Bloggsville Motor Inn / Restaurant Energy Audit

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Executive Summary

This report documents the energy savings opportunities found during the 2002 energy audit of the Bloggsville Motor Inn, restaurant and bars, located in Bloggsville, New Zealand.

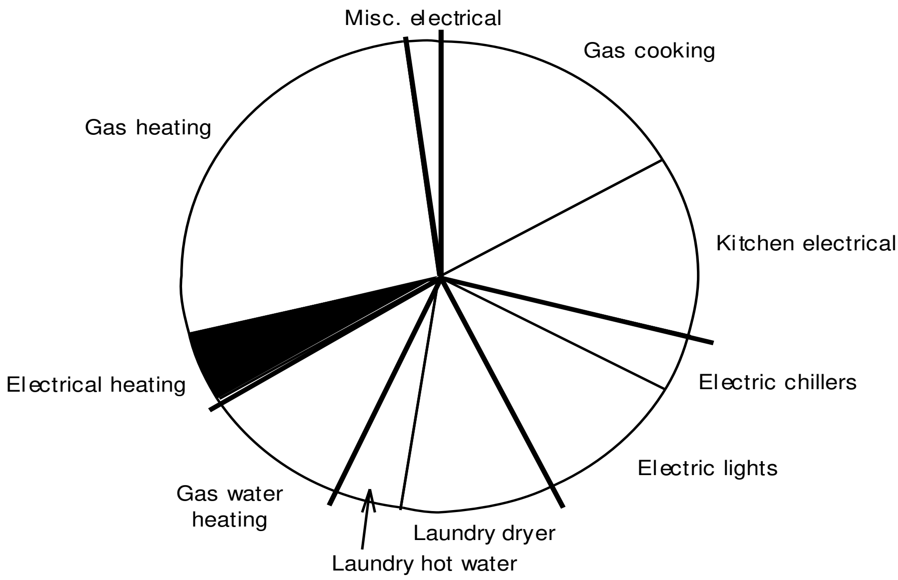
Total annual energy use in the twelve months up to 28 February 2002 is shown below.

Energy source	Annual usage	Average price	Annual cost
Natural gas	681,831 kWh/ yr	3.43¢/ kWh (energy + fixed charges)	$23,418
Electric energy	508,816 kWh/ yr	4.96¢/ kWh (energy only)	$25,253
Network charges	105 kVA	7.62¢/ kWh (energy plus network charges)	$13,535
Total	**1,190,647 kWh/yr**	**5.22 ¢/kWh**	**$62,206**

Energy tariffs are all the best that are available (as calculated in Section 2.4 and Appendix E.1).

The energy use index for this property is 357 kWh/ m^2 yr (as calculated in Section 2.3). This is much higher than the benchmark for New Zealand commercial buildings of this type, 250 kWh/ m^2 yr. **This means that the Bloggsville Motor Inn is spending about $18,000/yr more than it should by the New Zealand benchmark.**

The distribution of energy use, by end-use, is shown in the pie chart following.



About $3,200/ yr of the annual energy cost can be saved with the following "no-cost" opportunities.

Measure	Annual savings	Report reference
Reduce thermostat setpoint of space heating furnaces from 23° to 20°C	$2,700/ yr	3.1, E.2
Switch off unused office computers, printers, and copiers at night	$180/ yr	3.7, E.20
Keep kitchen freezer doors closed as much as possible to prevent coils icing	$100/ yr	3.5, E.17
Install 26 mm diameter fluorescent lamps during lamp replacement	$130/ yr	3.6, E.22

Installing the following equipment, at a capital cost of about $15,000, can save another $16,000/ yr, or 26% of annual energy cost. Thus they all yield high rates of return, averaging about 90%/ year. They are listed in the table below, in order of estimated cost-effectiveness.

Measure	Annual savings	Initial cost	Simple payback	Rate of return	Report references
Timer on kitchen exhaust fan	$2,100/ yr	$500	0.2 yrs	400%/ yr	3.4, E.15
Covers on space heating thermostats	$500/ yr	$150	0.3 yrs	320%/ yr	3.1, E.3
Timer on restaurant and bar boiler	$2,600/ yr	$1,000	0.4 yrs	250%/ yr	3.1, E.4
Tune boilers regularly	$250-$700/ yr	$100-200/ yr	0.5 yrs	200%/ yr	3.1, E.7
Destratification fan in the restaurant	$340–$1,700/ yr	$500	0.3 yrs–1.5yrs	48%/ yr–320%/ yr	3.1, E.5

Insulation on exposed pipes in boiler room	$289/ yr	$200	0.7 yrs	125%/ yr	3.1, E.8
Hot water cylinder insulation wraps	$270/ yr	$420	1.6 yrs	54%/ yr	3.2, E.9
Compact fluorescent lamps in restaurant	$1,530/ yr	$2,300	1.5 yrs	33%/ yr	3.6, E.24
Water-efficient shower heads (ten)	$280/ yr	$350	1.3 yrs	60%/ yr	3.2, E.10
Compact fluorescent lamps in lobby	$1,150/ yr	$1,800	1.6 yrs	14%/ yr	3.6, E.26
Occupancy sensors on urinal cisterns	$440/ yr (each)	$550-800	1.3 yrs–1.8 yrs	34%/ yr–58%/ yr	3.8, E.31
Power factor correction - 50 kVAr, to 0.99	$2,100/ yr	$3,500	1.7 yrs	49%/ yr	3.7, E.29
Insulation in guest room ceilings	$2,300/ yr	$2000–$4,000	0.9–1.7 yrs	53%/ yr–110%/ yr	3.1, E.6
Compact fluorescent lamps in bar	$330/ yr	$700	2.1 yrs	22%/ yr	3.6, E.25
Timers on beer coolers	$180+/ yr	$500	2.8 yrs	22%/ yr	3.5, E.18
Compact fluorescent lamps in Night Club	$300/ yr	$2,100	7.0 yrs	2%/ yr	3.6, E.27

Another 22% of annual energy costs may be able to be saved, in the following areas. However, more investigation is needed in these areas to confirm the costs to achieve these savings.

Measure	Potential savings	Report references
Consider additional heat recovery from dryer exhaust air	~$1,100/ yr	3.3, E.14
Consider cold-water laundry	$1,600/ yr	3.3, E.11
Investigate kitchen processes for energy use implications	~$1,850/ yr	3.4, E.19
Consider installing reflectors on fluorescent lights in kitchen	~$250/ yr	3.6, E.23
Consider heat recovery from refrigeration condensers to hot water	~$700/ yr	3.2, E.21
Consider reduced washing of bed linens on guests' request	~$3,400/ yr	3.3, E.12
Consider heat recovery from kitchen exhaust	~$1,860/ yr	3.4, E.16
Consider switching the laundry dryers to gas heat	$2,600/ yr	3.3, E.13
Investigate the phase imbalance on the switchboard	~$350/ yr	3.7, E.30

1 Introduction

The Bloggsville Motor Inn, restaurant and bars, located in Bloggsville New Zealand, is owned and operated by Mr. J. Bloggs.

In late 2001 Mr. Bloggs commissioned an energy audit of his properties. This report documents the energy audit performed on the Motor Inn on 4, 5, 16 and 17 April 2002 by Energy Solutions Ltd.

2 Historic Energy Usage and Comparison to Targets

The Bloggsville Motor Inn uses gas and electricity as its sources of purchased energy. The annualised energy use and cost (exclusive of GST) from the latest data available is summarised in Table 1, below.

