Small Business Lighting Audit and Retrofit Program

May 2010

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1 Executive Summary

This report summarises the outcomes for the Small Business Lighting Audit and Refit Program.

The objective for the program was to explore the potential opportunities for energy, greenhouse, cost and demand reductions from lighting retrofits in small businesses. The project was funded and project managed by Ausgrid.

A small high street in Sydney was chosen as it was considered to represent a typical high street of mixed retail and office type small businesses and was relatively well defined so that program participation was clear and limited to ensure a relatively modest project scale.

Access to the program was restricted to small businesses.

The NSW Department of Environment, Climate Change and Water (DECCW) were invited to collaborate on the program to assist in the development of DECCW's Small Business Energy Efficiency program. DECCW's involvement was restricted to providing financial assistance.

Further assistance was provided by the local Chamber of Commerce

The findings from the program are summarised as follows:

The total potential savings from the 42 lighting audits and the actual estimated savings based upon the implementation are listed below.

	Pre-refit Lighting kWh	% Total Bill	Savings kWh	% Lighting Savings	Savings kW	Savings $	Cost $	Simple Payback years
Total potential	386,033	23%	129,641	33%	36.5	$23,529	$114,170	4.9
Total actual	325,495	22%	111,696	34%	31.2	$20,020	$89,450	4.5

The range of lighting retrofit measures is summarised below:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years	% Overall Savings
Tubular fluorescent	415	40,542	11,521	$7,303	$53,250	7.3	31%
Lamp or ballast only	416	20,967	5,657	$4,005	$13,262	3.3	16%
IRC Downlights & Electronic transformers	564	52,412	14,472	$9,580	$33,661	3.5	41%
Miscellaneous	128	14,989	4,882	$2,350	$13,740	5.8	12%

For each of the retrofit options, the average abatement and demand reduction implementation costs were:

Refit Type	% Total Savings	$ per tonne	$/kW
Tubular fluorescent	31%	$1,228	$4,620
Lamp only	13%	$310	$1,260
Ballast only	3%	$1,635	$5,950
Downlights	41%	$600	$2,325
Metal halide	4%	$1,155	$3,020

Some conclusions which could be drawn from the program are:

- Low voltage downlights offer the largest (41% of total) and best opportunity to save energy, demand, greenhouse and costs with lighting in the small businesses trialled.
- Fluorescent lighting retrofits comprise the second largest component (31%) of the available energy efficiency opportunities from lighting in the small businesses trialled, but at a higher cost and increased complexity.
- Lighting comprises about a quarter of the total energy use in the small businesses trialled.
- Overall lighting savings of a third are possible.
- Program success rates of 80% are viable where there is no cost for the offer, but do require significant marketing, acquisition and program management resources.

Recommendations from this study would be to:

- Trial a downlight replacement program to further explore the potential energy, cost, demand and greenhouse savings.
- Circulate findings to Government to assist in policy and program development.
- Trial the sensitivity of the program success rate with participant cost.

2 Program Design & Objective

2.1 Objective

The objective for the program was to explore the potential opportunities for energy, greenhouse, cost and demand reductions from lighting retrofits in small businesses.

Development for Ausgrid's customer support programs identified small business energy efficiency as an area of interest and the delivery of an effective program which directly saved energy, greenhouse and costs for small businesses was selected as a preferred solution.

A number of factors were considered in selecting lighting as the preferred focus of the trial program. Key criteria in selecting preferred efficiency retrofit types were:

- saves energy, greenhouse and costs
- opportunities available to a wide variety of businesses
- unlikely to be perceived as negatively impacting business operations
- did not unnecessarily involve business process equipment
- relatively low cost payback (less than 10 year simple)
- easily understood and promoted

2.2 Energy use by Small Business

The definition of small business often varies, but for this review we have used those customers identified as 'Business' customers and billed under a network tariff where the annual consumption is less than 750,000 kWh. The total energy use by small and large non-residential and residential sectors in Ausgrid's network area is as follows:

- 32% residential
- 47% large site non-residential (>750,000 kWh pa)
- 21% small site non-residential (<750,000 kWh pa)

Within the small site non-residential sector, the breakdown for 2007/08 was:

- 25% Inclining block (EA050) and controlled load (EA030, EA040)
- 9% time of use < 40,000 kWh pa (EA225)
- 29% time of use 40-160,000 kWh pa (EA302)
- 37% time of use 160-750,000 kWh pa (EA305)

For the purposes of this trial, no specific small business sector was selected, but was based geographically. Of the 42 businesses audited as part of the program, 27 or 52% were on Tariff EA050, 11 or 26% were on Tariff EA302 and 5 or 12% were on Tariff EA305.

2.3 Program Design

The objective for the program was to explore the potential opportunities for energy, greenhouse, cost and demand reductions from lighting retrofits. The program offered the opportunity to explore both the opportunities available from lighting retrofits, but also an opportunity to test a variety of aspects of program design.

In order to identify all potential lighting refit options, all recommended lighting options would be implemented with no cost or payback cap set. In addition, the audit, design and install elements of the program were delivered in three slightly different ways.

For the first five businesses, the audit, design and install were delivered by a single lighting firm specialising in lighting design.

For the second package of sites, the lighting audit and install arm of a large lighting supplier delivered all aspects.

