Bloggs' Freight Warehouses

Sample Level One Energy Audit Report

Contents

Executive Summary

This report analyses the energy consumption patterns of the two Bloggs' Freight warehouses in New Zealand. It is based on the energy database, which was created by Energy Solutions Ltd, from the spreadsheets of historical information provided by Bloggs' Freight.

Table 1 below, shows the energy use for the 12-month period ending 30 June 2004. All prices are exclusive of GST.

Energy Source	Energy Consumption	Average Cost	Energy Expenditure
Electricity	1,190,423 kWh/ yr	10.57 c/ kWh (including network charges)	$125,822/ yr
Gas	652,028 kWh/ yr	4.00 c/ kWh	$26,077/ yr
Coal	532,168 kWh/ yr	1.32 c/ kWh	$7,025/ yr
Total	**2,374,619 kWh/yr**	**6.69 c/kWh**	**$158,954/yr**

Table 1: Summary of annual energy use

Bloggs' Auckland uses 56% of the energy consumption and 66% of the energy expenditure.

Recommendations:

- Investigate the gas consumption over summer at Bloggs' Auckland. This may save up to $2,160/ yr;
- Perform energy audits to at least level 2 standardat both sites.
- Install reflectors on fluorescent lights at Bloggs' Auckland.
- Install compact fluorescent bulbs in the office area at Bloggs' Auckland.
- Replace self ballasted mercury vapour lights with metal halide reflector lights.
- Continue a comprehensive planned maintenance programme at Bloggs' Auckland. This could save about 10 to 15% of the mechanical equipment use, which is likely to be very substantial for this building.

1. Introduction

This report analyses the energy consumption patterns of the two Bloggs' Freight warehouses in New Zealand. It is based on the historical energy consumption information provided by Bloggs' Freight. We have investigated the trends of consumption and expenditure and identified any anomalies. From this analysis, preliminary recommendations for energy cost savings are provided.

Bloggs' Freight is a packaging and mailing company, which stores items for shipment, then distributes them to other companies which ship the items overseas or around the rest of New Zealand. The two Bloggs' Freight sites are located in Auckland and Christchurch. The warehouse in Auckland uses electricity and gas as purchased forms of energy for its operations, and the Christchurch warehouse uses electricity, gas and coal.

This report will first outline the energy use of Bloggs' Freight as a whole, then reports on the initial observations and some potentially cost-effective energy savings opportunities from a brief site visit of the Bloggs' Auckland premises.

2. Overall Energy Consumption

The data used to generate the energy database for Bloggs' Freight gave a breakdown of the electricity invoices received for each tariff meter. Table 2 below, provides a fairly accurate indication of the energy use for the 12 month period ending 30 June 2004.

Energy Source	Energy Consumption	Average Cost	Energy Expenditure
Electricity	1,190,423 kWh/ yr	10.57 c/ kWh (including network charges)	$125,822/ yr
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Total	**2,374,619 kWh/yr**	**6.69 c/kWh**	**$158,954/yr**

Table 2: Summary of annual energy use

The following graph indicates the electricity patterns of the two warehouses.

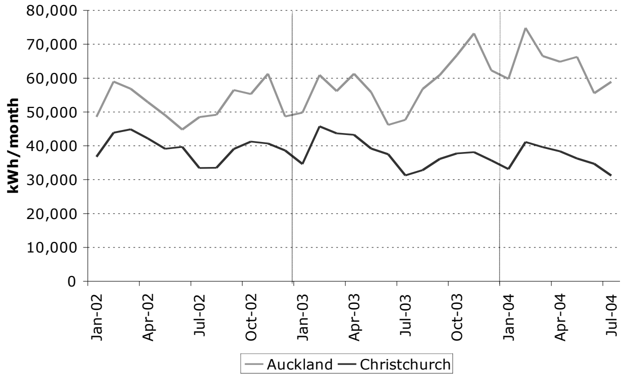


Figure 1: Monthly electricity consumption

The electricity use doesn't fluctuate greatly at either Bloggs' Auckland or Bloggs' Christchurch. There is however a seasonal pattern, with a dip in use in about July and an upturn in summer either side of Christmas in both centres. This summer peak suggests that much of the electricity is used for cooling. There is a consistent dip in energy use in December/ January during the Christmas break in both centres.

