97	8.9	21.0	21.5	22.0	22.8	21.9	15.2	20.7	29	36	43	33	477	Wed
25-Sep-97	12.0	21.7	22.4	22.5	23.2	22.6	17.7	21.6	39	44	59	40	475	Thu
26-Sep-97	9.9	22.0	22.4	22.5	22.5	22.4	13.8	21.0	34	40	55	37	462	Fri
27-Sep-97	9.3	20.8	20.8	21.8	21.7	21.2	15.5	20.3	31	39	46	35	407	Sat
28-Sep-97	14.0	21.3	21.0	21.9	21.9	21.4	18.4	21.0	40	47	57	42	402	Sun
29-Sep-97	15.7	23.1	23.2	23.2	23.2	23.2	20.6	22.8	38	46	51	41	465	Mon
30-Sep-97	12.6	22.4	22.3	22.7	21.7	22.1	13.3	21.2	40	47	73	42	460	Tue
Sum														
Avg	11.7	21.5	21.6	22.1	22.3	21.9	16.3	21.0	36	43	54	39	441	
Min	8.8	20.0	19.6	21.1	21.6	20.5	13.3	19.7	29	36	41	33	376	
Max	15.7	23.1	23.2	23.2	23.2	23.2	20.6	22.8	45	52	73	47	482	

Green on the Grand

Daily Summary

Indoor Comfort Conditions - Total Building

October 1997

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%) Tenant 1	Tenant 4	Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust. CO2 (ppm)	Day of Week
01-Oct-97	5.6	20.7	21.0	22.2	22.5	21.6	13.8	20.3	26	35	35	31	480	Wed
02-Oct-97	7.3	20.8	20.8	21.8	23.1	21.6	12.7	20.5	31	35	53	32	493	Thu
03-Oct-97	15.6	23.2	22.2	22.4	23.3	22.7	13.9	21.9	40	45	76	41	481	Fri
04-Oct-97	17.8	21.3	20.2	21.1	21.3	20.8	13.3	20.2	43	48	81	45	420	Sat
05-Oct-97	17.4	20.8	19.6	20.7	20.7	20.3	14.5	20.1	43	50	71	45	424	Sun
06-Oct-97	19.0	21.3	20.5	21.3	21.1	20.9	14.1	20.4	42	49	74	44	502	Mon
07-Oct-97	16.5	21.4	20.7	21.8	21.0	21.0	13.2	20.3	43	50	80	46	515	Tue
08-Oct-97	17.8	21.5	20.7	21.9	21.0	21.0	12.9	20.3	43	51	80	46	538	Wed
09-Oct-97	18.6	21.9	21.1	22.1	21.0	21.3	13.6	20.5	47	54	87	50	514	Thu
10-Oct-97	11.2	21.6	20.5	21.9	21.1	21.0	14.2	20.3	37	47	59	42	468	Fri
11-Oct-97	8.4	19.9	19.2	21.1	21.0	20.1	14.2	19.4	30	39	44	35	394	Sat
12-Oct-97	10.3	19.5	18.8	20.9	20.9	19.8	15.5	19.4	33	40	48	37	399	Sun
13-Oct-97	16.3	20.7	20.3	21.3	22.0	21.0	19.4	20.9	44	50	60	46	407	Mon
14-Oct-97	10.6	21.9	21.3	22.1	22.2	21.8	13.6	20.5	35	43	55	40	483	Tue
15-Oct-97	6.7	20.4	20.4	22.0	22.2	21.2	15.9	20.4	28	35	38	31	491	Wed
16-Oct-97	6.8	21.0	21.2	22.4	23.1	21.9	16.8	20.9	27	33	37	30	473	Thu
17-Oct-97	5.7	21.0	21.5	22.6	23.4	22.1	15.9	20.8	24	30	34	28	472	Fri
18-Oct-97	4.5	20.2	20.1	22.6	22.7	21.2	15.8	20.3	23	30	34	27	421	Sat
19-Oct-97	6.4	19.3	19.1	22.5	22.3	20.5	16.0	19.8	25	31	36	28	417	Sun
20-Oct-97	6.6	20.4	20.4	22.6	22.7	21.4	13.7	20.5	24	29	78	27	465	Mon
21-Oct-97	3.9	21.3	21.3	22.8	22.9	22.0	11.9	20.9	19	26	102	22	462	Tue
22-Oct-97	-0.3	20.5	20.7	21.9	22.7	21.5	12.8	20.5	16	24	99	20	455	Wed
23-Oct-97	1.4	21.5	21.1	21.7	22.9	21.8	12.8	21.0	14	23	95	18	483	Thu
24-Oct-97	5.4	22.3	21.3	21.7	23.6	22.3	12.9	21.4	18	26	106	21	487	Fri
25-Oct-97	3.7	22.0	20.7	21.2	22.7	21.6	12.8	21.1	16	24	103	19	405	Sat
26-Oct-97	-0.4	21.3	19.8	20.4	22.1	20.9	12.7	20.6	14	23	100	17	403	Sun
27-Oct-97	0.5	21.8	20.7	21.4	23.0	21.7	12.9	21.3	14	23	101	18	488	Mon
28-Oct-97	2.5	22.3	21.8	23.1	23.3	22.5	12.9	21.9	13	22	101	17	481	Tue
29-Oct-97	6.2	22.4	22.0	23.3	23.7	22.7	12.9	21.9	18	25	107	21	482	Wed
30-Oct-97	5.2	22.5	21.9	23.5	24.2	22.9	13.1	21.5	16	25	105	20	490	Thu
31-Oct-97	9.4	22.3	21.9	23.6	24.0	22.9	13.5	22.0	28	32	107	29	483	Fri
Sum														
Avg	**8.6**	**21.3**	**20.7**	**22.0**	**22.4**	**21.5**	**14.0**	**20.7**	**28**	**35**	**74**	**31**	**464**	
Min	**-0.4**	**19.3**	**18.8**	**20.4**	**20.7**	**19.8**	**11.9**	**19.4**	**13**	**22**	**34**	**17**	**394**	
Max	**19.0**	**23.2**	**22.2**	**23.6**	**24.2**	**22.9**	**19.4**	**22.0**	**47**	**54**	**107**	**50**	**538**	

Indoor Comfort Conditions - Total Building

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%) Tenant 1	Tenant 4	Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust. CO2 (ppm)	Day of Week
01-Nov-97	9.8	21.8	21.5	23.0	23.4	22.3	12.9	21.6	37	39		36	405	Sat
02-Nov-97	7.5	21.4	20.9	22.3	22.5	21.7	12.9	21.3	32	36		33	388	Sun
03-Nov-97	3.6	21.6	21.1	22.4	22.6	21.8	12.9	21.2	21	28	105	24	476	Mon
04-Nov-97	2.3	21.8	21.3	22.0	23.1	22.0	12.9	21.2	17	24	101	20	485	Tue
05-Nov-97	4.5	22.0	21.3	21.9	23.4	22.2	12.8	21.3	20	26	108	23	481	Wed
06-Nov-97	5.6	22.1	21.6	22.2	23.6	22.4	12.9	21.5	21	26	108	23	488	Thu
07-Nov-97	5.8	21.9	21.5	22.8	23.7	22.4	12.9	21.6	20	26	107	23	477	Fri
08-Nov-97	6.0	21.7	21.0	21.9	22.9	21.8	12.9	21.3	17	24	102	20	393	Sat
09-Nov-97	3.7	21.4	20.8	21.3	22.4	21.5	12.8	20.9	16	24	99	20	385	Sun
10-Nov-97	3.1	21.6	21.2	21.6	22.8	21.8	12.8	21.1	16	24	96	20	463	Mon
11-Nov-97	-0.6	21.6	21.3	22.4	22.9	22.0	12.8	21.3	11	21	83	16	473	Tue
12-Nov-97	-2.3	21.7	21.5	21.9	23.0	22.0	12.7	21.2	12	20	88	15	478	Wed
13-Nov-97	-2.1	21.5	21.3	21.6	22.9	21.9	12.6	21.0	10	19	82	14	477	Thu
14-Nov-97	-3.6	21.5	21.3	21.4	22.6	21.8	13.0	21.0	10	19	78	14	450	Fri
15-Nov-97	-3.5	21.5	20.5	21.6	21.9	21.3	13.5	21.1	10	20	76	13	385	Sat
16-Nov-97	-4.1	21.4	20.6	21.8	21.4	21.1	13.5	21.0	8	18	70	12	384	Sun
17-Nov-97	-2.4	21.6	21.0	22.1	22.1	21.6	13.5	21.1	11	20	80	14	484	Mon
18-Nov-97	-1.6	21.7	21.2	21.9	22.9	21.9	13.6	21.2	10	19	80	14	493	Tue
19-Nov-97	-0.1	21.6	21.1	21.8	23.3	22.0	13.5	21.2	12	19	83	15	484	Wed
20-Nov-97	0.4	21.6	21.1	21.6	23.3	22.0	13.7	21.2	12	20	88	15	472	Thu
26-Nov-97	4.7	21.8	22.1	21.7	23.5	22.5	13.7	21.5	19	25	97	21	489	Wed
27-Nov-97	2.4	21.9	22.0	22.1	23.5	22.5	13.7	21.6	14	21	85	17	484	Thu
28-Nov-97	5.0	22.1	22.0	22.4	23.5	22.6	13.7	21.6	18	25	91	21	485	Fri
29-Nov-97	1.0	21.8	21.4	22.3	22.9	22.0	13.5	21.4	13	22	81	17	425	Sat
30-Nov-97	2.3	21.8	20.9	21.7	22.6	21.7	13.6	21.1	13	22	80	17	405	Sun
Sum														
Avg	**1.9**	**21.7**	**21.3**	**22.0**	**22.9**	**21.9**	**13.2**	**21.3**	**16**	**24**	**90**	**19**	**452**	
Min	**-4.1**	**21.4**	**20.5**	**21.3**	**21.4**	**21.1**	**12.6**	**20.9**	**8**	**18**	**70**	**12**	**384**	
Max	**9.8**	**22.1**	**22.1**	**23.0**	**23.7**	**22.6**	**13.7**	**21.6**	**37**	**39**	**108**	**36**	**493**	