For the final package, a lighting contractor completed the audit, design and install for each site.

This mix of delivery models was not pre-planned, but was the result of program delivery difficulties leading to alternative approaches.

Funding for the program came from Ausgrid and the NSW Department of Environment and Climate Change (DECC). The decision to partner with DECC was not financial, but to engage with the primary government agency involved with energy efficiency programs in NSW and who were in the process of developing an energy efficiency support program for small businesses.

2.4 Local Business District

The selected high street was chosen as it both represented a common high street of mixed retail and office type businesses and was relatively well defined so that program participation was clear, and limited to ensure a modest project scale

A total of 58 businesses were identified as operating within this area, comprising a range of retail and office services. A breakdown of the business type was as follows:

ANZSIC Category	No. of Businesses
Retail - Personal & Household Goods	6
Retail – Food & Alcohol	6
Retail – Other Store	3
Cafes & Restaurants	7
Health Care	8
Other Services – Hair & Beauty	4
Other Services - Personal	1
Other Services – Repair & Maintenance	1
Other Services – Motor Vehicle Parts	1
Professional Services	9
Administration and Support Services	2
Vacant or closing	10

3 Results

3.1 Stage 1

Stage 1 of the program involved a lighting audit and refit at five businesses. The initial approach for Stage 1 was through the local Chamber of Commerce. The involvement of the Chamber of Commerce and, in particular, the participation by the business owned and operated by the chamber president, provided an endorsement to other businesses which simplified the time and costs commonly associated with signing up participants to a program.

A specialised lighting designer and associated installer were hired to complete the audits and provide retrofit recommendations for stage one of the program. This initial approach was selected as the capability to provide the design and installation service as a package would minimise overlap of tasks, reduce the time from audit to install and avoid misunderstandings or debate between the designer and the installer. The firms' design capabilities were also seen as a significant benefit and would potentially ensure that a thorough list of opportunities would be identified and lighting quality would not be negatively impacted.

Program participation was agreed with each business with a signed letter of agreement from each business.

The five audits were completed in first week of November, with savings reports provided to each business at the end of 2nd week of November, 2008. This report summarised their current electricity costs and estimated savings from the lighting retrofit.

After agreement was reached on the proposed lighting retrofit, installation works were carried out for all sites in the 3rd week of November, 2008. The summary savings from Stage 1 were:

Business	Pre-refit Lighting kWh	% Total Bill	Savings kWh	Savings kW	Savings $	Cost $	Simple Payback years
Business 1	5,426	42%	2,636	1.1	$545	$2,156	4.0
Business 2	9,088	63%	3,233	0.9	$491	$2,317	4.7
Business 3	7,258	85%	3,164	0.9	$483	$1,618	3.4
Business 4	7,259	59%	3,608	0.7	$720	$1,397	1.9
Business 5	2,187	26%	694	0.2	$109	$980	8.9

For this phase, there were eight separate lighting retrofit types, summarised as follows:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years
2 lamp T8 Elec fluorescent	1	208	69	$32	$200	6.3
1 lamp T8 Elec fluorescent	22	3,339	1,204	$606	$2,745	4.5
1 lamp T5 Elec fluorescent	12	890	303	$158	$1,650	10.4
Ballast only	2	438	50	$67	$200	3.0
IRC Downlight & Elec trans	68	5,520	1,768	$842	$3,076	3.7
Removal and timers	19	2,940	443	$472	$605	1.3

The replacement of 50 watt low voltage halogen downlights and the associated transformer with a more efficient infra red coated (IRC) downlight and electronic transformer generated over 40% of the savings, with tube fluorescent retrofits comprising 33% of savings, magnetic to electronic ballast replacement 3%, metal halide refits 3% and other retrofit options 19%. Savings from the miscellaneous retrofit options involved the removal of unnecessary lamps or fixtures and the installation of timers to control lighting.

Paybacks for the downlight and ballast replacements generated attractive 3-4 year paybacks, while the fluorescent refits averaged 5.8 years. The miscellaneous lighting options had only a 1.3 year payback. Note that all costs listed include all contractor and audit costs but do not include the program management, marketing or participant acquisition.

The process of securing agreement from business owners to proceed with the no cost lighting retrofit was not straightforward as owners sought to understand the impact upon their business and seek assurances that the changes would be beneficial. Typically this process required the supply of an energy review and sometimes considerable discussions by Ausgrid and contractor staff to explain the project scope and benefits.

Following discussions, all five businesses in phase 1 proceeded with the recommended implementation.

During this stage, some difficulty was experienced with the lighting designer / contractor and the decision was made to proceed with the remainder of the program using an alternate service provider. These difficulties were not associated with the quality or service provided to the business participant and did not impact upon the lighting retrofits provided.

3.2 Stage 2

For stage 2 of the program, a large lighting supplier was hired to complete the audit, design and install of lighting retrofits of a further package of 12 businesses. The firm has a turnkey design and install service business, which it typically offers to large businesses. For this program, the contractor agreed to supply these services to the small businesses participating in the program. The install element was completed by a subcontractor commonly used by the business.

Following the completion of stage one, the remaining local business owners were invited to view the lighting retrofits completed to date and speak with the owners of the five businesses.

Similarly to Stage 1, program participation was agreed with each business with a signed letter of agreement from each business and an energy savings report was provided to the business following the completion of the lighting audit.