From an annual perspective, Bloggs' Auckland is seeing a steep increase in electricity use of late. Bloggs' Christchurch has also experienced upturns in electricity use, although these have been curbed of late. The following graphs compare the difference in cumulative electricity use from year to year for each warehouse. This further demonstrates the increase in electricity use at Bloggs' Auckalnd and subsequent decrease in energy use at Bloggs' Christchurch.

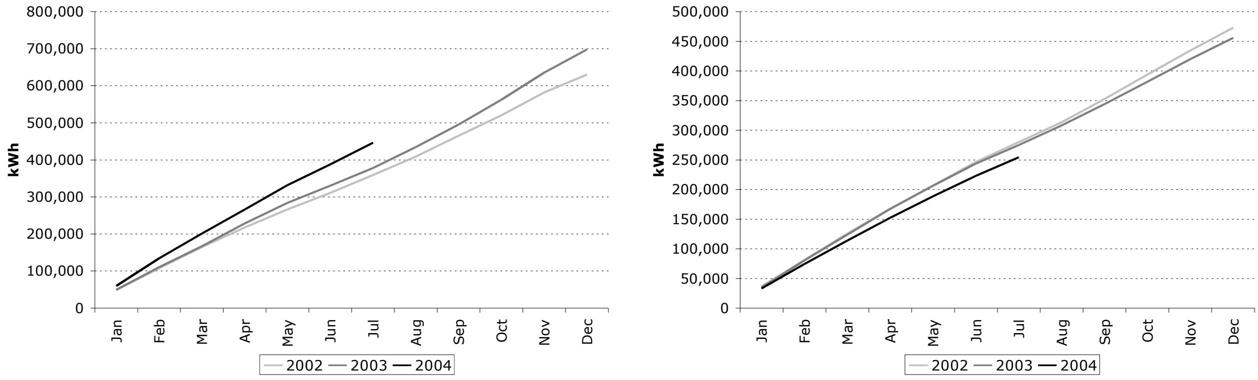


Figure 2: Cumulative monthly electricity use for Auckland (left) and Christchurch (right)

The following graph indicates the consumption patterns for gas, which is used at Bloggs' Auckland for space heating, water heating and staff kitchens.

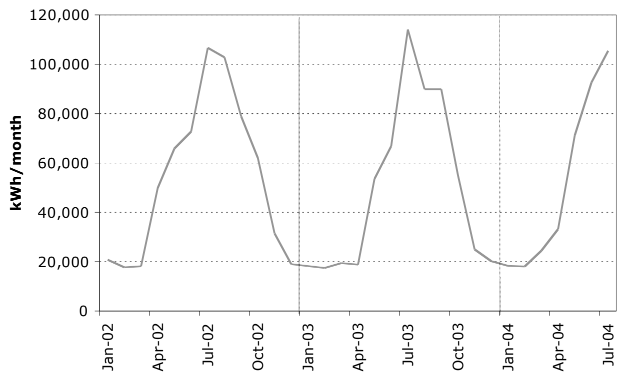
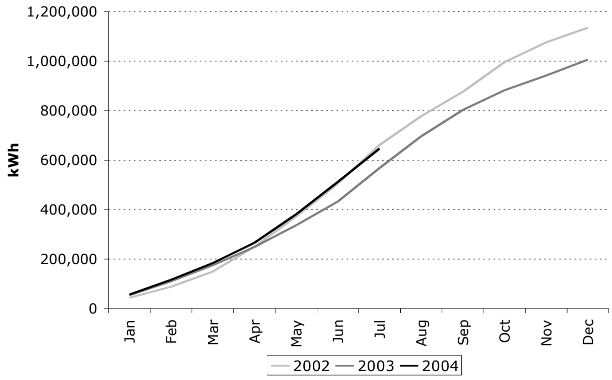


Figure 3: Monthly gas consumption - Auckland

The gas use is highly seasonal – peaking every winter. This suggests that most of the gas is used for space heating. However, there is a residual use over summer of about 20,000 kWh/month. This summertime gas use should be investigated, as this seems quite high for just water heating and kitchens. It is possible that much of the 20,000 kWh/month used in summer could be being wasted.

The following graphs compare the difference in cumulative gas use from year to year for each warehouse. At both warehouses the patterns for 2002 and 2004 are very similar, with a decrease in use occurring in 2003.