Table 1. Annual energy use, 2001-2002

Energy source	Annual usage	Average price	Annual cost
Natural gas	681,831 kWh/ yr	3.43¢/ kWh (energy + fixed charges)	$23,418
Electric energy	508,816 kWh/ yr	4.96¢/ kWh (energy only)	$25,253
Network charges	105 kVA	7.62¢/ kWh (energy plus network charges)	$13,535
Total	**1,190,647 kWh/yr**	**5.22 ¢/kWh**	**$62,206**

2.1 Gas purchase history

The pattern of natural gas use over the time period examined is shown in Figure 1, below. This presents the averaged daily gas use, in kWh/ day, for each billing period. The data for this chart is in Appendix A. Unfortunately, the monthly gas use before December 2000 was aggregated into larger bills, which loses information on the pattern of month to month use. However, it can be seen that, as expected, the gas use is significantly higher in winter than summer.

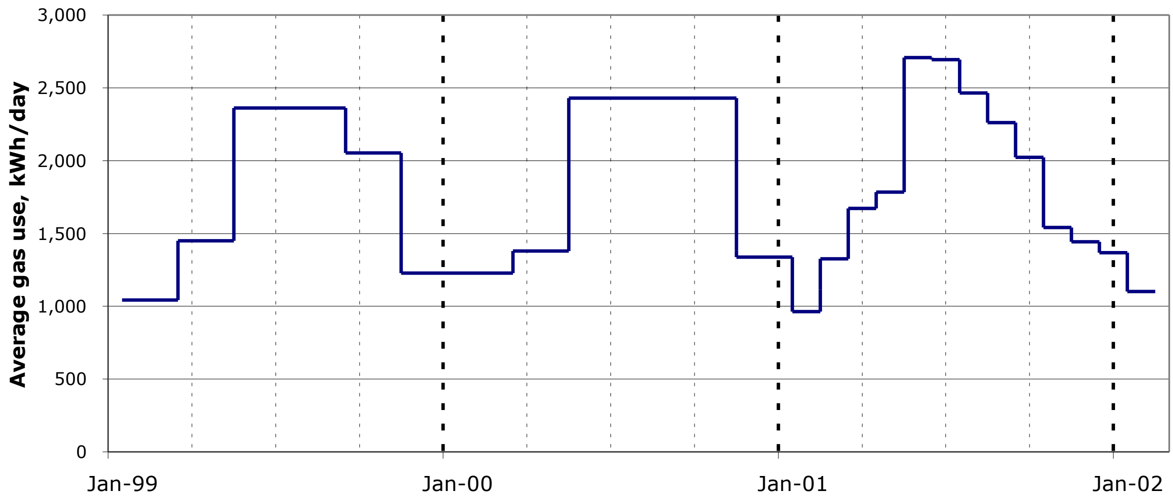


Figure 1. Average Daily Natural Gas Usage, by Month

As shown in Appendix A, the annual gas usage is up by 5% from 1999-2000 to 2000-2001, and the annual gas cost is up 38% over the same time frame, due to increased gas price.

The low summer gas use (about 1,000 kWh/ day) would be almost exclusively for cooking and water heating. This amount would be relatively constant month to month. The difference between winter and summer gas use, about 1,500 kWh/ day, represents the gas used for space heating.

2.1 Electricity purchase history

Historical electricity accounts are plotted in Figure 2, below , as the average kWh/ day. Night time units are shown as the lower line; total units as the top line. The data for this chart is also in Appendix A.

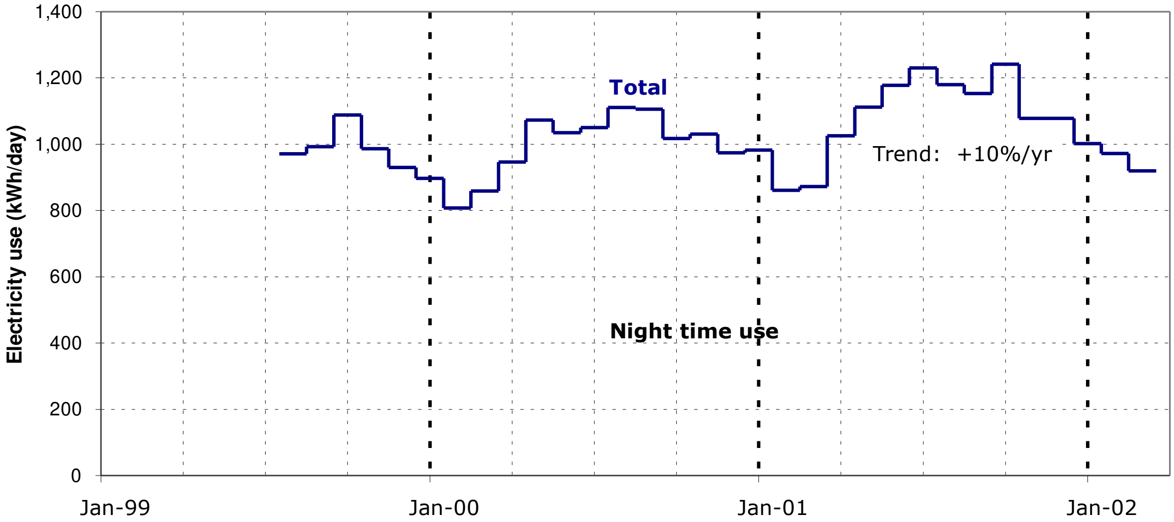


Figure 2. Average Daily Electricity Use, by Month

There is a significant seasonal trend in electricity use, as well as gas. This probably indicates that electricity is being used for space heating, in addition to the gas. The average electric energy use is about 1,000 kWh/ day. However, the electric energy use is showing an increasing trend, at about 10%/ year.

The half-hourly electricity purchases for February 2002 is plotted in Figures 3 and 4 below. These show the day-to-day and hour-to-hour patterns of electricity use.

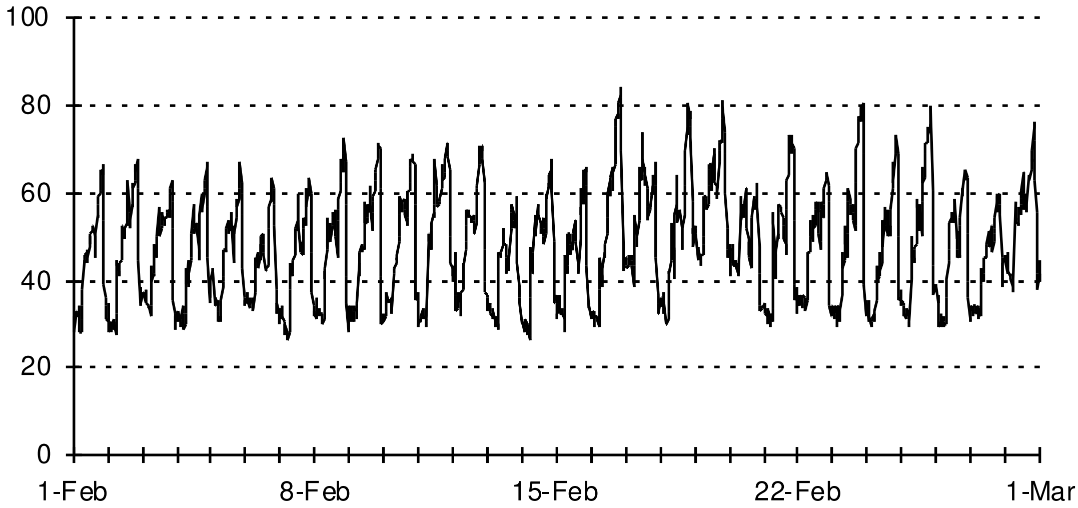


Figure 3. February 2002 Electricity Use

Figure 3 shows the electric energy use in the middle of summer when there is little or no electric heating energy used. The point directly above the mark on the time axis represents midnight, and the space between the ticks, 24 hours. These data are quite consistent.