Green on the Grand

Daily Summary

Indoor Comfort Conditions - Total Building

December 1997

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%) Tenant 1	Tenant 4	Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust CO2 (ppm)	Day of Week
01-Dec-97	-1.0	21.8	21.6	21.9	23.0	22.1	13.7	21.2	10	18	65	14	474	Mon
02-Dec-97	-1.5	22.1	21.9	21.9	23.5	22.4	13.6	21.2	8	17	68	13	477	Tue
03-Dec-97	-1.9	21.7	21.5	22.4	23.3	22.2	13.9	21.2	11	19	74	14	505	Wed
04-Dec-97	1.4	21.8	21.5	22.1	23.2	22.2	13.6	21.1	13	20	78	16	487	Thu
05-Dec-97	-0.8	21.7	21.3	21.6	23.3	22.0	13.7	21.0	11	19	70	14	468	Fri
06-Dec-97	-1.4	21.3	20.5	20.6	22.6	21.3	13.8	20.6	9	18	67	13	395	Sat
07-Dec-97	0.1	21.3	20.6	19.6	22.4	21.2	13.7	20.4	9	18	73	13	396	Sun
08-Dec-97	-0.3	21.7	21.3	20.1	22.9	21.8	13.7	20.7	10	18	68	13	478	Mon
09-Dec-97	-0.7	21.8	21.3	21.3	23.0	22.0	13.8	21.0	9	17	68	13	481	Tue
10-Dec-97	-2.7	21.7	21.3	21.7	23.0	22.0	13.6	20.9	9	18	65	13	480	Wed
11-Dec-97	-4.5	21.8	21.5	21.7	23.0	22.1	13.7	21.0	9	18	42	13	475	Thu
12-Dec-97	-3.6	22.1	21.8	21.7	23.1	22.3	13.9	21.1	10	18	22	13	472	Fri
13-Dec-97	-2.1	21.8	20.2	21.1	22.5	21.3	13.7	20.6	7	18	23	12	401	Sat
14-Dec-97	-3.6	21.8	19.9	21.0	22.4	21.1	13.6	20.5	5	15	23	11	396	Sun
15-Dec-97	0.5	22.1	21.0	21.8	23.0	21.9	13.9	21.0	8	17	22	12	488	Mon
16-Dec-97	2.6	22.2	21.7	22.2	23.3	22.3	13.8	21.3	9	18	21	13	498	Tue
17-Dec-97	0.0	22.2	21.7	22.4	23.6	22.5	13.8	21.5	10	18	21	14	496	Wed
18-Dec-97	-1.3	22.2	21.6	22.2	23.3	22.3	13.6	21.4	9	17	21	13	506	Thu
19-Dec-97	1.7	22.2	21.7	21.9	23.2	22.3	13.7	21.4	12	19	20	15	485	Fri
20-Dec-97	-0.9	22.0	20.5	21.3	22.7	21.5	13.6	21.0	8	18	21	13	399	Sat
21-Dec-97	-5.6	21.9	19.8	20.9	22.5	21.2	13.6	20.8	4	14	23	10	396	Sun
22-Dec-97	-3.9	21.9	20.8	21.3	22.7	21.7	13.7	21.1	6	14	22	11	463	Mon
23-Dec-97	-0.2	22.2	21.6	21.8	23.0	22.2	13.7	21.4	10	18	21	13	479	Tue
24-Dec-97	-0.1	21.8	21.3	21.3	23.0	21.9	13.8	21.1	8	17	22	12	426	Wed
25-Dec-97	0.6	21.2	20.5	20.2	22.3	21.2	13.6	20.6	9	18	21	13	392	Thu
26-Dec-97	-0.9	21.1	20.3	20.1	22.0	21.0	13.6	20.5	8	17	22	12	397	Fri
27-Dec-97	-3.0	21.1	20.2	20.0	22.0	20.9	13.6	20.6	6	16	22	11	389	Sat
28-Dec-97	-7.0	19.9	19.1	19.7	21.3	20.0	11.5	19.3	4	14	23	11	400	Sun
29-Dec-97	-1.8	18.0	18.2	19.7	20.4	19.1	13.1	18.7	8	17	22	12	481	Mon
30-Dec-97	-5.5	20.9	21.3	21.4	22.1	21.5	11.9	20.5	6	15	23	11	455	Tue
31-Dec-97	-13.0	20.4	21.3	20.8	22.3	21.5	1.6	18.6	3	13	28		431	Wed
Sum														
Avg	**-1.9**	**21.5**	**20.9**	**21.2**	**22.7**	**21.7**	**13.2**	**20.7**	**8**	**17**	**38**	**13**	**450**	
Min	**-13.0**	**18.0**	**18.2**	**19.6**	**20.4**	**19.1**	**1.6**	**18.6**	**3**	**13**	**20**	**10**	**389**	
Max	**2.6**	**22.2**	**21.9**	**22.4**	**23.6**	**22.5**	**13.9**	**21.5**	**13**	**20**	**78**	**16**	**506**	

Indoor Comfort Conditions - Total Building

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C)				Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%)		Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust CO2 (ppm)	Day of Week
		Tenant 1	Tenant 2	Tenant 3	Tenant 4				Tenant 1	Tenant 4				
01-Jan-98	-4.7	20.6	20.7	20.7	22.6	21.3	11.0	20.1	3	13	23		394	Thu
02-Jan-98	2.4	20.9	21.3	21.6	23.0	21.8	14.8	21.3	7	16	21	12	451	Fri
03-Jan-98	6.3	20.7	21.2	20.6	22.8	21.6	14.9	21.0	15	21	19	18	401	Sat
04-Jan-98	-0.8	20.7	21.1	19.8	22.8	21.5	14.4	20.8	13	21	18	17	395	Sun
05-Jan-98	2.6	20.9	21.7	20.3	23.2	21.9	13.0	20.8	15	22	19	19	514	Mon
06-Jan-98	8.6	22.1	22.3	21.5	23.5	22.6	11.9	21.0	29	33	46	32	500	Tue
07-Jan-98	4.5	22.8	22.1	21.4	23.3	22.5	11.8	20.9	24	29	29	28	485	Wed
08-Jan-98	0.7	22.5	21.6	21.7	23.1	22.3	11.8	20.8	16	23	16	21	481	Thu
09-Jan-98	-0.1	22.1	21.5	22.0	23.0	22.1	11.8	20.9	14	21	11	17	482	Fri
10-Jan-98	-2.8	22.0	20.9	21.9	22.8	21.8	12.6	20.9	8	18	11	13	410	Sat
11-Jan-98	-8.3	21.7	20.7	21.9	22.8	21.7	11.7	20.7	4	16		10	399	Sun
12-Jan-98	-5.8	22.1	21.3	22.3	23.4	22.2	11.1	20.7	6	15	12	12	560	Mon
13-Jan-98	-6.9	22.3	21.5	22.3	23.3	22.3	11.9	21.0	8	17	13	12	517	Tue
14-Jan-98	-9.4	22.2	21.0	22.2	23.3	22.1	11.2	20.7	7	15		11	525	Wed
15-Jan-98	-8.6	22.6	21.5	22.3	23.2	22.3	12.2	20.9	8	16		11	506	Thu
16-Jan-98	-8.5	22.3	21.4	22.2	23.2	22.2	12.2	20.9	8	16		11	511	Fri
17-Jan-98	-6.2	21.2	20.3	21.6	22.3	21.2	12.3	20.5	5	14		10	414	Sat
18-Jan-98	-3.9	21.0	19.9	21.3	21.6	20.8	12.3	20.4	3	14			407	Sun
19-Jan-98	-3.5	21.9	20.9	21.6	21.9	21.4	12.3	20.7	5	15		11	509	Mon
20-Jan-98	-5.5	23.0	21.4	21.5	22.3	22.0	12.3	20.7	5	16		11	512	Tue
21-Jan-98	-5.0	22.5	21.3	21.5	22.2	21.8	12.2	20.6	5	15		10	502	Wed
22-Jan-98	-7.6	22.7	21.8	22.0	22.0	22.0	12.2	20.7	6	15		11	502	Thu
23-Jan-98	-2.9	22.7	21.3	22.1	21.7	21.8	12.3	20.7	8	17	12	14	500	Fri
24-Jan-98	-2.8	22.5	20.5	21.5	20.6	21.0	12.4	20.3	4	16		11	405	Sat
25-Jan-98	-3.8	22.5	20.4	21.1	20.0	20.7	12.3	20.2	3	14			396	Sun
26-Jan-98	-6.7	22.7	21.7	21.7	20.8	21.6	12.2	20.6	5	15		10	514	Mon
27-Jan-98	-3.6	22.5	22.1	22.1	21.7	22.1	12.3	20.9	7	17		13	532	Tue
28-Jan-98	-3.1	22.7	22.1	22.4	22.2	22.3	12.2	21.0	8	18		12	545	Wed
29-Jan-98	-0.8	22.6	22.1	22.5	22.4	22.3	12.3	21.0	10	19	11	14	536	Thu
30-Jan-98	-1.6	22.6	22.0	22.5	22.5	22.3	12.2	21.0	10	18	10	14	516	Fri
31-Jan-98	-2.2	21.7	21.5	22.3	21.7	21.7	12.3	20.8	4	15		10	413	Sat
Sum														
Avg	**-2.9**	**22.0**	**21.3**	**21.7**	**22.4**	**21.8**	**12.3**	**20.8**	**9**	**18**	**18**	**14**	**475**	
Min	**-9.4**	**20.6**	**19.9**	**19.8**	**20.0**	**20.7**	**11.0**	**20.1**	**3**	**13**	**10**	**10**	**394**	
Max	**8.6**	**23.0**	**22.3**	**22.5**	**23.5**	**22.6**	**14.9**	**21.3**	**29**	**33**	**46**	**32**	**560**	