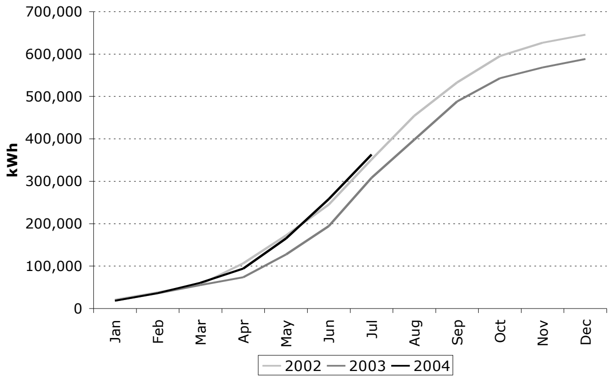


Figure 4: Cumulative monthly gas use for Auckland (left) and Christchurch (right)

The following graph indicates the consumption patterns for coal at Bloggs' Christchurch. This is said to be used for space and water heating there.

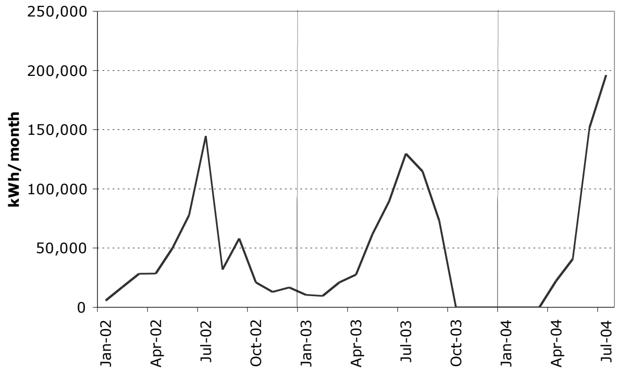


Figure 5: Monthly coal consumption - Christchurch

The use of coal at the Bloggs' Christchurch is also seasonal, suggesting that it too is used for space heating. It is a concern that the peak for the 2004 is so far considerably higher than the two previous winters. The following graph compares the difference in cumulative coal use from year to year for each warehouse. Although there is some data missing between October 2003 and March 2004, there is clearly a sharp increase in coal use from year to year.

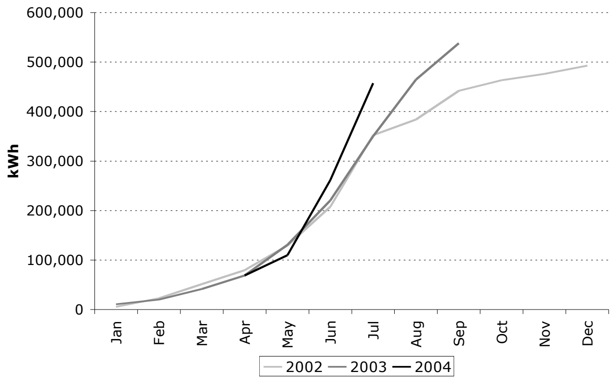


Figure 6: Cumulative monthly gas use - Christchurch

3. Warehouse Energy Consumption

Table 3 shows the electricity consumption for each of the Bloggs' Freight warehouses.

Division	sq.m	kWh/yr	$/yr	EUI (kWh/yr.m2)	c/kWh
Bloggs' Christchurch	2,591	435,067	$42,589	168	9.79
Bloggs' Auckland	6,742	755,356	$83,249	112	11.02
Total	**9,333**	**1,190,423**	**$125,838**	**128**	**10.57**

Table 3: Electricity use of each centre

Table 4 shows the gas/ coal consumption for each of the Bloggs' Freight warehouses.

Division	sq.m	kWh/yr	$/yr	EUI (kWh/yr.m2)	c/kWh
Bloggs' Christchurch Coal	2,591	532,168	$7,025	205	1.32
Bloggs' Auckland Gas	6,742	652,028	$26,077	97	4.00
Total	**9,333**	**1,184,196**	**$33,102**	**127**	**2.80**

Table 4: Gas use of each centre

The Christchurch EUI for coal is particularly high. The reason could be energy intensive and specialised equipment unique to Christchurch, or inefficiencies in how coal is used. Either way, a more extensive audit will help determine the cause of this high EUI.