Figure 4 shows the same data, but with each 24 hour period plotted on top of each other, so typical hour-to-hour trends can be seen. Also, the daily average (mean) electric demand is shown as the heavier line.

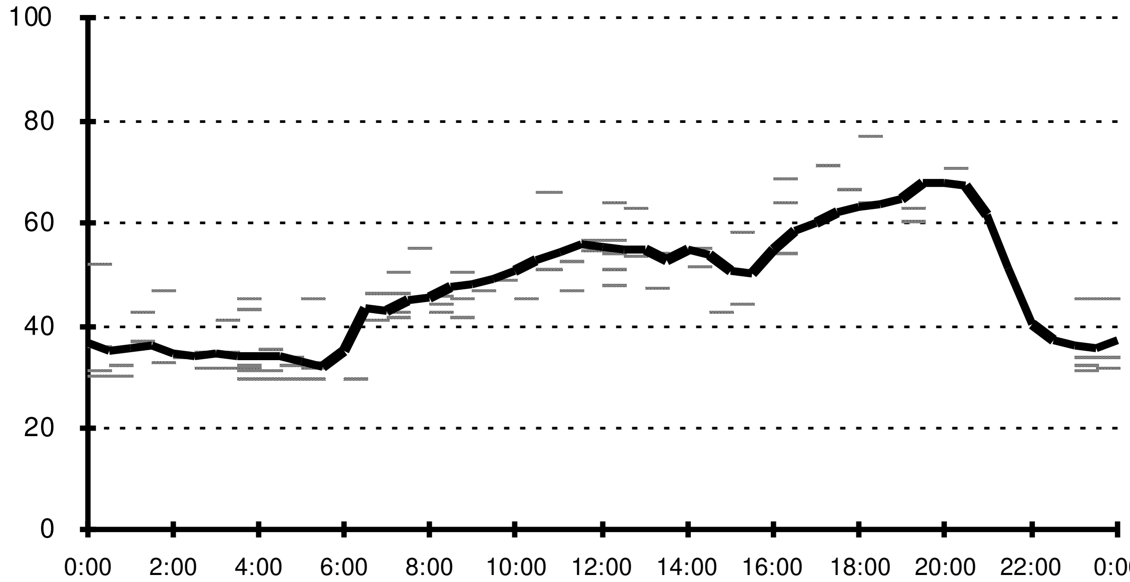


Figure 4. February 2002 Electricity Use - Average Daily Pattern

As can be seen, average electricity demand was at a minimum of about 33 kW from late evening until early morning. The rise in electricity use at about 6 AM is probably due to the kitchen starting up. Then, electricity use climbs to about 55 kW during the midday period, and rising to a peak of about 65 kW in early evening, when the guest rooms are occupied and the kitchen and bars are in full operation. The electricity demand drops off dramatically after about 10 PM, indicating that late-night use of the bars is not a significant contributor to electricity demand.

Figure 5 shows the expected distribution of electric energy use for the three main time intervals during the day. This information is from the energy balance calculated in Appendix D.

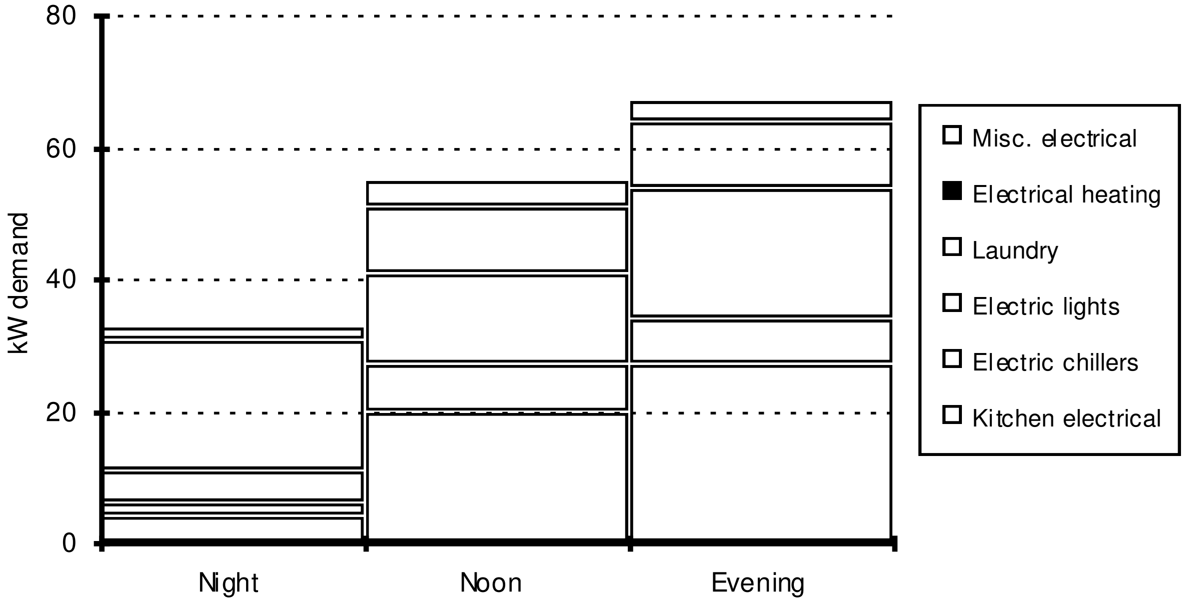


Figure 5 - Estimated February electrical end-uses, by time of day

As shown in Figure 5, the night time electricity use is dominated by the laundry clothes dryers, while the kitchen electrical demand is the main noon and evening electrical energy demand.

Figures 6 and 7 show the half-hourly patterns of electricity demand for August 2001, in the middle of winter, when there would be some electric space heating load. As expected, this is consistently about 10 kW higher than the summer load in Figure 3. However, there is even more load variability. For example, between 10–12 August the load never dropped below 60 kW. This may be due to a “cold snap” necessitating electric heating in most rooms.