Indoor Comfort Conditions - Total Building

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%) Tenant 1	Tenant 4	Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust CO2 (ppm)	Day of Week
01-Feb-98	-1.4	21.7	21.7	21.9	21.5	21.7	12.2	20.7	3	14			404	Sun
02-Feb-98	0.9	22.3	22.4	22.4	22.3	22.3	12.2	21.1	8	17		14	533	Mon
03-Feb-98	-4.2	22.6	22.4	22.4	22.6	22.5	12.2	21.0	7	16		11	519	Tue
04-Feb-98	-6.3	22.3	22.1	22.0	22.7	22.3	12.2	20.8	4	14		10	512	Wed
05-Feb-98	-4.6	22.3	21.7	22.5	22.8	22.3	12.2	20.9	4	14			506	Thu
06-Feb-98	-9.1	22.0	21.5	21.4	22.8	22.0	11.2	20.5	4	14			420	Fri
10-Feb-98	2.9	23.8	23.1	22.8	24.1	23.5	11.5	21.2	6	16		12	586	Tue
11-Feb-98	1.5	23.0	22.3	22.0	23.2	22.7	11.1	20.8	9	18	12	13	533	Wed
12-Feb-98	0.5	22.7	22.0	21.7	23.2	22.5	11.1	20.7	12	20	12	15	499	Thu
13-Feb-98	-3.9	22.5	21.7	21.0	22.6	22.1	11.1	20.4	8	16		11	507	Fri
14-Feb-98	-9.9	21.8	20.6	20.8	21.9	21.3	10.8	20.1	3	13			397	Sat
15-Feb-98	-6.0	21.3	19.8	20.5	21.8	20.8	10.8	19.9	3	13			388	Sun
16-Feb-98	-2.2	22.2	21.3	21.1	22.7	21.9	11.7	20.6	5	14		10	531	Mon
17-Feb-98	0.8	22.6	22.0	21.1	23.1	22.4	12.2	20.9	10	19	11	14	514	Tue
18-Feb-98	0.9	23.0	22.0	21.0	23.1	22.4	12.2	20.9	12	20	12	16	506	Wed
19-Feb-98	1.0	23.2	22.5	21.7	23.2	22.8	12.2	21.2	14	21	11	17	523	Thu
20-Feb-98	0.8	23.0	22.6	22.3	23.1	22.8	12.2	21.2	13	21	11	17	502	Fri
21-Feb-98	-0.3	22.1	21.7	21.3	21.9	21.8	12.3	20.6	8	18		13	406	Sat
22-Feb-98	-0.1	22.0	21.4	20.1	21.5	21.4	12.3	20.3	7	17		11	402	Sun
23-Feb-98	0.4	22.9	22.4	20.9	22.4	22.4	12.3	20.9	8	18		13	512	Mon
24-Feb-98	-0.7	23.2	22.3	22.2	22.7	22.6	12.3	21.1	8	17		12	517	Tue
25-Feb-98	1.4	23.3	22.4	23.0	23.1	22.9	12.2	21.2	10	19	11	15	517	Wed
26-Feb-98	1.8	23.4	22.4	23.2	23.3	23.0	12.3	21.2	10	19		14	515	Thu
27-Feb-98	1.4	23.6	22.0	22.9	23.3	22.8	12.2	21.1	10	18		13	513	Fri
28-Feb-98	2.7	22.3	21.3	21.5	22.4	21.9	12.3	20.6	12	21	22	16	424	Sat
Sum														
Avg	**-1.3**	**22.6**	**21.9**	**21.7**	**22.7**	**22.3**	**11.9**	**20.8**	**8**	**17**	**13**	**13**	**487**	
Min	**-9.9**	**21.3**	**19.8**	**20.1**	**21.5**	**20.8**	**10.8**	**19.9**	**3**	**13**	**11**	**10**	**388**	
Max	**2.9**	**23.8**	**23.1**	**23.2**	**24.1**	**23.5**	**12.3**	**21.2**	**14**	**21**	**22**	**17**	**586**	

Indoor Comfort Conditions - Total Building

Date	Outdoor Ambient Temp. (°C)	Tenant Suite Temperatures (°C) Tenant 1	Tenant 2	Tenant 3	Tenant 4	Avgerage Building Temp. (°C)	Avg. Vent. Supply Temp. (°C)	Avg. Vent. Exhaust Temp. (°C)	Tenant Suite RH (%) Tenant 1	Tenant 4	Average Supply RH (%)	Average Exhaust RH (%)	Average Exhaust. CO2 (ppm)	Day of Week
01-Mar-98	3.8	22.0	21.0	20.4	21.6	21.3	12.3	20.2	15	24	17	20	411	Sun
02-Mar-98	1.0	22.8	21.6	20.9	22.2	22.0	12.2	20.6	13	22	12	18	519	Mon
03-Mar-98	0.8	23.1	21.9	22.1	22.7	22.4	12.2	21.0	13	22	12	17	521	Tue
04-Mar-98	-0.6	23.1	21.9	21.6	22.6	22.3	12.2	20.8	10	19	10	15	514	Wed
05-Mar-98	-0.6	22.8	22.0	21.5	22.7	22.3	12.2	20.8	10	18		14	506	Thu
06-Mar-98	-1.0	22.7	22.2	22.2	22.8	22.5	12.2	20.9	9	17		12	504	Fri
07-Mar-98	0.3	21.9	21.7	21.8	21.8	21.8	12.3	20.6	6	16		11	417	Sat
08-Mar-98	0.4	21.4	21.4	21.2	21.7	21.5	12.3	20.4	7	17	12	12	406	Sun
09-Mar-98	3.1	22.2	22.0	21.9	22.5	22.2	12.3	20.9	17	25	21	20	503	Mon
10-Mar-98	-9.6	20.5	21.7	21.5	22.6	21.7	11.9	20.5	7	17		12	501	Tue
11-Mar-98	-11.2	20.6	21.5	21.5	22.5	21.7	10.3	20.1	3	14		10	508	Wed
12-Mar-98	-8.9	20.7	22.5	22.5	22.7	22.2	11.2	20.6	4	14			510	Thu
13-Mar-98	-5.1	20.4	22.4	22.1	22.5	22.1	12.2	20.6	4	14			491	Fri
14-Mar-98	-2.5	20.1	21.0	22.1	21.6	21.1	12.2	20.4	3	14			400	Sat
15-Mar-98	-7.5	20.4	20.8	21.7	22.0	21.2	11.9	20.3	3	13			399	Sun
16-Mar-98	-7.9	20.9	21.8	22.3	22.8	22.0	9.4	20.2	3	13			500	Mon
17-Mar-98	-3.1	21.4	22.9	22.9	22.8	22.6	11.6	20.9	4	13			507	Tue
18-Mar-98	0.3	22.0	21.6	23.0	22.8	22.2	12.3	21.1	9	18	12	13	509	Wed
19-Mar-98	0.2	22.5	21.5	22.9	22.7	22.2	12.3	21.1	11	19	12	15	513	Thu
20-Mar-98	-1.4	22.0	21.5	22.9	22.5	22.0	12.2	21.0	9	19	11	13	495	Fri
21-Mar-98	-3.3	21.7	20.7	22.0	21.6	21.3	12.3	20.5	5	14		10	398	Sat
22-Mar-98	-3.3	21.6	20.4	21.6	21.5	21.1	12.2	20.5	3	13			395	Sun
23-Mar-98	-4.3	22.6	21.7	22.4	22.7	22.2	12.2	20.9	4	13			508	Mon
24-Mar-98	-3.3	23.3	22.1	22.2	23.0	22.6	10.9	20.7	3	13			516	Tue
25-Mar-98	2.4	22.8	22.1	22.1	23.1	22.5	10.6	20.5	6	15	10	12	534	Wed
26-Mar-98	12.4	23.5	22.9	23.0	23.7	23.3	15.9	21.9	20	29	26	23	499	Thu
27-Mar-98	18.0	25.1	23.4	24.0	24.4	24.1	19.0	23.4	30	39	33	34	429	Fri
28-Mar-98	15.6	24.4	24.0	23.5	24.4	24.1	17.3	22.9	29	38	37	34	398	Sat
29-Mar-98	14.0	24.1	23.6	22.9	23.9	23.7	15.4	21.9	27	36	40	34	390	Sun
30-Mar-98	18.7	25.1	24.7	24.1	24.8	24.7	19.6	23.5	34	43	40	40	421	Mon
31-Mar-98	20.0	25.8	25.4	25.0	25.3	25.4	20.8	24.4	34	43	33	39	424	Tue
Sum														
Avg	**1.2**	**22.4**	**22.1**	**22.3**	**22.8**	**22.4**	**13.0**	**21.1**	**11**	**21**	**21**	**20**	**469**	
Min	**-11.2**	**20.1**	**20.4**	**20.4**	**21.5**	**21.1**	**9.4**	**20.1**	**3**	**13**	**10**	**10**	**390**	
Max	**20.0**	**25.8**	**25.4**	**25.0**	**25.3**	**25.4**	**20.8**	**24.4**	**34**	**43**	**40**	**40**	**534**	