Table 5 shows the total consumption for each centre, including the coal use at Bloggs' Christchurch.

Division	sq.m	kWh/yr	$/yr	EUI (kWh/yr.m2)	c/kWh
Bloggs' Christchurch	2,591	967,235	$49,614	373	5.13

Bloggs' Auckland	6,742	1,407,384	$109,310	209	7.77
Total	**9,333**	**2,374,619**	**$158,924**	**254**	**6.69**

Table 5: Overall energy use of each centre

The benchmark for existing commercial buildings in New Zealand is 200 kWh/ yr.m^2, and for new (commercial) buildings, 100 kWh/ yr.m^2. Therefore, energy use at both warehouses is much higher than normal and there will probably be significant, cost effective energy saving opportunities. Below is a graph of the distribution of annual energy use and expenditure.

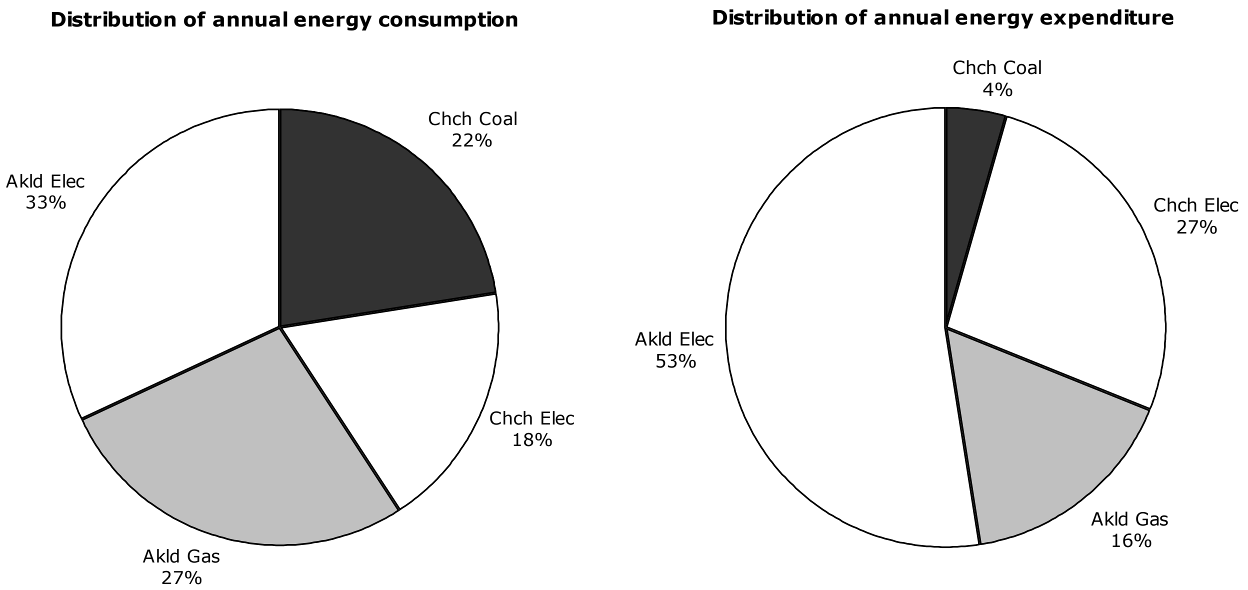


Figure 7: Distribution of annual consumption and expenditure

The electricity used at Bloggs' Auckland accounts for over half of Bloggs' Freight's total energy expenditure, but only a third of the overall consumption. Coal, by comparison is a much cheaper fuel, using almost a quarter of the overall Bloggs' Freight consumption for a virtually insignificant expenditure. So long as it remains available, it is a good idea for Bloggs' Freight to continue using gas and coal as much as possible.

Overall, Bloggs' Auckland accounts for 60% of the energy use, but 69% of the energy expenditure. Gas is already being used almost as much as electricity in Auckland, but the gas expenditure is only a third of that of electricity.

4. Bloggs' Auckland

The main Auckland warehouse processing and head office areas were both briefly surveyed during a site visit.

The lighting at the site tends to fall into two main categories: high bay lighting in processing and storage areas etc. and outside lighting, which is generally floodlights. The main office area is much less significant in terms of energy use when compared with the warehouses and the equipment used within them. There may be some savings available from turning office equipment off when it is not in use, although this was not fully explored.