Lighting audits were carried out in late November to mid December of 2008.

After agreement was reached on the proposed lighting retrofit, installation works were carried out in January 2009. The summary measures and savings from Stage 2 were:

Business	Pre-refit Lighting kWh	% Total Bill	Savings kWh	Savings kW	Savings $	Cost $	Simple Payback years
Business 6	13,221	21%	3,493	0.8	$507	$3,460	6.8
Business 7	26,122	20%	7,740	1.8	$1,295	$2,325	1.8
Business 8	10,330	45%	5,018	1.5	$1,139	$5,010	4.4
Business 9	5,229	7%	1,871	0.6	$296	$1,260	4.3
Business 10	26,875	26%	10,704	2.3	$1,765	$10,365	5.9
Business 11	9,335	67%	2,677	0.8	$607	$2,990	4.9
Business 12	1,172	23%	323	0.1	$49	$155	3.2
Business 12	1,187	29%	252	0.0	$38	$1,130	29.5
Business 14	12,939	30%	3,947	1.2	$853	$1,430	1.7
Business 15	3,443	7%	1,328	0.4	$221	$2,320	10.5
Business 16	12,707	13%	2,290	0.5	$407	$2,510	6.2
Business 17	23,332	43%	2,223	1.6	$605	$9,345	15.4

For this phase, there were eight separate lighting retrofit types, summarised as follows:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years
2 lamp T8 Elec fluorescent	19	3,975	914	$620	$3,150	5.1
2 lamp T5 Elec fluorescent	8	469	120	$78	$880	11.2
1 lamp T8 Elec fluorescent	119	16,969	3,905	$3,018	$20,135	6.7
Lamp only	187	10,120	2,468	$1,854	$1,930	1.0
Ballast only	77	3,171	1,029	$777	$6,430	8.3
IRC Downlight & Elec trans	122	9,469	2,980	$2,076	$7,855	3.8
Misc (inc removal of unnecessary fixtures)	10	-2,424	0	-$660	$1,920	-2.9

The replacement of 50 watt halogen downlights and the associated transformer with a more efficient infra red coated (IRC) low voltage downlight and electronic transformer generated 23% of the savings, with tube fluorescent retrofits comprising 51% of savings and lamp or ballast replacement 32%. Metal halide refits resulted in a 6% increase where the recommended design called for increasing the lighting wattage to improve the lighting in the space.

Paybacks for the downlight refits and lamp replacement generated attractive 3.8 and 1.0 year paybacks respectively, while the fluorescent refits averaged 6.5 years. Ballast replacement measures averaged over 8 years to pay back and the halogen retrofits resulted in increased electricity costs.

The difficulty in securing agreement from business owners to proceed with the no cost lighting retrofit was demonstrated in this phase, with 3 of the 12 businesses deciding not to proceed. The reasons provided for not proceeding were varied:

- could not be convinced of the potential savings
- did not like the look of the single lamp fluorescent fixtures with reflectors as a replacement for two lamp fixtures.
- claimed that the existing fluorescent lamps and fittings were unique and declined our offer of a retrofit.

These 3 projects comprised almost half the savings in this phase.

3.2.1 Stage 2 Light Levels

Lighting levels were obtained pre and post retrofit for 6 of the sites in this stage of the project. Light levels were reported as higher at all 6 sites post-retrofit, with 2 sites recording significantly higher light levels. The readings are as follows:

Site	Pre-refit average lm	Post-refit average lm	% Change
Business 16	400	695	74%
Business 15	200	880	340%
Business 9	270	291	8%
Business 6	200	426	113%
Business 7	160	164	3%
Business 14	217	220	2%

3.3 Stage 3

In stage 3 of the program, the installation contractor in stage 2 was commissioned to supply the complete audit, design and installation services for a further package of 13 businesses. The firm offered design services, and provided the option of testing an installer's perspective for the audit and design services.

Similarly to earlier stages, program participation was agreed with each business with a signed letter of agreement from each business and an energy savings report was provided to the business.

Lighting audits were carried out in mid December of 2008, with energy reviews provided to the business in mid January 2009.

After agreement was reached on the proposed lighting retrofit, installation works were carried out in February to March 2009. The summary measures and savings from Stage 3 were:

Business	Pre-refit Lighting kWh	% Total Bill	Savings kWh	Savings kW	Savings $	Cost $	Simple Payback years
Business 18	7,846	15%	1,611	0.5	$318	$2,292	7.2
Business 19	5,766	27%	2,952	1.0	$605	$2,215	3.7
Business 20	3,020	15%	606	0.2	$119	$1,886	15.8
Business 21	25,154	46%	7,728	2.4	$1,456	$6,516	4.5
Business 22	4,514	25%	1,388	0.1	$143	$1,132	7.9
Business 23	5,669	28%	1,894	0.6	$430	$1,374	3.2
Business 24	2,438	21%	823	0.3	$166	$1,442	8.7
Business 25	928	34%	353	0.3	$54	$982	18.3
Business 26	6,032	59%	2,153	0.8	$389	$1,720	4.4
Business 27	3,803	61%	709	0.2	$108	$792	7.4
Business 28	5,903	16%	2,328	1.1	$458	$2,594	5.7
Business 29	22,422	15%	6,027	1.6	$815	$3,827	4.7
Business 30	51,146	17%	19,918	3.4	$3,208	$6,850	2.1