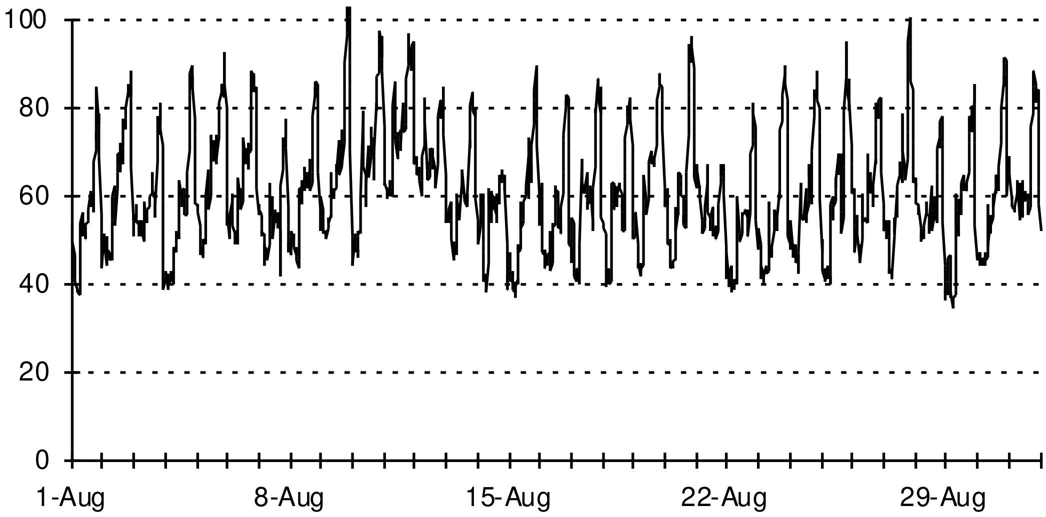


Figure 6. August 2001 Electricity Use

Figure 7 shows the same data, but with each 24 hour period plotted on top of each other, so typical hour-to-hour trends can be seen. Again, the daily average (mean) electric demand is shown as the heavier line.

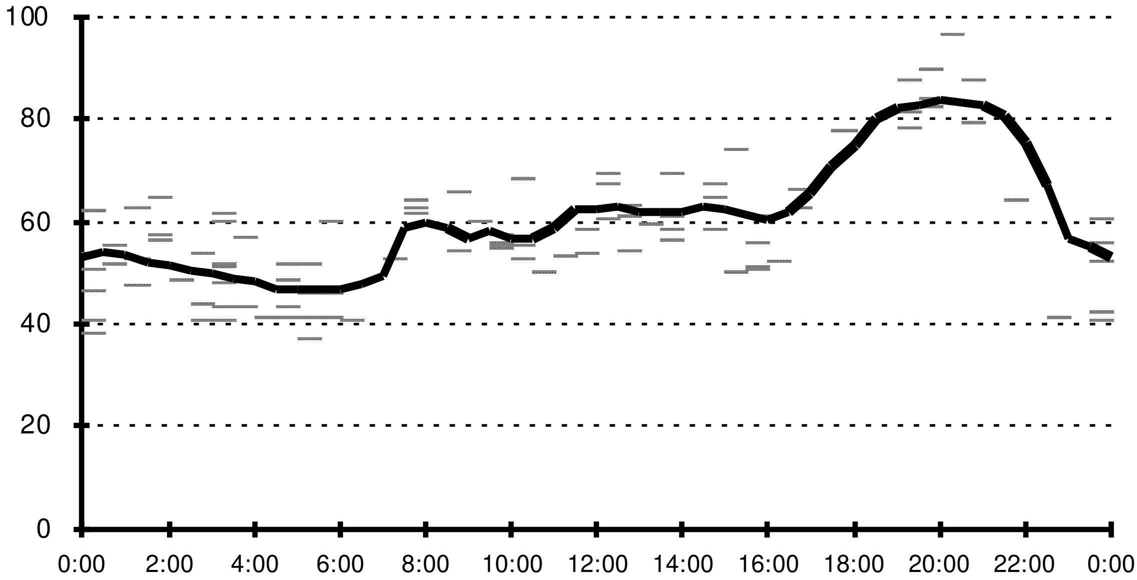


Figure 7. August 2001 Electricity Use - Average Daily Pattern

As can be seen, average electricity demand was at a minimum of about 50 kW from late evening until early morning, then climbing to about 65 kW during the midday period, and rising to a peak of about 85 kW in early evening, from which it dropped sharply.

Figure 8 shows the expected distribution of electric energy use for the three main time intervals during the day. This information is from the energy balance calculated in Appendix D.

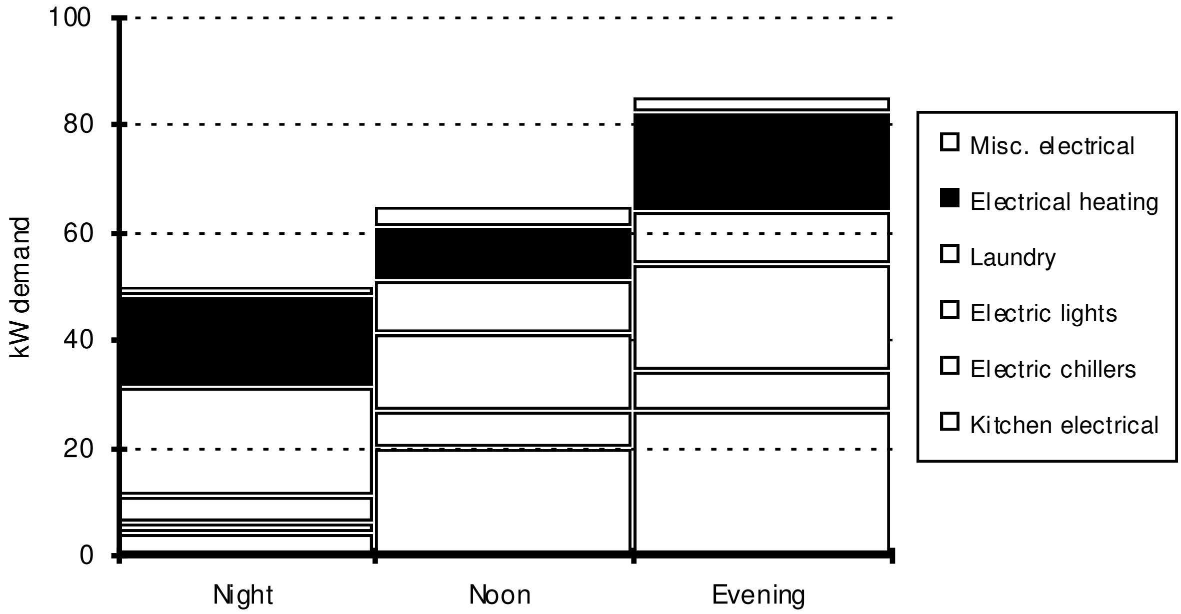


Figure 8 - Estimated August electrical end-uses, by time of day

As shown in Figure 8, the night time electricity use is dominated by the laundry clothes dryers and electric heating, while the kitchen electrical demand is still the main noon and evening electrical energy demand.

2.3 Energy Use Index

The building size was estimated by a calibrated pace to be 3390 square metres. The total energy use index (annual consumption divided by floor area) was then 357 kWh/ sq. m. year, which is significantly higher than the standard for existing buildings (200 kWh/ sq. m. year), but less than the standard for existing restaurants (400 kWh/ sq. m. year).[1]

As the restaurant and kitchens make up about one-quarter of the floor area of the facility, we suggest that the target energy use should be taken as 250 kWh/ sq. m. year, the weighted average of the two.

2.4 Tariff analysis

The gas use is on a "G9" (Declining block) tariff, where the price drops with increasing use. There is a fixed charge of 20¢ per day. The first 7000 units (kWh) of gas per month cost 4.02 ¢/ kWh, and the remaining units cost 3.26 ¢/ kWh. Because of the high average gas use, the average price is about 3.33¢/ kWh. (These, and all prices in this report are expressed exclusive of GST.)