Green on the Grand
Daily Summary

Air Handling Unit Performance

October 1997

Date	Fresh Air Temp (°C)	Fresh Air RH (%)	Supply Air Temp (°C)	Return Air Temp (°C)	Return Air RH (%)	Clg/Htg Mode	ERV Sensible Effect (kWh)	Htg/Clg Coil Effect (kWh) Senible	Latent	Total	HRV (kWh)	Energy Consumed Elec	Total	Day of Week
01-Oct-97	6.7	47	13.8	20.3	31	C	-0.4	0.0	0.0	0.0	285.3	79.9	79.9	Wed
02-Oct-97	8.0	68	12.7	20.5	32	C/H	-0.3	0.0	0.0	0.0	175.0	79.0	79.0	Thu
03-Oct-97	15.5	65	13.9	21.9	41	C/H	-2.2	-234.9	0.7	-234.2	-176.8	76.9	314.4	Fri
04-Oct-97	17.2	78	13.3	20.2	45	C	-61.6	-393.8	0.0	-393.8	-323.4	69.1	462.8	Sat
05-Oct-97	17.2	56	14.5	20.1	45	C	-65.9	-249.4	-0.9	-250.3	-201.3	69.0	321.4	Sun
06-Oct-97	18.8	51	14.1	20.4	44	C	-49.8	-383.7	0.8	-382.9	-249.4	77.3	461.1	Mon
07-Oct-97	16.2	67	13.2	20.3	46	C	-4.0	-400.9	-0.8	-401.7	-291.8	79.6	484.5	Tue
08-Oct-97	17.5	63	12.9	20.3	46	C	-30.8	-430.4	0.0	-430.4	-392.1	77.3	507.7	Wed
09-Oct-97	18.6	73	13.6	20.5	50	C	-19.6	-541.8	-0.7	-542.5	-499.7	77.5	622.5	Thu
10-Oct-97	12.0	50	14.2	20.3	42	C	1.9	-49.9	0.3	-49.6	93.1	79.3	132.9	Fri
11-Oct-97	8.9	53	14.2	19.4	35	C	2.2	-6.5	0.2	-6.4	170.0	70.3	87.4	Sat
12-Oct-97	10.8	56	15.5	19.4	37	C	1.8	21.4	5.0	26.4	152.2	69.0	96.0	Sun
13-Oct-97	16.5	60	19.4	20.9	46	C	-0.2	5.5	7.1	12.6	102.4	76.1	100.6	Mon
14-Oct-97	11.2	46	13.6	20.5	40	C	2.4	-14.5	-0.9	-15.4	106.4	77.8	95.0	Tue
15-Oct-97	7.6	41	15.9	20.4	31	C	168.2	-1.9	1.6	-0.3	273.3	78.2	78.8	Wed
16-Oct-97	7.4	41	16.8	20.9	30	C	294.5	-2.7	0.7	-2.0	255.4	79.2	81.5	Thu
17-Oct-97	6.2	43	15.9	20.8	28	C	214.1	-4.5	4.9	0.4	293.2	80.3	81.1	Fri
18-Oct-97	5.4	54	15.8	20.3	27	C	246.0	-3.1	2.3	-0.8	280.4	68.2	69.3	Sat
19-Oct-97	6.8	55	16.0	19.8	28	C	216.1	-2.0	0.7	-1.3	257.0	67.9	69.8	Sun
20-Oct-97	7.3	48	13.7	20.5	27	C/H	187.8	-0.7	0.5	-0.2	677.3	77.9	79.1	Mon
21-Oct-97	4.8	52	11.9	20.9	22	H	259.0	0.0	0.0	0.0	56.2	79.2	79.2	Tue
22-Oct-97	0.9	52	12.8	20.5	20	H	436.6	6.8	0.0	6.8	95.2	79.6	86.3	Wed
23-Oct-97	2.7	48	12.8	21.0	18	H	410.3	0.0	0.0	0.0	39.7	77.6	77.6	Thu
24-Oct-97	5.9	54	12.9	21.4	21	H	258.1	0.0	0.0	0.0	52.2	78.4	78.4	Fri
25-Oct-97	5.0	45	12.8	21.1	19	H	285.4	0.0	0.0	0.0	46.1	70.3	70.3	Sat
26-Oct-97	0.9	60	12.7	20.6	17	H	403.1	2.7	0.0	2.7	99.3	69.2	71.9	Sun
27-Oct-97	1.7	66	12.9	21.3	18	H	459.4	0.0	0.0	0.0	37.9	77.0	77.0	Mon
28-Oct-97	3.7	46	12.9	21.9	17	H	360.9	0.0	0.0	0.0	47.0	78.9	78.9	Tue
29-Oct-97	7.2	46	12.9	21.9	21	H	187.4	0.0	0.0	0.0	60.7	79.3	79.3	Wed
30-Oct-97	6.1	45	13.1	21.5	20	H	237.6	0.0	0.0	0.0	59.8	75.3	75.3	Thu
31-Oct-97	9.9	63	13.5	22.0	29	H	81.2	0.0	0.0	0.0	67.8	78.5	78.5	Fri
Sum							4,479.2	-2,684.2	21.3	2,662.9	1,648.2	2,353.1	5,157.9	
Avg	9.2	55	14.0	20.7	31		144.5	-86.6	0.7	-85.9	53.2	75.9	166.4	
Min	0.9	41	11.9	19.4	17		-65.9	-541.8	-0.9	-542.5	-499.7	67.9	69.3	
Max	18.8	78	19.4	22.0	50		459.4	21.4	7.1	26.4	677.3	80.3	622.5	

Air Handling Unit Performance

Date	Fresh Air Temp (°C)	Fresh Air RH (%)	Supply Air Temp (°C)	Return Air Temp (°C)	Return Air RH (%)	Clg/Htg Mode	ERV Sensible Effect (kWh)	Htg/Clg Coil Effect (kWh) Sensible	Latent	Total	HRV (kWh)	Energy Consumed Elec	Energy Consumed Total	Day of Week
01-Nov-97	10.4	78	12.9	21.6	36	H	36.3	0.0	0.0	0.0	67.0	68.5	68.5	Sat
02-Nov-97	8.6	64	12.9	21.3	33	H	129.9	0.0	0.0	0.0	60.3	68.1	68.1	Sun
03-Nov-97	4.7	58	12.9	21.2	24	H	314.4	0.0	0.0	0.0	49.7	76.6	76.6	Mon
04-Nov-97	3.3	61	12.9	21.2	20	H	382.1	0.0	0.0	0.0	43.3	77.7	77.7	Tue
05-Nov-97	5.2	66	12.8	21.3	23	H	288.5	0.0	0.0	0.0	50.6	77.8	77.8	Wed
06-Nov-97	6.3	57	12.9	21.5	23	H	232.8	0.0	0.0	0.0	57.8	78.8	78.8	Thu
07-Nov-97	6.8	52	12.9	21.6	23	H	210.1	0.0	0.0	0.0	59.8	79.3	79.3	Fri
08-Nov-97	7.3	39	12.9	21.3	20	H	173.3	0.0	0.0	0.0	55.4	73.5	73.5	Sat
09-Nov-97	4.8	53	12.8	20.9	20	H	291.5	0.0	0.0	0.0	45.4	69.1	69.1	Sun
10-Nov-97	4.0	56	12.8	21.1	20	H	341.4	0.0	0.0	0.0	46.2	77.5	77.5	Mon
11-Nov-97	0.5	43	12.8	21.3	16	H	429.8	7.0	0.0	7.0	120.1	77.7	84.7	Tue
12-Nov-97	-0.9	54	12.7	21.2	15	H	540.5	5.4	0.0	5.4	68.9	77.5	82.9	Wed
13-Nov-97	-1.2	45	12.6	21.0	14	H	402.7	39.8	0.0	39.8	210.9	78.4	118.2	Thu
14-Nov-97	-2.1	56	13.0	21.0	14	H	339.7	43.1	0.0	43.1	339.9	78.9	122.0	Fri
15-Nov-97	-1.9	52	13.5	21.1	13	H	358.2	31.2	0.0	31.2	298.4	68.6	99.7	Sat
16-Nov-97	-2.7	49	13.5	21.0	12	H	307.7	49.6	0.0	49.6	377.6	70.8	120.5	Sun
17-Nov-97	-1.1	50	13.5	21.1	14	H	409.9	19.8	0.0	19.8	241.2	76.8	96.6	Mon
18-Nov-97	-0.3	46	13.6	21.2	14	H	414.5	28.2	0.0	28.2	202.4	77.0	105.2	Tue
19-Nov-97	1.1	51	13.5	21.2	15	H	518.9	0.5	0.0	0.5	35.6	81.7	82.1	Wed
20-Nov-97	1.3	54	13.7	21.2	15	H	385.8	12.9	0.0	12.9	163.3	78.3	91.1	Thu
26-Nov-97	5.8	55	13.7	21.5	21	H	265.1	0.0	0.0	0.0	69.8	76.4	76.4	Wed
27-Nov-97	3.4	49	13.7	21.6	17	H	369.0	0.0	0.0	0.0	67.7	76.6	76.6	Thu
28-Nov-97	6.2	57	13.7	21.6	21	H	240.3	0.0	0.0	0.0	75.8	76.9	76.9	Fri
29-Nov-97	2.3	56	13.5	21.4	17	H	397.2	0.0	0.0	0.0	60.8	68.2	68.2	Sat
30-Nov-97	3.6	56	13.6	21.1	17	H	346.3	0.0	0.0	0.0	62.4	68.5	68.5	Sun
Sum							**8,125.9**	**237.4**	**0.0**	**237.4**	**2,930.2**	**1,879.1**	**2,116.6**	
Avg	**3.0**	**54**	**13.2**	**21.3**	**19**		**325.0**	**9.5**	**0.0**	**9.5**	**117.2**	**75.2**	**84.7**	
Min	**-2.7**	**39**	**12.6**	**20.9**	**12**		**36.3**	**0.0**	**0.0**	**0.0**	**35.6**	**68.1**	**68.1**	
Max	**10.4**	**78**	**13.7**	**21.6**	**36**		**540.5**	**49.6**	**0.0**	**49.6**	**377.6**	**81.7**	**122.0**	

Air Handling Unit Performance

Date	Fresh Air Temp (°C)	Fresh Air RH (%)	Supply Air Temp (°C)	Return Air Temp (°C)	Return Air RH (%)	Clg/Htg Mode	ERV Sensible Effect (kWh)	Htg/Clg Coil Effect (kWh) Senible	Latent	Total	HRV (kWh)	Energy Consumed Elec	Total	Day of Week
01-Dec-97	0.4	36	13.7	21.2	14	H	523.3	0.0	0.0	0.0	53.3	75.9	75.9	Mon
02-Dec-97	-0.4	41	13.6	21.2	13	H	545.6	0.0	0.0	0.0	54.7	76.1	76.1	Tue
03-Dec-97	-1.1	62	13.9	21.2	14	H	463.8	14.2	0.0	14.2	172.0	76.3	90.5	Wed
04-Dec-97	2.5	57	13.6	21.1	16	H	417.2	0.0	0.0	0.0	55.9	75.8	75.8	Thu
05-Dec-97	0.4	49	13.7	21.0	14	H	521.5	0.0	0.0	0.0	49.4	75.5	75.5	Fri
06-Dec-97	0.1	56	13.8	20.6	13	H	514.9	0.0	0.0	0.0	43.5	67.4	67.4	Sat
07-Dec-97	1.1	55	13.7	20.4	13	H	471.5	0.0	0.0	0.0	43.9	67.6	67.6	Sun
08-Dec-97	0.6	43	13.7	20.7	13	H	514.7	0.0	0.0	0.0	46.9	76.2	76.2	Mon
09-Dec-97	0.1	46	13.8	21.0	13	H	537.4	0.0	0.0	0.0	47.7	76.1	76.1	Tue
10-Dec-97	-1.6	49	13.6	20.9	13	H	601.9	0.0	0.0	0.0	50.9	76.1	76.1	Wed
11-Dec-97	-3.0	43	13.8	21.0	13	H	461.9	17.0	0.0	17.0	246.1	73.2	90.2	Thu
12-Dec-97	-2.1	47	13.9	21.1	13	H	509.5	11.6	0.0	11.6	175.1	77.6	89.2	Fri
13-Dec-97	-0.5	52	13.7	20.6	12	H	537.8	0.0	0.0	0.0	42.0	67.3	67.3	Sat
14-Dec-97	-2.1	38	13.6	20.5	11	H	496.7	25.0	0.0	25.0	158.0	67.9	92.9	Sun
15-Dec-97	1.6	37	13.9	21.0	12	H	442.8	1.1	0.0	1.1	82.4	78.5	79.5	Mon
16-Dec-97	3.8	36	13.8	21.3	13	H	354.3	0.1	0.0	0.1	69.8	75.2	75.3	Tue
17-Dec-97	0.9	53	13.8	21.5	14	H	498.0	0.8	0.0	0.8	58.8	75.8	76.7	Wed
18-Dec-97	0.1	54	13.6	21.4	13	H	450.2	6.1	0.0	6.1	118.7	78.0	84.1	Thu
19-Dec-97	2.6	56	13.7	21.4	15	H	417.0	0.0	0.0	0.0	56.2	77.4	77.4	Fri
20-Dec-97	0.2	49	13.6	21.0	13	H	508.4	0.0	0.0	0.0	46.3	68.7	68.7	Sat
21-Dec-97	-4.2	39	13.6	20.8	10	H	488.4	28.3	0.0	28.3	247.8	69.3	97.6	Sun
22-Dec-97	-3.0	50	13.7	21.1	11	H	528.8	14.6	0.0	14.6	182.2	76.6	91.1	Mon
23-Dec-97	0.6	63	13.7	21.4	13	H	503.1	0.0	0.0	0.0	53.3	76.3	76.3	Tue
24-Dec-97	0.6	48	13.8	21.1	12	H	515.6	0.0	0.0	0.0	50.2	77.2	77.2	Wed
25-Dec-97	1.4	64	13.6	20.6	13	H	467.2	0.0	0.0	0.0	51.5	76.6	76.6	Thu
26-Dec-97	0.5	55	13.6	20.5	12	H	517.6	0.0	0.0	0.0	48.3	75.9	75.9	Fri
27-Dec-97	-1.6	46	13.6	20.6	11	H	537.7	6.1	0.0	6.1	93.3	68.4	74.5	Sat
28-Dec-97	-6.0	42	11.5	19.3	11	H	308.5	31.9	0.0	31.9	397.6	70.2	102.9	Sun
29-Dec-97	-1.2	42	13.1	18.7	12	H	286.8	0.0	0.0	0.0	205.3	35.5	35.5	Mon
30-Dec-97	-4.4	39	11.9	20.5	11	H	241.8	0.0	0.0	0.0	278.3	23.3	23.3	Tue
31-Dec-97	-11.4	28	1.6	18.6		H	-0.2	0.0	0.0	0.0	432.5	25.3	25.3	Wed
Sum							**4,183.**	**156.9**	**0.0**	**156.9**	**3,711.9**	**2,156.9**	**2,314.7**	
Avg	**-0.8**	**47**	**13.2**	**20.7**	**13**		**457.5**	**5.1**	**0.0**	**5.1**	**119.7**	**69.6**	**74.7**	
Min	**-11.4**	**28**	**1.6**	**18.6**	**10**		**-0.2**	**0.0**	**0.0**	**0.0**	**42.0**	**23.3**	**23.3**	
Max	**3.8**	**64**	**13.9**	**21.5**	**16**		**601.9**	**31.9**	**0.0**	**31.9**	**432.5**	**78.5**	**102.9**	