For this phase, there were eight separate lighting retrofit types, summarised as follows:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years
2 lamp T5 Elec fluorescent	106	7,145	2,563	$1,334	$9,765	7.3
1 lamp T8 Elec fluorescent	1	81	27	$11	$75	6.8
1 lamp T5 Elec fluorescent	31	2,207	724	$428	$2,275	5.3
Lamp only	81	3,918	913	$662	$2,282	3.4
IRC Downlight & Elec trans	261	29,564	6,786	$5,040	$14,820	2.9
Misc (inc removal of unnecessary fixtures)	51	5,573	1,457	$794	$4,150	5.2

The replacement of 50 watt low voltage halogen downlights and the associated transformer with a more efficient infra red coated (IRC) downlight and electronic transformer generated 61% of the savings, with tube fluorescent retrofits comprising 20% of savings, metal halide retrofits 11% and lamp replacement 8%.

Paybacks for the downlight refits and lamp replacement generated attractive 2.9 and 3.4 year paybacks respectively, while the fluorescent refits averaged 6.8 years. The metal halide retrofits averaged 5.2 years to payback the investment.

All 13 businesses in this phase proceeded with the implementation.

3.4 Stage 4

To ensure that all businesses in the high street were given the opportunity to participate in the program, all remaining businesses were approached. Following this process, a further package of 12 businesses was signed up.

In stage 4 of the program, the contractor in stage 3 was commissioned to supply the complete audit, design and installation services for all remaining businesses. Similarly to earlier stages, program participation was agreed with each business with a signed letter of agreement from each business and an energy savings report was provided to the business.

Lighting audits were carried out in mid to late February, 2009, with energy reviews provided to the business in March 2009.

After agreement was reached on the proposed lighting retrofit, installation works were carried out in March to April 2009. The summary measures and savings from Stage 4 were:

Business	Pre-refit Lighting kWh	% Total Bill	Savings kWh	Savings kW	Savings $	Cost $	Simple Payback years
Business 31	3,594	48%	1,460	0.7	$222	$1,890	8.5
Business 32	8,444	41%	3,459	1.1	$785	$3,285	4.2
Business 33	15,404	33%	3,010	0.8	$539	$7,640	14.2
Business 34	1,986	52%	1,037	0.4	$158	$1,110	7.0
Business 35	4,310	22%	3,706	1.0	$841	$3,370	4.0
Business 36	992	26%	668	0.3	$110	$810	7.3
Business 37	468	26%	359	0.1	$59	$335	5.7
Business 38	208	26%	164	0.2	$27	$335	12.3
Business 39	8,385	19%	3,824	1.3	$652	$2,940	4.5
Business 40	15,321	24%	5,734	2.2	$1,302	$4,960	3.8
Business 41	4,575	24%	1,610	0.6	$287	$2,320	8.1
Business 42	597	65%	307	0.1	$47	$785	16.8

For this phase, there were ten separate lighting retrofit types, summarised as follows:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years
2 lamp T8 Elec fluorescent	1	-139	-47	-$24	$200	-8.4
2 lamp T5 Elec fluorescent	31	2,502	896	$502	$4,550	9.1
1 lamp T8 Elec fluorescent	2	116	36	$26	$150	5.7
1 lamp T5 Elec fluorescent	62	2,779	807	$513	$7,475	14.6
Lamp only	40	2,475	965	$494	$1,260	2.5
Ballast only	29	844	232	$151	$1,160	7.7
IRC Downlight & Elec trans	113	7,859	2,938	$1,623	$7,910	4.9
Misc (inc removal of unnecessary fixtures)	48	8,901	2,982	$1,743	$7,065	4.1

The replacement of 50 watt low voltage halogen downlights and the associated transformer with a more efficient infra red coated (IRC) downlight and electronic transformer generated 31% of the savings, with tube fluorescent retrofits comprising 21% of savings, metal halide retrofits 11% and lamp and ballast replacement 13%, CFL install 6% and miscellaneous refits 19%.

The miscellaneous retrofits involved new fittings with efficient halogen A-type bulbs and LED lighting.

Paybacks for the downlight refits and lamp replacement generated attractive 4.9 and 3.7 year paybacks respectively, while the fluorescent refits averaged 12.2 years. The metal halide retrofits averaged 5.3 years, CFL replacement 1.2 years and the miscellaneous retrofits 4.3 years to pay back the investment.

All 12 businesses in this phase proceeded with the implementation.

3.5 Summary

In total, 58 businesses in the high street were approached with 42 agreeing to the lighting audit or 72% of businesses. Of the 16 which did not accept the offer of a no cost audit and retrofit, 10 were identified as closing or no longer in business. Six businesses rejected the offer.

Of the 42 businesses receiving a lighting audit, 39 accepted the offer of a free installation, or 93%. Total take-up for all business addresses was 67%.

The total potential savings from the 42 lighting audits and the actual estimated savings based upon the implementation are listed below.