The electricity for the main premises is purchased on BloggsPower's Time of Use Tariff. This rather complicated tariff charges different prices for electricity use during different hours, with the highest prices (5.94¢/ kWh) for electricity used when the power company's peak demand is (early evening) and the lowest prices (2.67¢/ kWh) when the power company's demand is minimum (during the night). There is also a charge for maximum demand ($12.08/ kW-month). The details of this tariff are given in Appendix B.

Essentially, this allows the electricity price to be reduced if the load profile is flattened (the peak minimized), and more electricity is used at night than during the day. With the load profile of this facility, the average price of electricity is 7.93¢/ kWh. This is well below the standard commercial rate of 13.48¢/ kWh, and the simple "Time of Day" tariff of about 12¢/ kWh, so the facility appears to have optimised its energy tariffs.

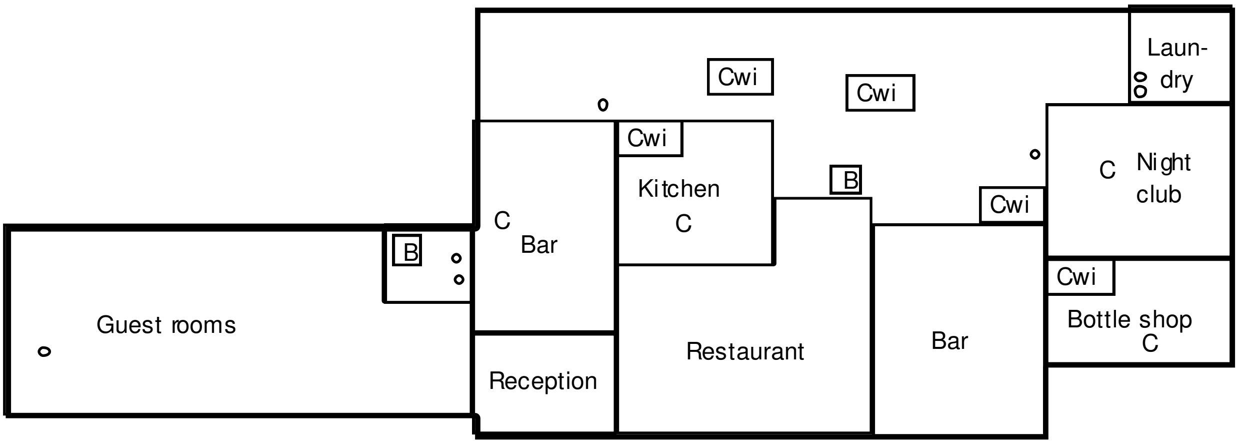
Recommendations

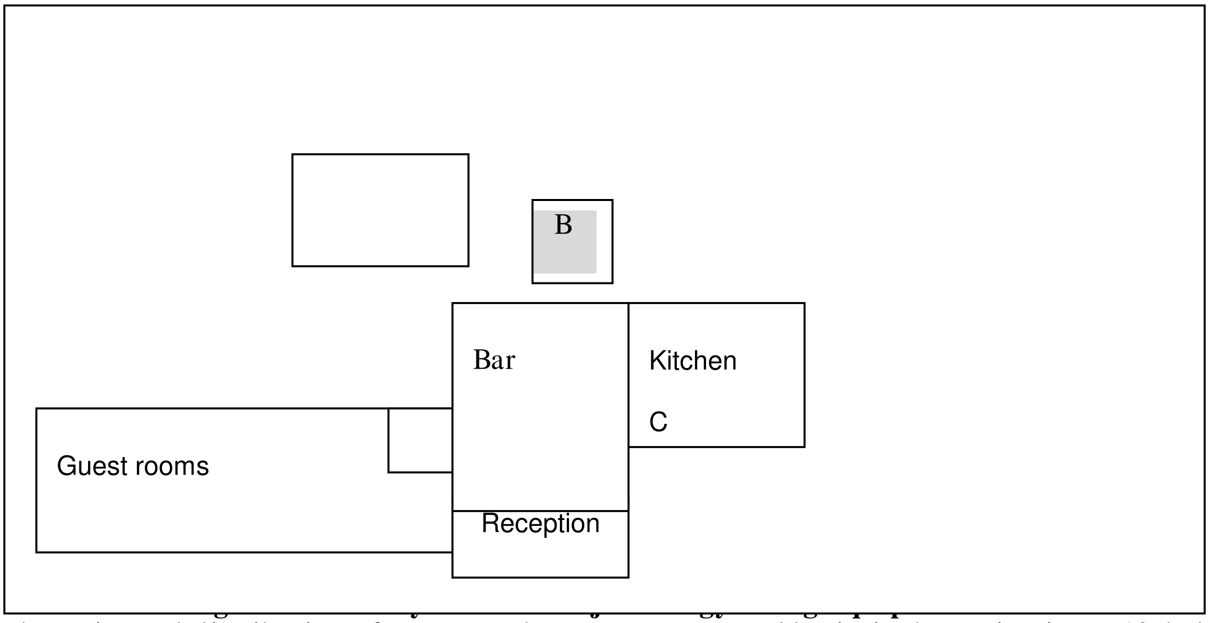
Keep all the energy tariffs that presently apply at Bloggsville Motor Inn, as they appear to be the lowest cost options available.

[1] New Zealand Standard NZS 4220:1984 (*Code of Practice for Energy Conservation in Non-Residential Buildings*) recommends 100 kWh/ sq.m. yr for new buildings, and 200 kWh/ sq.m. yr for existing buildings. Table 1 in this standard recommends 200 kWh/ sq.m. yr for new restaurants, and 400 kWh/ sq.m. yr for existing restaurants.

3 Energy end-uses

The layout of the Bloggsville Motor Inn, restaurant and bars are as shown in Figure 9 below. Public areas are shaded, while offices, storage and non-public spaces are unshaded. Walk-in coolers are marked as “C_{wi}”, and beverage chillers as “C”. Boilers (with integral air handlers) are marked as “B”, and hot water cylinders are shown as circles.





The estimated distribution of energy end-uses, on an annual basis, is shown in Figure 10, below.

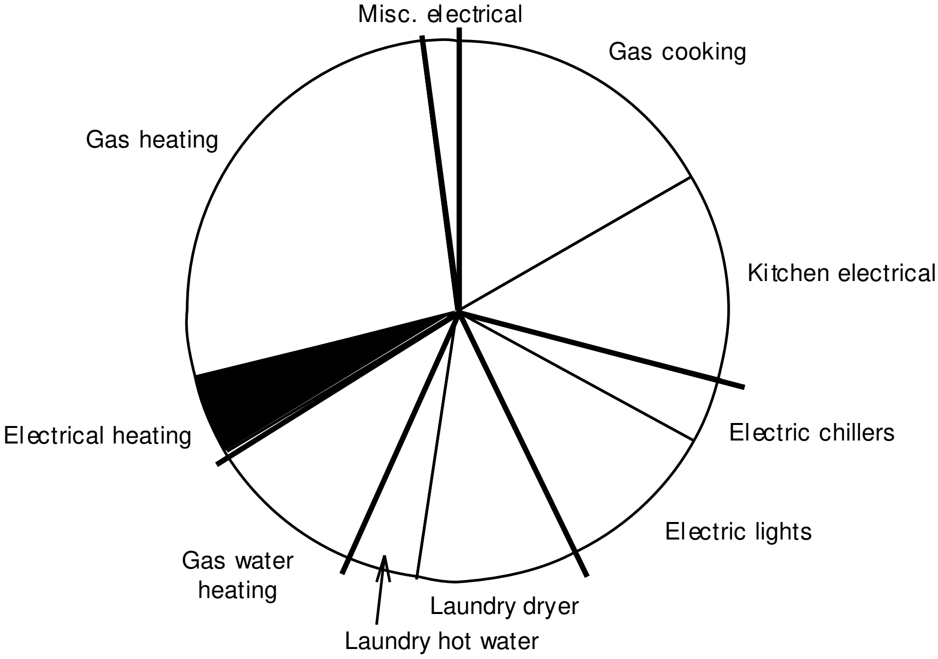


Figure 10 Estimated Annual Distribution of Energy End-Uses

This is determined from the energy balance done on the facility, as described in Appendix D. As can be seen, space heating is the largest energy end-use, accounting for about one-third of the total annual energy consumption. The second largest end-use is the kitchen, which uses over one-quarter of the facility's energy)not counting the hot water used for washing). The laundry uses about 15%, including one-third of the hot water. Lighting, chillers, other water-heating and miscellaneous electrical loads make up the rest of the energy use.