Lighting is likely to be the most significant electric energy end uses. Space heating is likely to account for most of the gas use.

The main conclusions of the visit to Bloggs' Auckland were:

1) Power factor correction is required. According to Joe Bloggs, owner of Bloggs' Auckland, the building was found to have an average power factor of 0.88 when the electricity use is at peak demand (11 am). This is unnecessarily low. Increasing the power factor will provide network cost savings.
2) The lighting scheme is in need of updating. Most of the lamps in the main warehouse area were self-ballasted mercury vapour and their power could be reduced by at least 50% if more efficient lamps were used and reflectors were installed to deflect light down towards where it is needed. The warehouse fluorescents also use 38 mm diameter (T12) lamps. Changing these to 26 mm (T8) lamps will reduce the wattage while retaining the same light output. There were also many incandescent bulbs found in the office area that should be replaced with compact fluorescents.
3) Energy management is just beginning to be considered at Bloggs' Frieght. Once an energy management programme is up and running, with all staff informed of their responsibilities, energy efficiency should increase.
4) A level 2 energy audit is likely to uncover considerable energy savings, as energy use awareness is not evident, and a handful of potential energy efficiency improvements were found in a short space of time without comprehensive searching.

5. Tariff Analysis

5.1 Natural Gas - Auckland

Natural gas, available only from BloggsGas, is priced at $7.50/ day (fixed charge) plus $11.06/ GJ (or 3.98 ¢/ kWh). These prices are exclusive of GST.

For last year, the average gas price was 4.00 ¢/ kWh including fixed charges.. The ***gross*** price, used when evaluating measures from energy purchases, is 3.98 ¢/ kWh. This is the marginal cost of saving one kWh of gas from being purchased.

5.2 Electricity – Auckland

The following tariffs are the choices available from BloggsPower as of February 2002. These prices are all exclusive of GST. Bloggs' Auckland is presently on the Time of Use tariff.

Standard Tariff

All units (energy plus demand)	11.65 ¢/ kWh

Day/Night Tariff

Day Time units (7 AM - 11 PM, energy plus demand)	14.10 ¢/ kWh
Night Time units (11 PM - 7 AM, energy plus demand)	6.75 ¢/ kWh

Time of Use

Time of Use prices	**Weekday (exc. statutory holidays)**		**Weekend (inc. statutory holidays)**	
Auckland	**Day (7 am – 11 pm)**	**Night (11 pm – 7 am)**	**Day (7 am – 11 pm)**	**Night (11 am – 7 am)**
Summer (Oct - Apr)	6.82 ¢/ kWh	4.49 ¢/ kWh	6.52 ¢/ kWh	4.21 ¢/ kWh
Winter (May - Sep)	7.64 ¢/ kWh	4.49 ¢/ kWh	7.28 ¢/ kWh	4.21 ¢/ kWh

Monthly Maximum Demand (highest half-hourly average load) is $12.08/ kVA (per month)

For calculations, the price of electricity is taken as **11.02 ¢/kWh** for units used across all 24 hours. This is the average price of electricity, including network charges, on the present tariff.

According to the electricity meter readings supplied by BloggsPower, Bloggs' Auckland is on the "Time of Use" electricity tariff. Under this tariff, the annual electricity energy use is 755,356 kWh/ year, at an annual total cost of **$83,249/year**. This gives an average price of **11.02 ¢/kWh.**

This is a quite low price, as evidenced by comparison with the alternative options.

By comparison, at the Standard Tariff rate of 11.65 ¢/ kWh, the annual electric energy cost would be:

755,356 kWh/ yr x $0.1165/ kWh = **$133,594/year**

And, on the Day/ Night Tariff of 14.10 ¢/ kWh for day time units and 6.75 ¢/ kWh for night time units, the annual electric energy cost would be:

Day	631,455 kWh/ yr	x $0.1410/ kWh	= $89,035/ year
Night	123,901 kWh/ yr	x $0.0675/ kWh	= $8,364/ year
Total	755,356 kWh/ yr		= **$97,399/year**

There may be savings in energy costs by tendering competitively for electricity and gas supplies. But this requires a reasonable amount of analysis and negotiation, which is beyond the scope of this report.