Air Handling Unit Performance

Date	Fresh Air		Supply Air	Return Air		Clg/Htg	ERV Sensible	Htg/Clg Coil Effect (kWh)			HRV	Energy Consumed		Day of
	Temp (°C)	RH (%)	Temp (°C)	Temp (°C)	RH (%)	Mode	Effect (kWh)	Senible	Latent	Total	(kWh)	Elec	Total	Week
01-Jan-98	-3.1	34	11.0	20.1		H	236.7	0.0	0.0	0.0	213.5	23.6	23.6	Thu
02-Jan-98	3.6	39	14.8	21.3	12	H	329.0	0.0	0.0	0.0	21.5	23.4	23.4	Fri
03-Jan-98	7.2	51	14.9	21.0	18	H	258.9	0.0	0.0	0.0	46.1	68.3	68.3	Sat
04-Jan-98	0.0	65	14.4	20.8	17	H	480.3	0.0	0.0	0.0	120.1	68.7	68.7	Sun
05-Jan-98	2.8	81	13.0	20.8	19	H	318.7	0.0	0.0	0.0	68.3	65.5	65.5	Mon
06-Jan-98	9.0	85	11.9	21.0	32	H	44.6	0.0	0.0	0.0	72.0	66.4	66.4	Tue
07-Jan-98	5.8	81	11.8	20.9	28	H	180.0	0.0	0.0	0.0	66.6	67.7	67.7	Wed
08-Jan-98	1.7	76	11.8	20.8	21	H	362.0	0.0	0.0	0.0	55.3	66.2	66.2	Thu
09-Jan-98	1.0	73	11.8	20.9	17	H	380.2	0.0	0.0	0.0	56.0	65.0	65.0	Fri
10-Jan-98	-0.7	41	12.6	20.9	13	H	456.4	0.0	0.0	0.0	41.9	53.3	53.3	Sat
11-Jan-98	-6.5	45	11.7	20.7	10	H	430.8	0.0	0.0	0.0	262.7	51.7	51.7	Sun
12-Jan-98	-4.4	54	11.1	20.7	12	H	353.4	0.0	0.0	0.0	201.3	42.9	42.9	Mon
13-Jan-98	-5.5	49	11.9	21.0	13	H	618.5	0.0	0.0	0.0	45.0	48.3	48.3	Tue
14-Jan-98	-8.1	43	11.2	20.7	11	H	690.6	-0.2	0.0	-0.2	35.0	48.5	48.7	Wed
15-Jan-98	-7.0	56	12.2	20.9	11	H	674.7	0.0	0.0	0.0	45.7	52.6	52.6	Thu
16-Jan-98	-6.6	50	12.2	20.9	11	H	672.1	0.0	0.0	0.0	30.6	49.9	49.9	Fri
17-Jan-98	-4.7	59	12.3	20.5	10	H	609.8	0.0	0.0	0.0	33.1	50.9	50.9	Sat
18-Jan-98	-2.8	61	12.3	20.4		H	529.7	0.0	0.0	0.0	36.9	50.7	50.7	Sun
19-Jan-98	-2.2	56	12.3	20.7	11	H	496.1	0.0	0.0	0.0	39.0	52.6	52.6	Mon
20-Jan-98	-4.0	54	12.3	20.7	11	H	568.4	0.0	0.0	0.0	33.9	48.7	48.7	Tue
21-Jan-98	-3.6	45	12.2	20.6	10	H	551.3	0.0	0.0	0.0	35.0	48.7	48.7	Wed
22-Jan-98	-6.2	53	12.2	20.7	11	H	656.7	0.0	0.0	0.0	32.0	48.5	48.5	Thu
23-Jan-98	-1.6	69	12.3	20.7	14	H	467.6	0.0	0.0	0.0	39.7	49.1	49.1	Fri
24-Jan-98	-1.6	56	12.4	20.3	11	H	483.5	0.0	0.0	0.0	38.5	51.0	51.0	Sat
25-Jan-98	-2.5	52	12.3	20.2		H	519.6	0.0	0.0	0.0	35.6	51.9	51.9	Sun
26-Jan-98	-5.5	57	12.2	20.6	11	H	582.2	0.0	0.0	0.0	86.0	48.8	48.8	Mon
27-Jan-98	-2.8	65	12.3	20.9	13	H	524.4	0.0	0.0	0.0	36.9	48.3	48.3	Tue
28-Jan-98	-2.1	66	12.2	21.0	13	H	454.9	0.0	0.0	0.0	50.9	47.5	47.5	Wed
29-Jan-98	-0.1	76	12.3	21.0	14	H	414.2	0.0	0.0	0.0	43.9	48.3	48.3	Thu
30-Jan-98	-0.4	59	12.2	21.0	14	H	421.7	0.0	0.0	0.0	44.5	48.5	48.5	Fri
31-Jan-98	-1.0	49	12.3	20.8	10	H	454.6	0.0	0.0	0.0	42.1	51.3	51.3	Sat
Sum							**14,221.3**	**-0.2**	**0.0**	**-0.2**	**2,009.6**	**1,606.7**	**1,607.0**	
Avg	**-1.7**	**58**	**12.3**	**20.8**	**14**		**458.8**	**0.0**	**0.0**	**0.0**	**64.8**	**51.8**	**51.8**	
Min	**-8.1**	**34**	**11.0**	**20.1**	**10**		**44.6**	**-0.2**	**0.0**	**-0.2**	**21.5**	**23.4**	**23.4**	
Max	**9.0**	**85**	**14.9**	**21.3**	**32**		**690.6**	**0.0**	**0.0**	**0.0**	**262.7**	**68.7**	**68.7**	

Air Handling Unit Performance

Date	Fresh Air		Supply Air	Return Air		Clg/Htg	ERV Sensible	Htg/Clg Coil Effect (kWh)			HRV	Energy Consumed		Day of
	Temp (°C)	RH (%)	Temp (°C)	Temp (°C)	RH (%)	Mode	Effect (kWh)	Senible	Latent	Total	(kWh)	Elec	Total	Week
01-Feb-98	-0.1	50	12.2	20.7		H	406.9	0.0	0.0	0.0	45.5	51.1	51.1	Sun
02-Feb-98	2.1	45	12.2	21.1	14	H	315.1	0.0	0.0	0.0	49.7	48.5	48.5	Mon
03-Feb-98	-2.7	46	12.2	21.0	11	H	511.0	0.0	0.0	0.0	38.8	48.0	48.0	Tue
04-Feb-98	-4.6	35	12.2	20.8	10	H	416.6	0.0	0.0	0.0	81.5	48.2	48.2	Wed
05-Feb-98	-3.0	21	12.2	20.9		H	176.2	0.0	0.0	0.0	9.0	47.9	47.9	Thu
06-Feb-98	-8.2	48	11.4	20.5		H	154.2	0.0	0.0	0.0	39.2	7.5	7.5	Fri
10-Feb-98	3.3	35	11.5	21.2	12	H	138.5	0.0	0.0	0.0	33.7	29.8	29.8	Tue
11-Feb-98	1.3	59	11.1	20.8	13	H	301.6	0.0	0.0	0.0	55.2	48.4	48.4	Wed
12-Feb-98	1.3	65	11.1	20.7	15	H	304.2	0.0	0.0	0.0	55.1	48.4	48.4	Thu
13-Feb-98	-2.2	44	11.1	20.4	11	H	445.0	0.0	0.0	0.0	44.9	48.0	48.0	Fri
14-Feb-98	-7.8	31	10.8	20.1		H	504.6	0.0	0.0	0.0	122.6	51.6	51.6	Sat
15-Feb-98	-5.1	40	10.8	19.9		H	215.2	0.0	0.0	0.0	121.2	51.8	51.8	Sun
16-Feb-98	-1.3	50	11.7	20.6	10	H	276.0	0.0	0.0	0.0	33.5	49.5	49.5	Mon
17-Feb-98	1.6	76	12.2	20.9	14	H	339.5	0.0	0.0	0.0	47.5	48.2	48.2	Tue
18-Feb-98	1.8	78	12.2	20.9	16	H	333.0	0.0	0.0	0.0	47.5	48.2	48.2	Wed
19-Feb-98	2.0	76	12.2	21.2	17	H	325.3	0.0	0.0	0.0	49.4	48.9	48.9	Thu
20-Feb-98	2.0	69	12.2	21.2	17	H	323.4	0.0	0.0	0.0	49.9	48.3	48.3	Fri
21-Feb-98	0.9	57	12.3	20.6	13	H	381.3	0.0	0.0	0.0	45.3	51.4	51.4	Sat
22-Feb-98	1.0	58	12.3	20.3	11	H	379.7	0.0	0.0	0.0	43.0	51.4	51.4	Sun
23-Feb-98	1.5	51	12.3	20.9	13	H	350.5	0.0	0.0	0.0	45.9	48.1	48.1	Mon
24-Feb-98	0.8	49	12.3	21.1	12	H	375.7	0.0	0.0	0.0	46.2	48.4	48.4	Tue
25-Feb-98	2.5	55	12.2	21.2	15	H	300.4	0.0	0.0	0.0	50.2	48.2	48.2	Wed
26-Feb-98	2.7	47	12.3	21.2	14	H	296.9	0.0	0.0	0.0	50.6	48.5	48.5	Thu
27-Feb-98	2.4	40	12.2	21.1	13	H	307.2	0.0	0.0	0.0	50.0	48.1	48.1	Fri
28-Feb-98	3.8	62	12.3	20.6	16	H	249.3	0.0	0.0	0.0	51.2	52.0	52.0	Sat
Sum							**8,127.3**	**-0.1**	**0.0**	**-0.1**	**1,306.6**	**1,168.6**	**1,168.6**	
Avg	**-0.2**	**52**	**11.9**	**20.8**	**13**		**325.1**	**0.0**	**0.0**	**0.0**	**52.3**	**46.7**	**46.7**	
Min	**-8.2**	**21**	**10.8**	**19.9**	**10**		**138.5**	**0.0**	**0.0**	**0.0**	**9.0**	**7.5**	**7.5**	
Max	**3.8**	**78**	**12.3**	**21.2**	**17**		**511.0**	**0.0**	**0.0**	**0.0**	**122.6**	**52.0**	**52.0**	