Each major end-use is discussed separately, in the following sections. The recommendations for cost-effective improvements are listed at the end of each section. The details of the cost-effectiveness calculations are listed in order of appearance in Appendix E.

3.1 Heating and cooling

Description

In 2001, the gas use for space heating was about 316,000 kWh/ year, worth about $10,000. The boilers should be tuned to maximum efficiency as often as is cost-effective, to minimize the total cost. In this context, the total cost is the cost of extra fuel use due to inefficiency plus the cost of tune-ups.

Two gas-burning boilers, with forced air heat distribution, heated the building and there was a refrigerative cooling coil connected to at least one of them (though it may have been disconnected, as the manager was not aware of its existence). Heating is available twelve months of the year from the furnaces, and controlled by three manual thermostats, which are accessible for occupant adjustment.

There were also individual electric fan heaters, of 1.2 kW output, in each guest room.

The corridors and storage areas were generally unheated, but remained comfortable from heat "leaking" from other parts of the facility.

Observations

The building was described by the manager as warm enough (when the heaters were operating) in winter and cool enough in summer. There was said to be adequate ventilation.

Gas is the most cost-effective heating fuel, at less than half the cost of electric heating, so should be retained as long as possible, while the furnaces are operating well.

The furnaces all appeared tidy and well serviced, though there was no indication that the efficiency was tuned up regularly. No insulation was visible on the air supply ducts.

The building was said to sometimes overheat if staff increased the thermostat setpoints (the thermostats were placed on walls in the centre of the spaces to be heated.) Normal thermostat setpoints were said to be 23°C–24°C, and the building was at a uniform 23°C at the time of the

survey. Thermostat setpoints were apparently not adjusted seasonally. Spaces were apparently heated for 24 hours/ day, not just when they were occupied.
The boilers were not operating at the time of the survey (late morning, in summer), but the building was quite warm at this time.
The ceiling in the restaurant is high enough that stratification of hot air could occur.
The boiler room has a number of uninsulated pipes and valves that are losing significant quantities of heat, wasting fuel and making the boiler room very hot and unpleasant to enter.
The largest single heat loss is from a horizontal 50 mm diameter pipe about 9 metres long, about 3 metres above floor level, which has a surface temperature of 100°C. This is calculated in Appendix E to be losing over 800 Watts continuously. This totals over 6,600 kWh/ yr, worth over $200/ year.
There is another similar pipe leading from the boiler nearest the door, which is also 50 mm in diameter and about 2.5 metres in total length. This pipe is losing about 230 W to the surroundings. Over a year, the total heat loss is about 1,800 kWh, worth about $60/ year.
There are also twelve uninsulated valves in the boiler room. The calculated heat loss of the valves is about 40 W. Over a year, these lose about 300 kWh, worth about $10/ year.
The predicted savings from insulating these pipes and valves are in proportion to the increase in thermal resistance (R-value) gained by insulating them. 25 mm thick fibreglass insulation will raise the R-value from the present R-0.11 to about R-0.6, and 50 mm of fibreglass will raise this to about R-1.1. Thus the heat loss will be reduced by about 80% with 25 mm thick insulation, and by about 90% with 50 mm thick.
As shown in Appendix E, the optimal frequency of boiler tune-up depends on the rate of efficiency decline, and the cost of using the boiler, and the cost of tune-up. The efficiency decline is expected to be in the range 0.3%–2%/ month.
For the conditions prevailing here, if the efficiency declines at 2%/ month, the boilers should be tuned at the start of the heating season (March), then again every three months (June, September) for lowest costs. This will save about $670/ year (compared to annual tune-ups) for an annual extra cost of about $200. However, if the efficiency declines at only 1%/ month, they should be tuned at the start of the heating season (March), then again after four months (July). This will save about $250/ year for an annual extra cost of about $100.
The actual efficiency increases to be gained can only be determined by testing the decline in efficiency over time.
Thus, it is recommended to test the efficiency of the boilers and tune them for maximum efficiency in March (the normal annual tune-up and servicing, at a cost of $100).
In June, the boilers' efficiency should be re-tested and recorded, then re-tuned to note the efficiency change over this time span (at a cost of another $100).
After this, and depending on the change measured at that time, it is recommended to continue ongoing boiler maintenance to maximising the net cost savings.

Recommendations

Reduce the thermostat setpoint temperatures to about 20°C year round. This will save about $1,400/year at no cost, and will still provide good comfort.
Install sealed covers on the space heating thermostats, to make them less accessible for occupant adjustment. This will save about $400/year, at a cost of about $150.
Ensure that regular tune-ups, with combustion efficiency measurements, are included in the boiler maintenance procedures. This will save about $250–$700/year, at a cost of about $100-$200/year.
Insulate the roof of the guest room block, with 100 or 150 mm thick loosefill or batt insulation. This will save about $2,500/year, at a cost of about $2,000 (loosefill) or $4,000 (batts).
Insulate the two large exposed pipes in the boiler room, with 25 mm thick fibreglass pipe wrap insulation. This will save about $330/year, at a cost of about $200.
Consider installing timers on the boilers, to avoid heating spaces all night when they are unoccupied. This will save about $1,000/year, at a cost of about $1,000 ($500 each).
Investigate the temperatures at the restaurant ceiling during winter. If they are more than about 2°C warmer than the floor, consider installing destratification fans to pull hot air from the restaurant ceiling down to the floor. This will save about $140–$550/year, at a cost of about $200.

3.2 Domestic hot water

Description

Domestic hot water was supplied by seven gas-fired domestic-sized hot water cylinders, two located in the boiler and storage room for the hotel guest rooms, one at the far end of the upstairs guest room corridor, one outside the kitchen, two in the laundry, and one in the lockup area behind the bar.

The hot water was used for showers and hand basins in the guest rooms. The hand basin hot taps had adequate but not excessive flow rates, which indicates that there would not be scope for flow reduction there. However, there were a diversity of different shower heads in use, and shower flow rates seemed high in several of the rooms.

Observations

Hotel staff indicated that in the past guest room hot water would run out before all guests had showered, but that presently the hot water supply seemed adequate. The main problems seemed to occur when many showers were being used at once, and were more due to low pressures and flow rates than low water temperature. However, there were instances of long-distance truckers preferring specific rooms, because of the quality of the showers there.

Gas is the most cost-effective water heating fuel, at less than half the cost of electric heating, so should be retained.