5.3 Electricity – Christchurch

The following tariffs are the choices available from BloggsPower as of February 2002. These prices are all exclusive of GST. Bloggs' Christchurch is presently on the Time of Use tariff.

Standard Tariff

All units (energy plus demand) 10.48 ¢/ kWh

Day/Night Tariff

Day Time units (7 AM - 11 PM, energy plus demand) 13.40 ¢/ kWh
Night Time units (11 PM - 7 AM, energy plus demand) 6.25 ¢/ kWh

Time of Use

Time of Use prices	**Weekday (exc. statutory holidays)**		**Weekend (inc. statutory holidays)**	
Christchurch	**Day (7 am – 11 pm)**	**Night (11 pm – 7 am)**	**Day (7 am – 11 pm)**	**Night (11 am – 7 am)**
Summer (Oct - Apr)	6.40 ¢/ kWh	4.49 ¢/ kWh	6.18 ¢/ kWh	4.21 ¢/ kWh
Winter (May - Sep)	7.05 ¢/ kWh	4.49 ¢/ kWh	6.77 ¢/ kWh	4.21 ¢/ kWh

Monthly Maximum Demand (highest half-hourly average load) is $12.08/ kVA (per month).

For calculations, the price of electricity is taken as **9.79 ¢/kWh** for units used across all 24 hours. This is the average price of electricity, including network charges, on the present tariff.

According to the BloggsPower invoices, Bloggs' Christchurch is on the "Time of Use" electricity tariff. Under this tariff, the annual electricity energy use is 435,067 kWh/ year, at an annual total cost of **$42,589/year**. This gives an average price of **9.79 ¢/kWh.**
This is a quite low price, as evidenced by comparison with the alternative options.

By comparison, at the Standard Tariff rate of 10.48 ¢/ kWh, the annual electric energy cost would be:

435,067 kWh/ yr x $0.1048/ kWh = **$45,595/year**

And, on the Day/ Night Tariff of 13.40 ¢/ kWh for day time units and 6.25 ¢/ kWh for night time units the annual electric energy cost would be:

Day	(358,216 kWh/ yr)	x ($0.1340/ kWh)	= $48,001/ year
Night	(76,851 kWh/ yr)	x ($0.0625/ kWh)	= $4,803/ year
Total	(435,067 kWh/ yr)		= **$52,804/year**

Again, there may be savings in energy costs by tendering competitively for electricity supplies. But this requires a reasonable amount of analysis and negotiation, which is beyond the scope of this report.

5.4 Coal – Christchurch

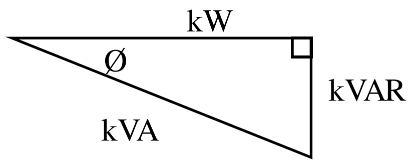
Coal was purchased from Smokin' Energy at $85/ tonne. The is Reefton coal, graded at 23.2 GJ/ tonne, or 6444 kWh/ tonne. This corresponds to **1.32 ¢/kWh.**

6. Recommendations

Install power factor correction at the Bloggs' Auckland. The power factor at Bloggs' Auckland during peak demand is 0.88. This should be improved.

BloggsPower bases their network charges on peak demands in kVA, which equal the kW of actual power demand divided by the power factor. Motors and lights cause a reduction in power factor, because of the nature of their operation. Power factor correction circuitry is often installed to bring this close to unity, so excess kVA charges can be avoided.

The effect of power factor is calculated from the "Power Triangle", as shown below.



This is a right angled triangle with kW (real power) on the horizontal axis, kVAr (reactive power) on the vertical axis, and kVA (charged power) on the hypotenuse. The angle between kW and kVA is the phase angle, Ø. The ratio of the kW to kVA is, geometrically, the cosine of the phase angle, and is called the power factor. The other elements can be determined from basic trigonometry.

In this case, we know that the peak kVA at the Auckland warehouse is about 240 kVA, and the power factor at that point is 0.88.

Thus, peak power factor = kW / kVA = cosine Ø.

kW = kVA x cosine Ø = (240 kVA) x (0.88) = 211 kW.

If cosine Ø = 0.88, then Ø = arc cosine (0.88) = 28.4°

Then, kVAr = kVA x sine Ø = (240 kVA) x (sine 28.4°)

= (240 kVA) x (0.476) = 114 kVAr. (inductive)

If 100 kVAr (capacitive) of power factor correction is added, this will result in 14 kVAr (inductive).