Air Handling Unit Performance

Date	Fresh Air		Supply Air	Return Air		Clg/Htg	ERV Sensible	Htg/Clg Coil Effect (kWh)			HRV	Energy Consumed		Day of
	Temp (°C)	RH (%)	Temp (°C)	Temp (°C)	RH (%)	Mode	Effect (kWh)	Senible	Latent	Total	(kWh)	Elec	Total	Week
01-Mar-98	4.8	70	12.3	20.2	20	H	220.5	0.0	0.0	0.0	51.9	51.1	51.1	Sun
02-Mar-98	2.1	66	12.2	20.6	18	H	320.0	0.0	0.0	0.0	46.9	47.7	47.7	Mon
03-Mar-98	2.0	64	12.2	21.0	17	H	321.9	0.0	0.0	0.0	49.0	47.5	47.5	Tue
04-Mar-98	0.6	58	12.2	20.8	15	H	382.7	0.0	0.0	0.0	44.4	47.8	47.8	Wed
05-Mar-98	0.7	52	12.2	20.8	14	H	378.5	0.0	0.0	0.0	43.9	48.5	48.5	Thu
06-Mar-98	0.1	50	12.2	20.9	12	H	404.9	0.0	0.0	0.0	43.0	48.9	48.9	Fri
07-Mar-98	1.4	52	12.3	20.6	11	H	351.2	0.0	0.0	0.0	45.8	52.1	52.1	Sat
08-Mar-98	1.3	66	12.3	20.4	12	H	366.6	0.0	0.0	0.0	44.4	51.3	51.3	Sun
09-Mar-98	4.1	72	12.3	20.9	20	H	237.3	0.0	0.0	0.0	52.4	47.4	47.4	Mon
10-Mar-98	-7.8	37	11.9	20.5	12	H	572.6	0.0	0.0	0.0	162.5	48.2	48.2	Tue
11-Mar-98	-9.1	33	10.3	20.1	10	H	358.4	0.0	0.0	0.0	363.9	46.9	46.9	Wed
12-Mar-98	-7.0	38	11.2	20.6		H	468.5	0.0	0.0	0.0	214.2	48.6	48.6	Thu
13-Mar-98	-3.4	41	12.2	20.6		H	490.5	0.0	0.0	0.0	29.6	48.1	48.1	Fri
14-Mar-98	-1.1	64	12.2	20.4		H	454.5	0.0	0.0	0.0	41.0	58.6	58.6	Sat
15-Mar-98	-5.8	45	11.9	20.3		H	612.5	0.0	0.0	0.0	54.1	51.7	51.7	Sun
16-Mar-98	-6.5	30	9.4	20.2		H	369.4	0.0	0.0	0.0	227.4	49.1	49.1	Mon
17-Mar-98	-2.2	40	11.6	20.9		H	303.8	0.0	0.0	0.0	126.6	52.0	52.0	Tue
18-Mar-98	1.0	75	12.3	21.1	13	H	372.6	0.0	0.0	0.0	44.1	48.7	48.7	Wed
19-Mar-98	1.0	79	12.3	21.1	15	H	372.6	0.0	0.0	0.0	45.1	66.1	66.1	Thu
20-Mar-98	0.0	62	12.2	21.0	13	H	410.1	0.0	0.0	0.0	43.3	48.2	48.2	Fri
21-Mar-98	-1.8	61	12.3	20.5	10	H	494.7	0.0	0.0	0.0	38.3	51.1	51.1	Sat
22-Mar-98	-1.5	52	12.2	20.5		H	470.2	0.0	0.0	0.0	39.4	50.9	50.9	Sun
23-Mar-98	-2.9	38	12.2	20.9		H	477.4	0.0	0.0	0.0	53.3	48.3	48.3	Mon
24-Mar-98	-1.8	34	10.9	20.7		H	311.2	0.0	0.0	0.0	93.7	48.5	48.5	Tue
25-Mar-98	3.8	26	10.6	20.5	12	H	157.6	0.0	0.0	0.0	49.0	44.8	44.8	Wed
26-Mar-98	14.1	39	15.9	21.9	23	H	16.9	0.0	0.0	0.0	42.6	40.9	40.9	Thu
27-Mar-98	17.9	41	19.0	23.4	34	H	3.5	0.0	0.0	0.0	42.6	72.8	72.8	Fri
28-Mar-98	16.1	46	17.3	22.9	34	H	6.4	0.0	0.0	0.0	38.2	56.7	56.7	Sat
29-Mar-98	14.1	47	15.4	21.9	34	H	7.0	0.0	0.0	0.0	41.5	52.1	52.1	Sun
30-Mar-98	18.6	47	19.6	23.5	40	H	1.9	0.0	0.0	0.0	38.2	69.5	69.5	Mon
31-Mar-98	19.8	38	20.8	24.4	39	H	1.8	0.0	0.0	0.0	39.5	70.1	70.1	Tue
Sum							**9,717.6**	**0.0**	**0.0**	**0.0**	**2,290.0**	**1,614.2**	**1,614.2**	
Avg	**2.3**	**50**	**13.0**	**21.1**	**20**		**313.5**	**0.0**	**0.0**	**0.0**	**73.9**	**52.1**	**52.1**	
Min	**-9.1**	**26**	**9.4**	**20.1**	**10**		**1.8**	**0.0**	**0.0**	**0.0**	**29.6**	**40.9**	**40.9**	
Max	**19.8**	**79**	**20.8**	**24.4**	**40**		**612.5**	**0.0**	**0.0**	**0.0**	**363.9**	**72.8**	**72.8**	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
20-Sep-97	14.1	C	0	0			18	21	0.00	0.00	1.88		Sat
21-Sep-97	9.6	C	0	0			19	20	0.00	0.00	1.84		Sun
22-Sep-97	12.9	C	0	0			19	19	0.70	0.00	42.93		Mon
23-Sep-97	12.2	C	20	20	8	1	14	19	-143.53	264.77	69.83	0.54	Tue
24-Sep-97	9.7	C	0	0			18	19	0.20	0.00	36.43		Wed
25-Sep-97	12.6	C	0	0			19	17	0.05	0.00	80.70		Thu
26-Sep-97	10.7	C	22	22	8	1	14	18	-151.74	264.33	42.82	0.57	Fri
27-Sep-97	9.7	C	0	0			17	18	-0.73	0.00	44.57		Sat
28-Sep-97	14.1	C	0	0			20	18	-0.44	0.00	101.81		Sun
29-Sep-97	16.0	C	0	0			21	18	1.72	0.00	135.81		Mon
30-Sep-97	13.3	C	17	18	9	32	10	18	-458.24	566.01	124.11	0.81	Tue
Sum			59	60					-752.02	1,095.11	682.73		
Avg	12		5	5	8	11	17	19	-68.37	99.56	62.07	0.64	
Min	10		0	0	8	1	10	17	-458.24	0.00	1.84	0.54	
Max	16		22	22	9	32	21	21	1.72	566.01	135.81	0.81	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Oct-97	6.7	C	0	0			17	19	-4.15	0.00	2.71		Wed
02-Oct-97	8.0	C/H	5	46	9	6	37	18	79.67	228.97	32.85	0.35	Thu
03-Oct-97	15.5	C/H	6	29	18	24	28	17	-425.47	572.70	99.92	0.74	Fri
04-Oct-97	17.2	C	12	12	9	65	7	19	-606.40	630.53	119.40	0.96	Sat
05-Oct-97	17.2	C	58	58	7	2	10	22	-435.23	695.00	110.85	0.63	Sun
06-Oct-97	18.8	C	36	37	6	20	7	26	-656.80	789.35	146.60	0.83	Mon
07-Oct-97	16.2	C	25	25	7	35	6	27	-639.71	762.24	148.52	0.84	Tue
08-Oct-97	17.5	C	31	30	6	27	5	28	-667.23	763.05	147.49	0.87	Wed
09-Oct-97	18.6	C	24	24	6	39	7	29	-758.97	764.77	148.65	0.99	Thu
10-Oct-97	12.0	C	50	50	6	1	8	26	-232.95	496.50	88.99	0.47	Fri
11-Oct-97	8.9	C	14	14	6	2	13	22	-58.33	147.49	34.64	0.40	Sat
12-Oct-97	10.8	C	0	0			17	20	-1.34	0.00	53.15		Sun
13-Oct-97	16.5	C	0	0			21	19	0.00	0.00	99.55		Mon
14-Oct-97	11.2	C	62	62	6	1	11	19	-240.36	559.36	105.34	0.43	Tue
15-Oct-97	7.6	C	0	0			15	20	0.00	0.00	1.84		Wed
16-Oct-97	7.4	C	0	0			18	19	0.00	0.00	1.81		Thu
17-Oct-97	6.2	C	0	0			17	19	0.00	0.00	1.82		Fri
18-Oct-97	5.4	C	0	0			17	19	0.00	0.00	1.82		Sat
19-Oct-97	6.8	C	0	0			17	19	0.00	0.00	1.83		Sun
20-Oct-97	7.3	C/H	57	57	4	0	36	19	141.35	318.55	38.92	0.44	Mon
21-Oct-97	4.8	H	46	46	3	0	38	19	86.83	201.58	54.37	0.43	Tue
22-Oct-97	0.9	H	73	73	3	0	46	19	150.35	389.95	55.50	0.39	Wed
23-Oct-97	2.7	H	87	87	3	0	55	18	103.83	381.61	54.35	0.27	Thu
24-Oct-97	5.9	H	75	75	3	0	55	18	54.36	313.45	53.33	0.17	Fri
25-Oct-97	5.0	H	85	85	3	0	55	18	73.09	339.24	55.80	0.22	Sat
26-Oct-97	0.9	H	105	105	3	0	55	18	162.19	438.25	55.89	0.37	Sun
27-Oct-97	1.7	H	108	108	3	0	55	18	191.52	462.12	56.56	0.41	Mon
28-Oct-97	3.7	H	93	93	3	0	55	18	130.70	396.50	121.59	0.33	Tue
29-Oct-97	7.2	H	69	69	3	0	55	18	39.78	284.86	53.29	0.14	Wed
30-Oct-97	6.1	H	62	62	3	0	56	18	33.15	267.11	51.88	0.12	Thu
31-Oct-97	9.9	H	49	49	3	0	55	18	3.66	213.71	46.63	0.02	Fri
Sum			**1229**	**1292**					**-3,476.47**	**10,416.90**	**2,045.90**		
Avg	**9**		**40**	**42**	**5**	**10**	**29**	**20**	**-112.14**	**336.03**	**66.00**	**0.47**	
Min	**1**		**0**	**0**	**3**	**0**	**5**	**17**	**-758.97**	**0.00**	**1.81**	**0.02**	
Max	**19**		**108**	**108**	**18**	**65**	**56**	**29**	**191.52**	**789.35**	**148.65**	**0.99**	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	HI Start (count)	Lo Start (count)	Avg. Cycle Time (min) HI Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Nov-97	10.4	H	49	49	3	0	56	18	-6.27	210.55	51.44	0.03	Sat