The surface temperature of the Rheem (80 gallon) cylinder in the hotel storage room was measured as 32°C, in a 23°C space. The surface temperature of the Parker (30 gallon) cylinder in the same room was measured as 30°C. This indicates that there would be sufficient heat loss to make hot water cylinder wraps cost-effective on both cylinders. If this was done, however, care would need to be taken not to block the air draught space beneath the cylinder, as that is the combustion air supply.

The hot water was supplied at the guest room hand basins at 47°C, when measured in late morning, as the hot water cylinders were recharging from the morning's use. This indicates that typical storage temperature is about 55°C, the preferred hot water storage temperature. This is hot enough to avoid concerns about Legionella, and also cool enough to avoid concerns about scalding and excess standing heat loss from the cylinder.

The hot water cylinder in the lockup was inaccessible, but would likely have the same high surface temperature and high heat loss as the others.

Recommendations

Consider installing hot water cylinder wraps to reduce the heat losses from the seven hot water cylinders. These will save about $65/year each, and cost about $60/each. If this is done, be sure not to block the air draught space under the cylinder.

Consider replacing some of the shower heads in the showers that had high flow rates with more water-efficient ones. This will save about $35/year each at a cost of about $35 each.

3.3 Laundry

The total energy demand of the laundry was estimated to be about 117,000 kWh/ year of electricity, worth about $8,600/ year, mostly for the electric dryers, and 52,000 kWh/ year of gas, worth about $1,600/ year, for the water heating. Together these are worth about $10,200/ year.

Description

There were two clothes washers and one large clothes dryer, which drew about 20 kW (according to its nameplate). These dryers were said to operate year-round, continuously from 10 PM until 6 AM daily, on a night shift, and a few more hours during the day. A typical washing or drying cycle is said to take about 45 minutes.

There were two hot water cylinders (each gas-fired, 6 kW input) in the laundry room, which were used exclusively for the laundry operation.

There was also a large electric sheet iron, which was used to iron the sheets.

Observations

The electric clothes dryer would use most of the energy of the laundry operation. There was a heat exchanger on the back of the dryer, to recover some of the exhaust heat to the inlet air, but it was small and somewhat clogged with lint.

The temperatures at the surface of the heat exchangers were measured as 36°C leaving the dryer, to 34°C at the exhaust, and 24°C on the fresh air inlet, to 25°C entering the dryer.

The effectiveness of the heat exchanger was estimated at about 13%, from the temperatures measured at its inlets and outlets' surfaces (as calculated below). This is much lower than the typical effectiveness of air-to-air heat exchangers of at least 30%.

Recommendations

Consider using a larger heat exchanger on the electric dryer exhaust, to preheat incoming air. This could save up to $1,100/year of energy costs.

Consider cold water washing of bed linens, with a cold water detergent. This will save about $1,600/year of water heating energy, at a cost of more expensive detergent.

Consider asking guests staying more than one night if they would like to keep the same bed linens. If laundry can be reduced by one-third, this will save $3,400/year of energy costs, plus some labour costs and some maintenance on the laundry equipment.

Consider switching the dryer heat source from electricity to gas. This would save about $5,200/year of energy costs.

3.4 Kitchen

Description

The kitchen appeared to be the highest energy use area of the hotel, using about 146,000 kWh/ yr of electricity, worth about $11,100/ year, and 200,000 kWh/ yr of gas, worth about $6,200/ year. In addition to the cooking load, there are large refrigeration and hot water loads.

Observations

Figure 11 shows the result of detailed monitoring[2] of the kitchen and chiller electricity consumption for four days. These data are recorded every five minutes to look for peak demand "spikes" and variability. The dates are at the mark on the time axis corresponding with midnight.

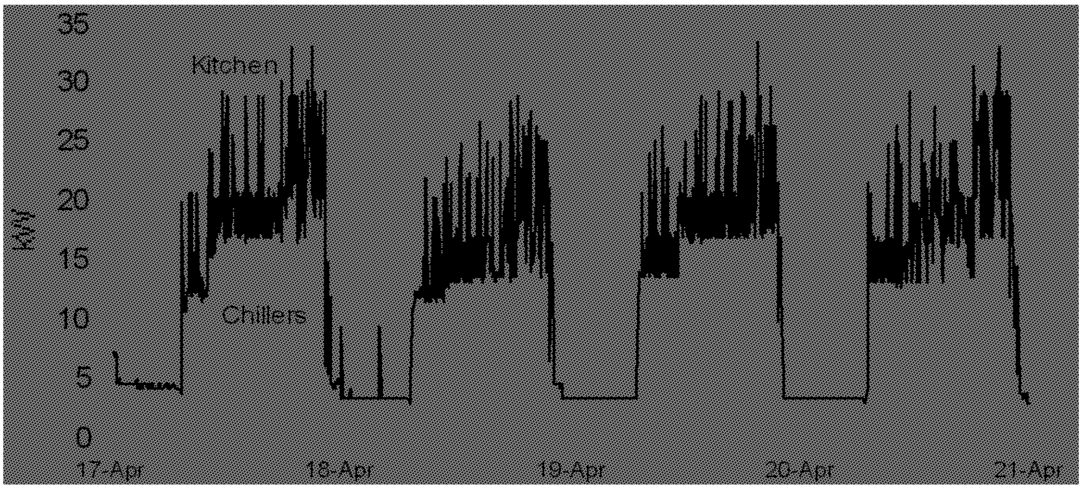


Figure 11 Kitchen and Chiller Electricity Use

For the energy balance in Appendix C, the average kitchen demand is taken as 4 kW at night, 20 kW at noon, and 25 kW in the evening.

The kitchen equipment was seen to be mostly quite old, with some non-functional and others out of adjustment. In particular, the deep fryer oil was noted to be smoking, and its temperature was measured as 175°C, when the thermostat appeared to be operating correctly and set at about 140°C. This indicated the thermostat was faulty, and should be replaced. This would result in improved cooking quality, and savings in cooking oil, as well as electricity savings.

Recommendations

Consider using a timer on the cooking range exhaust, to turn off the extract fan when the kitchen is not in use. This would save about $2,000/year of energy costs at an installed cost of about $150.

Consider using an air-to-air heat exchanger on the cooking range exhaust, for the hours it is in use, to preheat incoming air. This would save about $1,300/year of energy costs.

Commission a more detailed study of kitchen energy use. If 10% energy savings can be achieved, this will be worth about $2,100/year.

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2 These data are measured as currents in one electrical phase (red) to the distribution boards marked "Kitchen" and "Chillers" from the main switchboard. The currents are multiplied by 230 volts and 3 phases to get (approximate) total power.

3.5 Refrigeration

Description

There were four walk-in cool rooms in use in the facility, and several smaller glass-fronted beverage and food chillers.