	Pre-refit Lighting kWh	% Total Bill	Savings kWh	% Lighting Savings	Savings kW	Savings $	Cost $	Simple Payback years
Total potential	386,033	23%	129,641	33%	36.5	$23,529	$114,170	4.9
Total actual	325,495	22%	111,696	34%	31.2	$20,020	$89,450	4.5

Based upon 39 implemented projects, savings were 2,864 kWh, 0.80 kW and $513 per business, saving, on average, 34% of the lighting energy use which typically comprised 22% of the overall business electricity use. Average costs for audit, design and implementation were $2,294 per business.

The average greenhouse emission reductions are calculated to be about 3 tonnes in NSW indicating an average implementation cost to abate of $760 per tonne. The average implementation cost per demand reduction was $4,220 per kW.

The range of lighting retrofit measures is summarised below:

Refit Type	Number	Savings kWh	Savings Watts	Savings $	Cost $	Simple Payback years	% Overall Savings
2 lamp T8 Elec fluorescent	21	4,044	936	$628	$3,550	5.7	3%
2 lamp T5 Elec fluorescent	145	10,117	3,579	$1,914	$15,195	7.9	8%
1 lamp T8 Elec fluorescent	144	20,506	5,172	$3,662	$23,105	6.3	16%
1 lamp T5 Elec fluorescent	105	5,875	1,834	$1,099	$11,400	10.4	5%
Lamp only	308	16,513	4,346	$3,010	$5,472	1.8	13%
Ballast only	108	4,453	1,311	$995	$7,790	7.8	16%
IRC Downlight & Elec trans	564	52,412	14,472	$9,580	$33,661	3.5	41%

CFL	31	2,065	707	$400	$2,110	5.3	2%
Metal halide	44	5,233	2,143	$480	$6,470	13.5	4%
Miscellaneous	53	7,691	2,032	$1,470	$5,160	3.5	6%

The replacement of 50 watt low voltage halogen downlights and the associated transformer with a more efficient infra red coated (IRC) downlight and electronic transformer generated 37% of the savings, with tube fluorescent retrofits comprising 27% of savings, metal halide retrofits 3% and lamp and ballast replacement 27%, CFL install 2% and miscellaneous refits 3%.

Paybacks for the downlight refits and lamp and ballast replacement generated attractive 3.5 and 3.3 year paybacks respectively, while the fluorescent refits averaged 7.3 years. The metal halide retrofits averaged 13.5 years, CFL replacement 5.3 years and the miscellaneous retrofits 3.5 years to pay back the investment.

For each of the main retrofit options, the average abatement and demand reduction implementation costs were:

Refit Type	% Total Savings	$ per tonne	$/kW
Tubular fluorescent	31%	$1,228	$4,620
Lamp only	13%	$310	$1,260
Ballast only	3%	$1,635	$5,950
Downlights	41%	$600	$2,325
Metal halide	4%	$1,155	$3,020

Note that the low cost for the lamp only option was skewed by the presence of over 120 incandescent bulbs with simple low cost retrofit options.

3.6 Downlight Research

Due to a combination of an attractive investment payback (avg 3.5 years) and significant identified opportunities (41% of savings), halogen downlight technology was researched further to explore the risks and benefits from a replacement program.

For the 42 businesses audited, 564 halogen downlights were identified with a total of 564 replaced. Typically, the lights previously installed were 50 watt dichroic halogen lamps with magnetic transformers. These transformers convert the mains voltage to the 24 volt operating voltage of the lamp and use about 10 watts when the lamp is on fully. Combined, the total power is about 60-62 watts per lamp.

The typical replacement recommended in the lighting audit was a 35 watt lamp paired with an electronic transformer using a total of about 36 watts per lamp. The resultant estimated savings is 25 watts per lamp and about 90 kWh for the average business operation (3575 hours per year) resulting in a bill savings of about $17 per lamp and transformer replaced. At an average cost of $60 per fitting, the average payback was a relatively low 3.5 years. Considering that the program design did not openly tender for the installation, program costs would likely be higher than would be achievable.

A brief review of the costs associated with the supply and install of halogen downlights indicates that supply and install costs of $35-50 per downlight would be achievable. This would result in a simple payback of 2 to 3 years.

To assist in confirming lamp efficacy and savings, a consultant was commissioned to test a range of lamps and ballast to determine performance. A total of 24 commonly available lamps and transformers were tested at the lighting laboratory at the Queensland University of Technology. The lamps were selected so as to represent the brands widely available and those claiming to offer an efficiency improvement over the standard lamp.

The average lumens for the range of lamps are shown in the chart below:

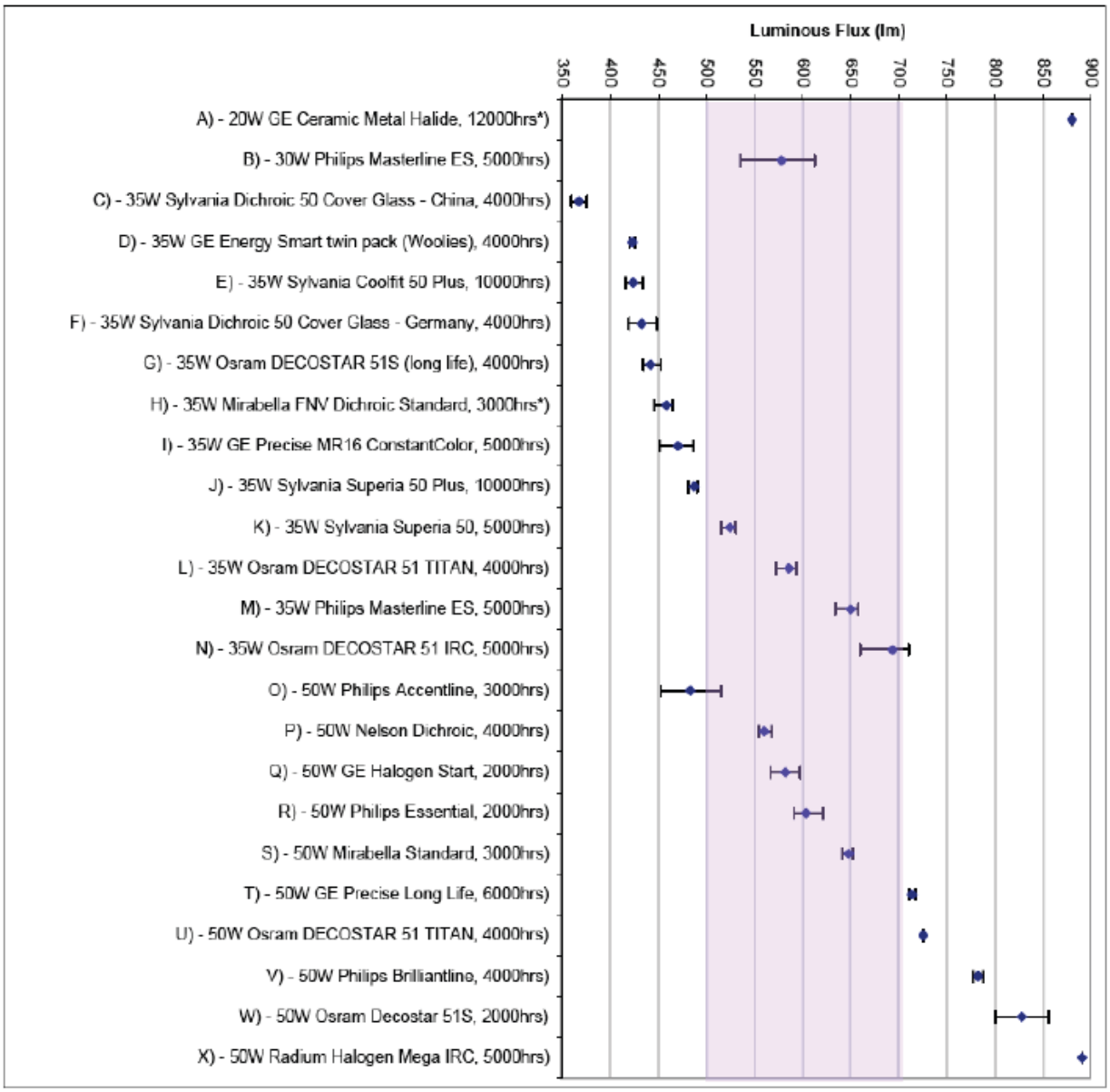

Figure 3 – Measured luminous flux

*Note – as discussed in section 3.1, model A (12˚ lamp) will tend to have over-estimated flux whereas model H (60˚ lamp) will tend to have under-estimated flux. This is expected to be in the order of around 10% for each lamp.

The lamp selected for the program was type N, the 35 watt Osram Decostar 51 IRC.

The average efficacy is described in the following chart.

Figure 4 graphs the average measured efficacy of each model (lamp only). this takes into account the light output and measured lamp power.