With the same kW load, the new power factor phase angle will be

tangent Ø = kVAr / kW , or Ø = arc tangent (14 / 211) = 3.8°

So, power factor = cosine Ø = cosine (3.8°) = .9978

And the resulting kVA = kW / cosine Ø = 211 kW / 0.9978 = 211.4 kVA.

As kVA are charged to the nearest one, this will save (240 - 211) = 29 kVA of network charges.

Savings = 29 kVA x $12.08/ kVA month x 12 months/ year = $**4,204/yr (say 4,200/yr)**

Install 26 mm diameter fluorescent tubes. A typical 1200 mm long, 38 mm diameter fluorescent tube uses about 40 watts. This can be reduced to about 36 watts by using the newer generation of 26 mm diameter tubes. The fluorescent ballast draws about 9 watts in either case.

The fluorescent lights in the main warehouse are on about 10 hours/ day (8 AM–6 PM) 351 days per year. Thus the savings from switching from 38 mm diameter lamps to 26 mm diameter lamps is about:

(40 W – 36 W) x 10 hr/ day x 351 days/ year = 14 kWh/ year (per 1200 mm lamp)

At current electricity prices of about 11.02 ¢/ kWh (including peak charges), this is worth:

14 kWh/ year x $0.01102/ kWh = **$1.50/year (per 1200 mm lamp).**

This energy saving can be achieved at no cost (normally the 26 mm tubes have about a 10% lower price) by changing to 26 mm diameter tubes during normal replacement.

However, if a new 38 mm diameter lamp must be thrown away, and replaced with a ($10) 26 mm diameter lamp (if replacements are done for energy saving alone, instead of during normal maintenance), then the “Simple Payback” for this is:

Simple payback = Capital cost / Annual savings = $10 / ($1.50/ year) = 7 years.

Thus, this improvement is best done during regular lighting maintenance.

The energy saving are proportionally larger for larger lamps.

There were 48 of the old style 38 mm diameter fluorescent lamps noted at Bloggs’ Auckland during the site visit. At an average $1.50/ year energy savings from each, the total annual savings from replacing them would be **$72/yr**.

The quality control problems that characterised the original batch of 26 mm tubes that was made in New Zealand in the 1980s have long ago been resolved, and all the fluorescent tubes currently sold in New Zealand are imported from Australia or Asia. However, bad memories still linger, and some facilities, to their detriment, still avoid 26 mm tubes.

Install reflectors on fluorescent lights. Imaging specular reflectors are a technology that uses mirrors to roughly double the light output from normal fluorescent lights.

The Bloggs' Auckland warehouse contains 120 36W fluorescent lamps, in use about 10 hours/ day. Their annual energy use would be:

120 lights x 36W/ light x 10 hours/ day x 365 days/ yr = 15,768 kWh/ yr.

This is worth:

15,768 kWh/ yr x $0.01102/ kWh = $1,738/ yr

Reflectors could save about half of this, or about **$850/yr** and maintain the same illumination.

Investigate the gas consumption over summer. Bloggs' Auckland uses about 60 MWh of gas during the 3-month summer period. During the summer there should be no need for heating in Auckland. If the gas is being used for heating it should be shut off. Assuming 10% of the curren t gas use is used for water heating and kitchen use, the savings could be:

60,000 kWh/ yr x 4 c/ kWh x 90% (of gas is used for heating) = **$2,160/yr**

It is likely that the gas is being used for legitimate reasons, but it is worth checking as part of a Level 2 energy audit of these facilities.

Continue a comprehensive planned maintenance programme carrying out all recommended maintenance at the specified intervals in hours. The influence that quality of maintenance has on energy use should not be underestimated. The efficiencies of mechanical equipment in general can be increased typically by 10 to 15% by proper maintenance. Improved maintenance is generally a very accessible and cost-effective efficiency improving measure.

Install compact fluorescent bulbs in the smaller warehouse. In the offices of Bloggs' Auckland, there are 60 100 W light bulbs running from 8 AM till about 6 PM, 351 days a year.

The annual operating time of these bulbs is about

(10 hours/ day) x (365 days/ year) = 3,650 (say 3,600) hours/ year

These bulbs have about a 1000 hour life, so they are probably replaced about every two months.