Observations

The electrical load to the chillers was measured for several days from their distribution board. The measured chiller load data is shown in Figure 11, above. For the energy balance in Appendix C, the average chiller demand is 2 kW at night, and 7 kW at the other times.
The kitchen walk-in chiller was found to have an interior temperature of 8°C, the optimal temperature for food preservation and energy efficiency. Its evaporator coils seemed to have uniform temperatures across their surfaces, and showed no signs of icing up.
The second kitchen cool room, across the corridor from the kitchen, had an interior temperature of about 3°C, and about -10°C in its freezer compartment. Its evaporator coil was icing up significantly. This would cause a reduction in heat transfer, with a drop in efficiency and eventually a breakdown. This problem was caused by too much humid air leaking in from outside, either from air leaks into the freezer compartment or from the door being left open.
The bottle shop walk-in cooler had a temperature of 6°C. Its evaporator cleanliness, condition and temperature uniformity all seemed fine.
The downstairs beer cooler, which supplied bulk beer to the public bar was locked so could not be investigated. However, its temperature was visible from a thermometer above its door, and was at 3°C. This is considered normal.
There was no insulation observed on any refrigerant line. There were no leaks noted. The refrigeration condenser coils from the bar area appeared to need cleaning, though the ones mounted outside the kitchen appeared to be fine. There were no timers seen on any of the refrigeration compressors, which would allow them to be shut off at night when there was no demand.

Recommendations

Educate staff about the necessity to close cool room doors when they are not in use. If the cool room across the corridor from the kitchen could be managed better, so that less humid air leaked in, this would give about $100/year of energy savings, and possibly some significant maintenance savings, at no cost.
Install timers on the beer refrigeration units to switch off the coolers for several hours each night. This will save at least $180/year at a cost of about $500.
Clean chiller evaporator coils during scheduled maintenance.
Consider installing a desuperheater heat recovery unit, to recover some of the exhausted heat from the refrigeration chillers to hot water. A desuperheater would save about $100/year of refrigeration energy and about $600/year of water heating energy. This should be examined to see if it is practical and cost-effective.

3.6 Lighting

Description

There were a variety of different types of lamps and luminaires in place at the Bloggsville Motor Inn. Most lamps were fluorescent (generally the most efficient type), although there were many incandescent lamps seen. These included standard domestic light bulbs, many reflector spotlights, and a few halogen lamps. All these are generally low efficiency, and short lifetime.
The types of lamps and luminaires in use are tabulated in Appendix B for each major area, as well as when each area is used. There are also comments on whether any fixtures contain PCBs.

Observations

The reception area of the Bloggsville Motor Inn was very well lit, with illumination (lux) levels well above the recommended level, while most other areas were quite dark.
For reference, the standard illumination levels from the local Code of Practice[3] are listed in Table 2, below.

Table 2 - Measured and recommended lighting levels

Area	Measured Average Lux (Range measured)	Fraction of Recommended	Recommended Lux Level
Hotel lobbies	1200 lux	1200%	100 lux
Halls	30 lux (3–150)	40%	75 lux
Bars	20 lux(10–40)	12%	150 lux
Restaurants	30 lux (10–150)	30%	100 lux
Kitchen working areas	150 lux (70–300)	30%	500 lux

As can be seen, there was room to improve the lighting levels in most areas, especially the kitchen, where the low illumination levels may have Health and Safety Act implications. Although increasing the lighting levels would probably increase the energy demand, it would probably be worthwhile.
If the kitchen and other areas lit with fluorescents are to be improved, reflectors should be considered, as these provide the same light with about half the energy use of conventional fluorescent lighting.

Recommendations

Install 26 mm diameter fluorescent lamps to replace the 38 mm ones during lamp replacement, wherever possible. This will save about $2/year per lamp in energy costs.
Commission a lighting study, to confirm the following four points. This will ensure that all the recommendations are acceptable in terms of lamp appearance and fit, optimise the lux levels to meet the facility's needs, and seek the lowest costs for equipment.

- ***Replace the incandescent bulbs in the restaurant with compact fluorescents. This will save about $2,000/year, at a cost of about $2300.***
- ***Replace the incandescent bulbs in the bar with compact fluorescents. This will save about $580/year, at a cost of about $700.***
- ***Replace the spotlight bulbs in the lobby with compact fluorescents in reflective fixtures. This will save about $1,200/year, at a cost of about $1,800 (nine lamps at $200/fixture).***
- ***Consider installing reflectors in the kitchen fluorescent fixtures, if lighting levels are to be increased to standard levels.***

3.7 Other electrical end-uses

Description

There is a small amount of office equipment in use, which is apparently left on 24 hours/ day. This should be switched off when not in use, as this improves the lifetime of the equipment (contrary to popular belief). All major computer manufacturers recommend switching this type of equipment off when it is not in use.

Observations

The power factor meter on the main switchboard indicated 0.83 during the audit, and examination of half-hourly power demand data (from BloggsPower) indicates that the power factor is about 0.85 at peak load.
A power factor of 0.85 at a peak load of 105 kVA indicates reactive loads of about 55 kVAr, as calculated in Appendix E. This causes extra kVA demands of about 16 kVA.
BloggsPower bases their network charges on peak demands in kVA,. At the present network charge of $11.10/ kVA-month, this is worth over $2,100/ year. Power factor correction circuitry of 50 kVAr is recommended to bring the power factor at peak load from 0.85 to near 1.00.

3 New Zealand Standard NZS 6703:1984 *Code of Practice for Interior Lighting Design*

The phase voltages and currents were measured at the switchboard, and found to be slightly imbalanced (230/ 225/ 227 volts from ground). This is presumably due to single-phase loads (lights, small motors) unequally loaded onto the three phases.

Ideally, phase voltages should be balanced as closely as possible. Although it is not widely appreciated, even small imbalances, caused by single phase loads being placed more on one phase than the others, can cause significant problems with three phase motors. The effect of this imbalance is difficult to quantify, but can be put into perspective by noting that a 3.5% voltage imbalance has been reported to increase motor losses by about 25%, raise motor winding temperatures by 25% (above ambient) and cut motor life in half.[4]

Recommendations

Switch off all unused computers and printers when not in use, especially overnight. If a typical computer, printer, or other office machine is shut off for 16 hours/day, the savings are about $60/year.

Install 50 kVAr of power factor correction circuitry (a capacitor bank) to bring the power factor close to unity at full load. This will cost about $3,500, and save about $2,100/year.

Monitor the voltages and currents on each phase of the main electrical supply for about a week, to see how regular the imbalance is. If the imbalance is regular, balance the single-phase loads on each electrical phase, for example by switching some lights from the red to the blue phase, until the current draws and voltages again balance closely. This could save about $350/year.

4 Drivepower Technology Atlas, August 1993, p. 255 and 277, published by E SOURCE INC., 1050 Walnut Street, Boulder CO USA 80302.

3.8 Water end-uses

Description

Water is used in guest room showers, toilets, urinals, and dish washing in the facility, which are all areas where it may be cost-effectively saved.

Observations

The effect of water-efficient showers on energy use was described in section 3.4, above. As calculated in Appendix D, each water-efficient shower head will save about 14 cubic metres of water and 740 kWh of heat per year. This is worth about $38/ year of gas and about $4/ year of water (at 30¢/ cubic metre cost of water).

Automatic flushing urinals use 2 – 20 cubic metres of water per day. The water flow rate of one urinal that was measured at Bloggsville Motor Inn automatically flushed its 20 litre cistern every 6 minutes. This indicates a water flow rate of 4.8 cubic metres per day.

At least 80% of this can be saved by using an automatic flushing valve, so the urinal is only flushed when necessary, not continuously.

Dish washing in the restaurant kitchen was not observed during the audit, but there may be some savings available there as well.

Recommendations

Install water-efficient shower heads wherever appropriate in guest rooms. As described in section 3.4, they will save at least $38/year of gas each, and will also save another $4/year of water.

Install urinal occupancy sensors. These should save about 1,460 cubic metres of water per year, worth about $4400/year each, at a cost of about $800 each, installed.