02-Nov-97	8.6	H	73	73	3	0	56	18	70.11	312.95	54.36	0.22	Sun
03-Nov-97	4.7	H	76	76	3	0	55	18	92.37	331.97	53.67	0.28	Mon
04-Nov-97	3.3	H	74	74	3	0	55	18	91.62	324.28	53.18	0.28	Tue
05-Nov-97	5.2	H	33	66	3	3	55	18	64.89	254.95	53.98	0.25	Wed
06-Nov-97	6.3	H	0	61		6	55	18	46.20	226.82	55.34	0.20	Thu
07-Nov-97	6.8	H	0	60		6	55	17	47.33	218.40	55.43	0.22	Fri
08-Nov-97	7.3	H	0	65		6	55	17	61.23	238.61	56.23	0.26	Sat
09-Nov-97	4.8	H	0	74		6	55	17	101.41	281.33	58.05	0.36	Sun
10-Nov-97	4.0	H	0	68		7	55	17	107.20	281.08	56.98	0.38	Mon
11-Nov-97	0.5	H	0	69		8	55	17	139.62	311.60	57.10	0.45	Tue
12-Nov-97	-0.9	H	0	70		7	55	17	126.84	312.94	57.14	0.41	Wed
13-Nov-97	-1.2	H	0	67		10	54	17	192.84	385.03	58.36	0.50	Thu
14-Nov-97	-2.1	H	0	71		10	54	17	230.50	419.10	59.32	0.55	Fri
15-Nov-97	-1.9	H	0	74		11	54	17	281.40	464.70	61.88	0.61	Sat
16-Nov-97	-2.7	H	0	72		12	54	17	342.76	522.56	63.48	0.66	Sun
17-Nov-97	-1.1	H	0	69		9	54	17	198.95	384.03	57.79	0.52	Mon
18-Nov-97	-0.3	H	0	62		9	54	17	162.46	339.21	56.28	0.48	Tue
19-Nov-97	1.1	H	0	67		7	55	16	99.85	285.46	55.88	0.35	Wed
20-Nov-97	1.3	H	0	61		9	55	16	125.98	317.43	56.60	0.40	Thu
26-Nov-97	5.8	H	0	68		6	55	16	84.34	256.45	56.02	0.33	Wed
27-Nov-97	3.4	H	0	66		7	55	17	105.72	292.09	56.21	0.36	Thu
28-Nov-97	6.2	H	0	63		6	55	15	64.30	244.87	54.82	0.26	Fri
29-Nov-97	2.3	H	0	76		8	55		161.19	363.14	61.07	0.44	Sat
30-Nov-97	3.6	H	0	85		8	55		199.12	394.25	60.34	0.51	Sun
Sum			305	1702					3,191.95	7,973.82	1,420.93		
Avg	3		12	68	3	7	55	17	127.68	318.95	56.84	0.37	
Min	-3		0	49	3	0	54	15	-6.27	210.55	51.44	0.03	
Max	10		76	85	3	12	56	18	342.76	522.56	63.48	0.66	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Dec-97	0.4	H	0	72		8	55		171.16	351.84	57.60	0.49	Mon
02-Dec-97	-0.4	H	0	69		7	55		128.49	301.62	56.48	0.43	Tue
03-Dec-97	-1.1	H	0	73		8	55		173.75	353.23	57.64	0.49	Wed
04-Dec-97	2.5	H	0	64		7	55		98.63	268.02	57.26	0.37	Thu
05-Dec-97	0.4	H	0	71		7	55	17	117.02	292.26	54.91	0.40	Fri
06-Dec-97	0.1	H	0	87		8	55	17	230.39	420.22	59.64	0.55	Sat
07-Dec-97	1.1	H	0	89		8	55	17	250.91	432.20	60.98	0.58	Sun
08-Dec-97	0.6	H	0	79		7	55	17	158.16	339.51	122.17	0.47	Mon
09-Dec-97	0.1	H	0	79		7	55	17	144.10	332.50	57.68	0.43	Tue
10-Dec-97	-1.6	H	0	82		7	55	17	160.54	353.34	58.02	0.45	Wed
11-Dec-97	-3.0	H	0	71		9	54	17	224.22	401.41	57.07	0.56	Thu
12-Dec-97	-2.1	H	0	73		9	54	17	201.01	385.86	122.04	0.52	Fri
13-Dec-97	-0.5	H	0	82		9	55	17	286.16	467.12	62.00	0.61	Sat
14-Dec-97	-2.1	H	0	75		11	54	17	331.72	510.02	127.24	0.65	Sun
15-Dec-97	1.6	H	0	69		8	55	17	146.10	321.43	116.14	0.45	Mon
16-Dec-97	3.8	H	0	65		7	55	17	89.00	266.36	44.81	0.33	Tue
17-Dec-97	0.9	H	0	71		7	55	17	103.22	285.62	44.99	0.36	Wed
18-Dec-97	0.1	H	0	76		8	54	17	170.42	372.04	47.34	0.46	Thu
19-Dec-97	2.6	H	0	75		7	55	17	130.70	322.99	46.40	0.40	Fri
20-Dec-97	0.2	H	0	84		9	54	17	273.18	467.02	50.58	0.58	Sat
21-Dec-97	-4.2	H	0	63		16	53	17	392.31	596.47	53.39	0.66	Sun
22-Dec-97	-3.0	H	0	64		14	54	17	324.45	526.30	51.56	0.62	Mon
23-Dec-97	0.6	H	0	78		8	55	17	186.53	373.96	48.43	0.50	Tue
24-Dec-97	0.6	H	0	82		8	55	17	187.32	375.63	50.02	0.50	Wed
25-Dec-97	1.4	H	0	83		10	54	17	285.09	476.88	51.88	0.60	Thu
26-Dec-97	0.5	H	0	79		11	54	17	340.21	527.98	52.83	0.64	Fri
27-Dec-97	-1.6	H	0	77		12	54	17	338.69	531.85	52.89	0.64	Sat
28-Dec-97	-6.0	H	0	17		37	29	17	252.77	367.11	38.74	0.69	Sun
29-Dec-97	-1.2	H	0	29		21	30	16	239.97	361.10	103.42	0.66	Mon
30-Dec-97	-4.4	H	0	71		11	54	16	278.09	475.88	49.46	0.58	Tue
31-Dec-97	-11.4	H	0	35		34	52	17	502.25	722.59	54.57	0.70	Wed
Sum			**0**	**2178**					**6,916.56**	**12,580.37**	**1,968.18**		
Avg	**-1**		**0**	**70**		**11**	**53**	**17**	**223.11**	**405.82**	**63.49**	**0.53**	
Min	**-11**		**0**	**17**		**7**	**29**	**16**	**89.00**	**266.36**	**38.74**	**0.33**	
Max	**4**		**0**	**89**		**37**	**55**	**17**	**502.25**	**722.59**	**127.24**	**0.70**	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Jan-98	-3.1	H	0	50		22	53	16	437.09	649.44	53.28	0.67	Thu
02-Jan-98	3.6	H	0	68		8	55	16	156.50	337.72	46.62	0.46	Fri
03-Jan-98	7.2	H	0	77		7	55	16	149.48	320.18	46.39	0.47	Sat
04-Jan-98	0.0	H	0	80		9	54	16	257.54	448.98	48.90	0.57	Sun
05-Jan-98	2.8	H	0	68		7	55	16	94.69	277.64	45.20	0.34	Mon
06-Jan-98	9.0	H	0	55		5	56	16	19.36	178.63	42.42	0.11	Tue
07-Jan-98	5.8	H	0	72		6	55	16	73.22	258.42	45.75	0.28	Wed
08-Jan-98	1.7	H	0	80		7	55	16	136.51	333.51	47.73	0.41	Thu
09-Jan-98	1.0	H	0	75		8	55	16	169.09	358.64	48.07	0.47	Fri
10-Jan-98	-0.7	H	0	76		11	54	16	293.65	484.17	50.75	0.61	Sat
11-Jan-98	-6.5	H	0	56		19	54	16	435.41	643.70	118.00	0.68	Sun
12-Jan-98	-4.4	H	0	56		13	54	16	231.27	430.01	48.48	0.54	Mon
13-Jan-98	-5.5	H	0	74		9	54	16	205.15	408.56	50.76	0.50	Tue
14-Jan-98	-8.1	H	0	68		13	54	16	308.07	520.21	51.93	0.59	Wed
15-Jan-98	-7.0	H	0	71		11	54	16	271.97	485.35	52.97	0.56	Thu
16-Jan-98	-6.6	H	0	70		11	54	16	224.60	442.03	48.28	0.51	Fri
17-Jan-98	-4.7	H	0	79		10	54	16	278.42	493.37	50.48	0.56	Sat
18-Jan-98	-2.8	H	0	78		11	54	16	295.45	504.87	53.46	0.59	Sun
19-Jan-98	-2.2	H	0	76		8	55	16	143.24	353.08	46.39	0.41	Mon
20-Jan-98	-4.0	H	0	72		7	55	16	99.17	301.85	44.83	0.33	Tue
21-Jan-98	-3.6	H	0	80		8	55	16	157.12	366.88	46.92	0.43	Wed
22-Jan-98	-6.2	H	0	78		9	54	16	210.60	424.65	48.19	0.50	Thu
23-Jan-98	-1.6	H	0	80		8	55	16	165.58	361.70	46.66	0.46	Fri
24-Jan-98	-1.6	H	0	82		9	55	16	248.78	430.92	49.55	0.58	Sat
25-Jan-98	-2.5	H	0	84		9	55	16	279.29	458.96	50.15	0.61	Sun
26-Jan-98	-5.5	H	0	82		9	55	16	237.18	422.28	49.14	0.56	Mon
27-Jan-98	-2.8	H	0	71		8	55	16	159.44	338.54	46.70	0.47	Tue
28-Jan-98	-2.1	H	0	70		8	55	16	147.56	322.40	46.00	0.46	Wed
29-Jan-98	-0.1	H	0	75		7	55	16	116.07	295.14	45.57	0.39	Thu
30-Jan-98	-0.4	H	0	76		7	55	16	129.30	311.26	46.44	0.42	Fri
31-Jan-98	-1.0	H	0	82		9	54	16	274.96	448.84	49.62	0.61	Sat
Sum			**0**	**2255**					**6,405.75**	**12,411.95**	**1,565.65**		
Avg	**-2**		**0**	**73**		**9**	**55**	**16**	**206.64**	**400.39**	**50.50**	**0.49**	
Min	**-8**		**0**	**50**		**5**	**53**	**16**	**19.36**	**178.63**	**42.42**	**0.11**	
Max	**9**		**0**	**84**		**22**	**56**	**16**	**437.09**	**649.44**	**118.00**	**0.68**	