Their annual energy use is:

(100 Watts) x (3,600 hours/ year) = 360 kWh/ year, per lamp

The annual cost of running these lamps is:

(360 kWh/ year) x ($0.01102/ kWh) = $39.60/ year (say $40/ year) per lamp

Compact fluorescent lamps would provide as much light at about one-quarter the energy use, and with about ten times the lifetime.

The annual energy savings of a 25 Watt compact fluorescent replacing a 100 Watt bulb is:

(3/ 4) x ($40/ year) = **$30/year (per lamp).**

These also allow maintenance savings from not having to replace the bulbs as often. If these avoid the cost of six light bulbs per year, at $1 each (excluding the cost of labour), the total savings are:

$30/ year + (6 x $1) = **$36/year (per lamp).**

Thus, the total annual cost savings would be

60 lamps x $36/ year (per lamp) = **$2,160/year.**

However, these savings would be offset by some extra heating requirement. Assuming the warehouse needed heating for 200 days/ year, for the whole 10 hours/ day of operation, then the extra heat required to make up the lost heat from the more efficient lights would be:

200 days/ year x 10 hour/ day x 60 lamps x (100 – 25) W/ lamp = **9,000 kWh/yr**

The cost of gas heat to make this up would be:

9,000 kWh/ yr x $0.04/ kWh = **$360/year**

Thus the net annual energy cost savings would be:

$2,160/ year – $360/ year = **$1,800/year**

The cost of compact fluorescents is between $25 and $50 per lamp. At an average price of $35, the total cost would be:

60 lamps x $35/ lamp = $2,100

This would yield a "simple payback" of 1.2 years, corresponding to a rate of return of 85%/ year.

Perform energy audits to at least level 2 standard. Energy savings have already been found at Auckland after a brief visit. A more thorough investigation will undoubtedly uncover even more energy savings.

Bloggs' Christchurch should also be audited, as it has a very high EUI (373 kWh/ m^2 year). If Bloggs' Christchurch dropped its EUI to 250 kWh/ m2 year, the following savings would result:

373 kWh/ yr.m^2 – 250 kWh/ yr.m^2	= 123 kWh/ yr.m^2
123 kWh/ yr.m^2 x 2,591 m^2	= 318,693 kWh/ yr
318,693 kWh/ yr x 5.13 c/ kWh	**= $16,350/yr, say $16,000/yr**

There may be operations that are performed at Christchurch and not at Auckland, which cause it to be more energy intensive. However, if it is found on the site visit to Christchurch that the two warehouses operate similarly, the Christchurch warehouse EUI may be able to be reduced further.

Replace self-ballasted mercury vapour with metal halide reflector lights. Many storage areas are illuminated using Mercury Vapour lamps, which are quite inefficient. A Metal Halide lamp will provide as much luminous flux (light output) as a Mercury Vapour lamp but at a much lower wattage. The Mercury Vapour lamps are 500W self ballasted, which provide 13,000 lm (26 lumens/ watt) when new. The same light output and lamp life can be provided by a Metal Halide lamp rated at only 150W, or 163W including ballast (at 80 lumens/ watt). During the site visit 36 Mercury Vapour lamps were counted.

Each Metal Halide lamp saves:

500 W	-	163 W		= 337 W

The lamps are on for an average 10 hours per day, which is:

10 hours/ day	x	315 days/ yr			= 3,510 hours
36 lamps	x	337 W/ lamp	x	3,510 hrs/ yr	= 42,583 kWh/ yr, worth
42,583 x	11.02 c/ kWh				**= $4,693/yr (say $4,700/yr)**

The cost provided by Philips New Zealand of a suitable metal halide lamp (Philips CDM-TP) to replace the mercury vapour lamps is about $190 each (including control gear). The lamps have the same GES base as Mercury Vapour lamps and thus the whole fitting does not need to be replaced. Since this is a direct lamp replacement, labour cost will be minimal and is estimated at $20/ lamp.

36 lamps	x	$210/ lamp	= $7,560

The simple payback is:

$7,560 / $4,693 **= 1.6 years**

To refit the lighting optimally, it will be possible to improve the existing layout and thus to reduce the number of lamps present, making larger savings than those shown above. However, this will require more design and installation costs, and was not calculated in detail.