Boiler/Chiller Performance

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Feb-98	-0.1	H	0	82		9	54	16	279.30	448.57	49.79	0.62	Sun
02-Feb-98	2.1	H	0	74		7	55	16	120.78	298.32	45.38	0.40	Mon
03-Feb-98	-2.7	H	0	73		7	55	16	135.05	308.39	108.66	0.44	Tue
04-Feb-98	-4.6	H	0	77		8	55	16	176.11	367.07	46.01	0.48	Wed
05-Feb-98	-3.0	H	0	78		8	55	16	170.66	358.69	46.29	0.48	Thu
06-Feb-98	-8.2	H	0	23		13	54	16	108.68	169.80	15.28	0.64	Fri
10-Feb-98	3.3	H	0	29		6	55	16	-5.37	94.22	87.34	0.06	Tue
11-Feb-98	1.3	H	0	69		6	55	16	63.40	255.91	44.63	0.25	Wed
12-Feb-98	1.3	H	0	70		6	55	16	50.25	242.52	44.35	0.21	Thu
13-Feb-98	-2.2	H	0	76		7	55	16	124.29	314.64	47.82	0.40	Fri
14-Feb-98	-7.8	H	0	78		11	54	16	298.55	493.19	50.28	0.61	Sat
15-Feb-98	-5.1	H	0	72		13	54	16	366.07	555.11	51.44	0.66	Sun
16-Feb-98	-1.3	H	0	72		9	55	16	193.31	379.11	47.60	0.51	Mon
17-Feb-98	1.6	H	0	73		6	55	16	79.07	269.64	44.94	0.29	Tue
18-Feb-98	1.8	H	0	71		6	55	16	87.94	273.93	46.63	0.32	Wed
19-Feb-98	2.0	H	0	80		6	55	16	111.82	301.71	46.95	0.37	Thu
20-Feb-98	2.0	H	0	72		6	55	16	86.27	265.79	45.18	0.32	Fri
21-Feb-98	0.9	H	0	87		7	55	16	185.04	365.15	49.08	0.51	Sat
22-Feb-98	1.0	H	0	88		8	55	16	220.52	405.55	48.91	0.54	Sun
23-Feb-98	1.5	H	0	78		7	55	16	130.85	314.51	46.71	0.42	Mon
24-Feb-98	0.8	H	0	74		6	55	16	93.17	279.84	45.79	0.33	Tue
25-Feb-98	2.5	H	0	63		6	55	16	57.09	233.68	107.49	0.24	Wed
26-Feb-98	2.7	H	0	64		6	55	16	53.44	235.89	44.51	0.23	Thu
27-Feb-98	2.4	H	0	67		6	55	16	51.84	231.80	43.42	0.22	Fri
28-Feb-98	3.8	H	0	68		6	55	16	45.84	237.61	112.14	0.19	Sat
Sum			**0**	**1753**					**3,283.98**	**7,700.66**	**1,366.63**		
Avg	**0**		**0**	**70**		**7**	**55**	**16**	**131.36**	**308.03**	**54.67**	**0.39**	
Min	**-8**		**0**	**23**		**6**	**54**	**16**	**-5.37**	**94.22**	**15.28**	**0.06**	
Max	**4**		**0**	**88**		**13**	**55**	**16**	**366.07**	**555.11**	**112.14**	**0.66**	

Boiler/Chiller Performance

March 1998

Date	Outdoor Ambient Temp (°C)	Clg/Htg Mode	Hi Start (count)	Lo Start (count)	Avg. Cycle Time (min) Hi Fire	Avg. Cycle Time (min) Lo Fire	Evap. Supply Temp (°C)	Cond. Return Temp (°C)	Q Delivered (kWh)	Fuel Consumed (kWh)	Elec. Consumed (kWh)	Daily COPth	Day of Week
01-Mar-98	4.8	H	0	70		6	55	16	63.47	256.32	45.30	0.25	Sun
02-Mar-98	2.1	H	0	73		6	55	16	92.77	278.55	45.66	0.33	Mon
03-Mar-98	2.0	H	0	68		6	55	16	64.14	245.18	44.35	0.26	Tue
04-Mar-98	0.6	H	0	69		6	55	16	62.83	245.02	43.84	0.26	Wed
05-Mar-98	0.7	H	0	75		6	55	16	98.37	282.29	45.19	0.35	Thu
06-Mar-98	0.1	H	0	78		7	55	16	127.12	304.02	46.12	0.42	Fri
07-Mar-98	1.4	H	0	81		8	55	16	196.73	370.82	50.44	0.53	Sat
08-Mar-98	1.3	H	0	87		8	55	16	230.27	407.34	112.65	0.57	Sun
09-Mar-98	4.1	H	0	60		6	55	16	80.32	230.98	43.03	0.35	Mon
10-Mar-98	-7.8	H	0	74		8	55	16	166.21	342.40	45.38	0.49	Tue
11-Mar-98	-9.1	H	0	75		10	54	16	261.85	443.84	47.37	0.59	Wed
12-Mar-98	-7.0	H	0	66		11	54	16	239.91	423.65	47.29	0.57	Thu
13-Mar-98	-3.4	H	0	71		8	55	16	151.05	337.56	45.38	0.45	Fri
14-Mar-98	-1.1	H	0	80		9	54	16	230.42	417.29	49.15	0.55	Sat
15-Mar-98	-5.8	H	0	77		10	54	16	249.90	439.78	49.27	0.57	Sun
16-Mar-98	-6.5	H	0	61		12	54	16	250.30	440.83	48.16	0.57	Mon
17-Mar-98	-2.2	H	0	60		9	55	16	133.20	315.65	45.30	0.42	Tue
18-Mar-98	1.0	H	0	66		6	55	16	38.71	231.37	44.72	0.17	Wed
19-Mar-98	1.0	H	0	68		6	55	16	48.39	237.96	45.57	0.20	Thu
20-Mar-98	0.0	H	0	70		7	55	16	84.94	272.66	45.28	0.31	Fri
21-Mar-98	-1.8	H	0	79		9	55	16	212.67	402.17	49.49	0.53	Sat
22-Mar-98	-1.5	H	0	80		9	54	16	237.63	425.20	48.86	0.56	Sun
23-Mar-98	-2.9	H	0	71		8	55	16	152.96	338.02	45.82	0.45	Mon
24-Mar-98	-1.8	H	0	70		7	55	16	109.02	289.36	45.09	0.38	Tue
25-Mar-98	3.8	H	0	60		6	55	16	48.34	210.30	43.55	0.23	Wed
26-Mar-98	14.1	H	0	30		6	50	15	-1.16	110.83	30.95	0.01	Thu
27-Mar-98	17.9	H	0	3		6	32	15	-7.66	11.35	21.33	0.67	Fri
28-Mar-98	16.1	H	0	2		23	29	15	8.21	27.81	17.91	0.30	Sat
29-Mar-98	14.1	H	0	0			24	15	-0.23	0.00	17.49		Sun
30-Mar-98	18.6	H	0	0			22	15	-0.07	0.00	10.00		Mon
31-Mar-98	19.8	H	0	0			20	15	0.00	0.00	1.85		Tue
Sum			**0**	**1818**					**3,630.60**	**8,338.56**	**1,321.77**		
Avg	**2**		**0**	**59**		**8**	**50**	**16**	**117.12**	**268.99**	**42.64**	**0.40**	
Min	**-9**		**0**	**0**		**6**	**20**	**15**	**-7.66**	**0.00**	**1.85**	**0.01**	
Max	**20**		**0**	**87**		**23**	**55**	**16**	**261.85**	**443.84**	**112.65**	**0.67**	