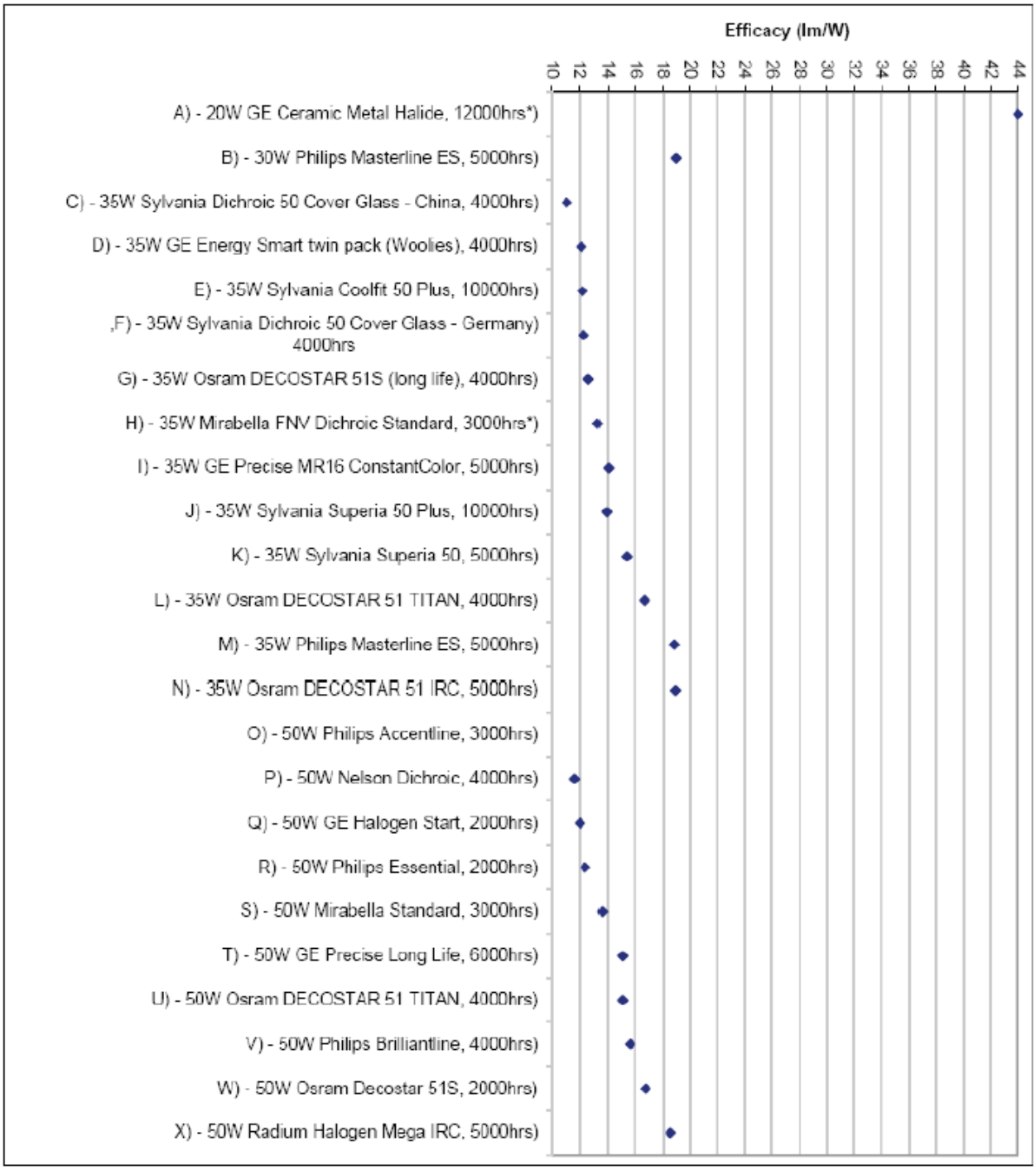

Figure 4 – Average measured lamp efficacy

Lamp types B, M and N were found to offer the most efficient replacement lamps for low voltage downlight replacements at about 19 lumens per watt. Typical downlights performed at 12-16 lumens per watt.

Several lamps were also tested with a range of transformers to identify the typical losses from the transformers. These losses are shown in the chart below:

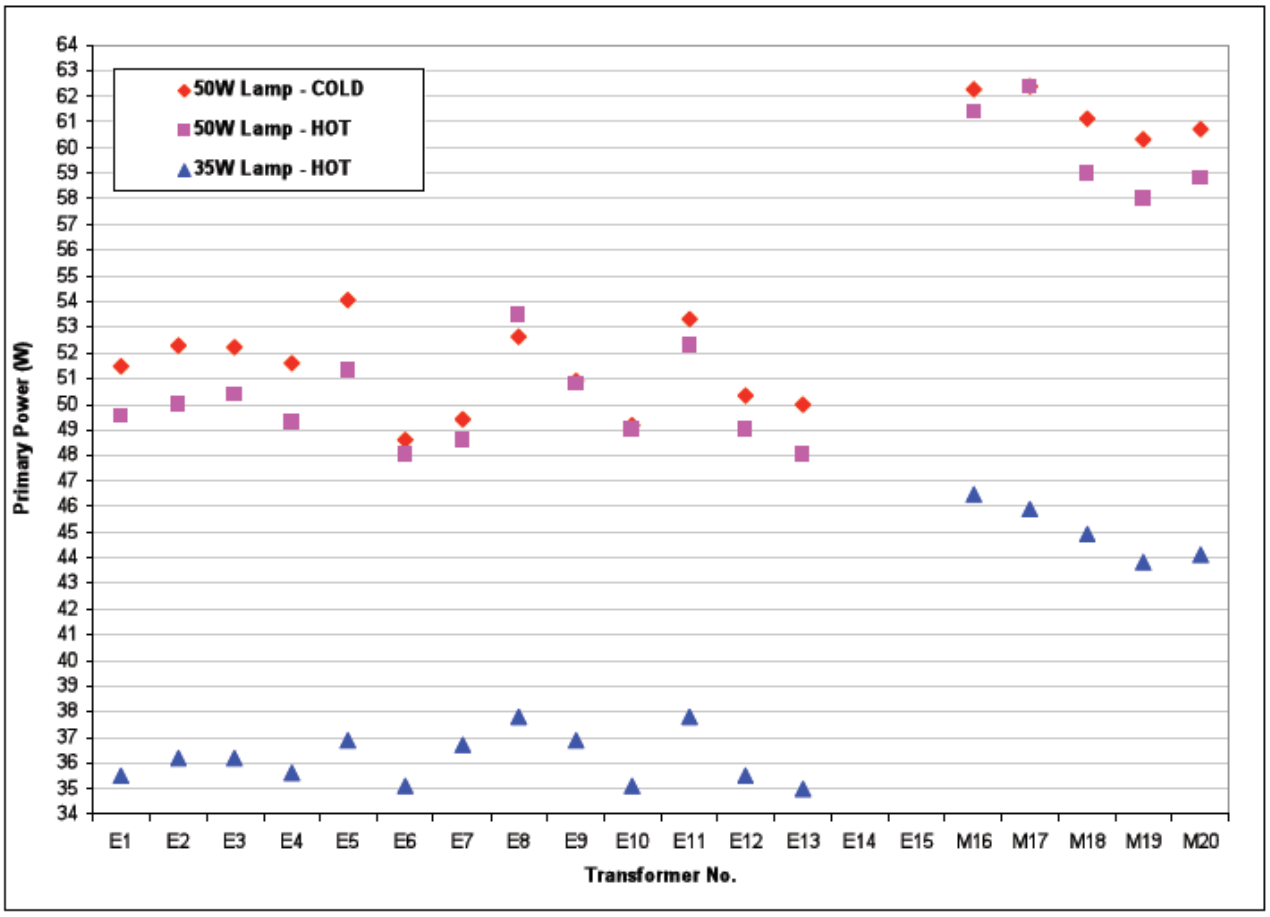

Figure 5 – Transformer primary power

For 35 watt lamps paired with electronic transformers, the samples tested had a power draw of about 35 to 38 watts. When paired with a magnetic transformer, the 35 watt lamps drew 44-46 watts. 50 watt lamps paired with electronic transformers had a wider test range of 48-54 watt; and with magnetic transformers a range of 58-62 watts.

Power factor of the transformers was also tested and results detailed in the chart below:

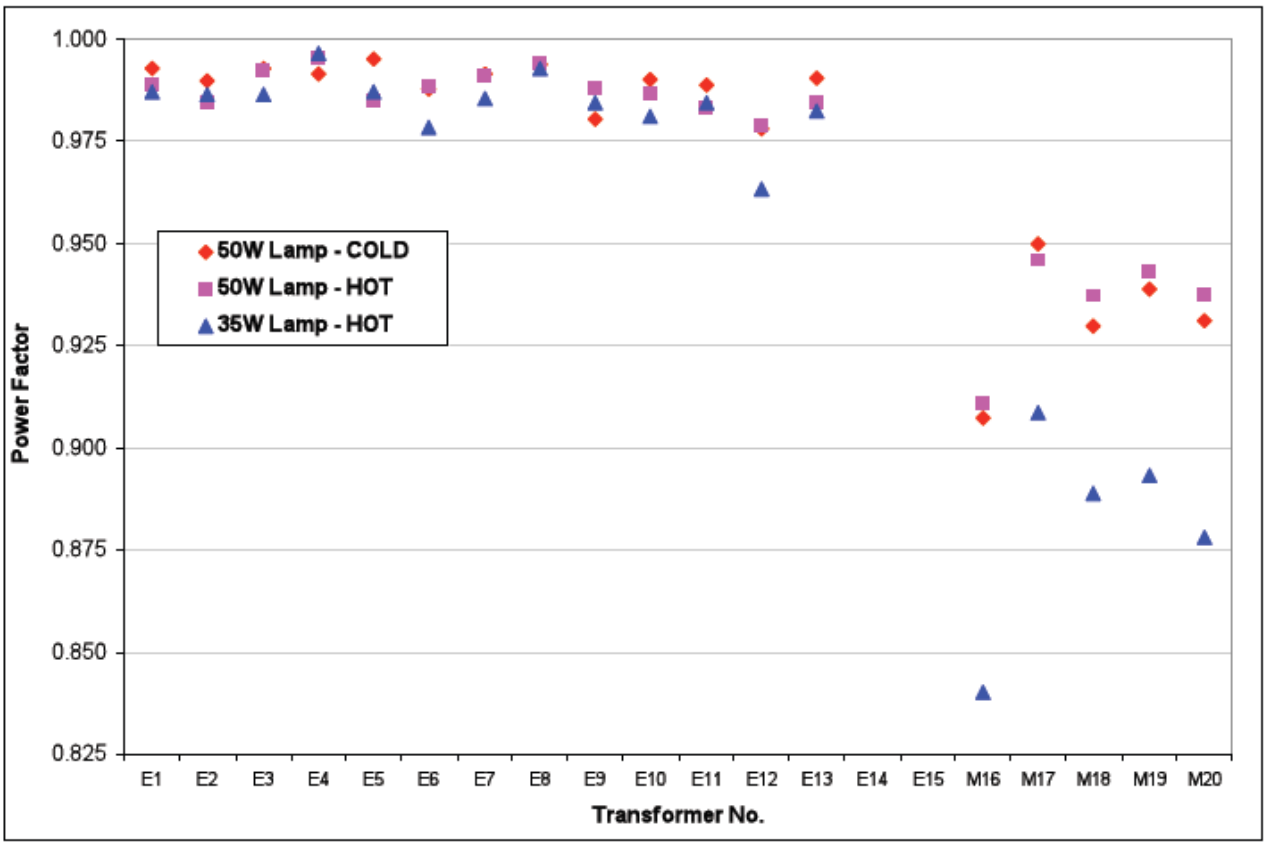

Figure 7 – Measured power factor

Electronic transformers were found to perform at about 98% power factor while magnetic, or iron core, transformers operated across a wide range of 84-95%.

4 Discussion

The objective for the program was to explore the potential opportunities for energy, greenhouse, cost and demand reductions from lighting retrofits in small businesses.

In the program 58 businesses were approached for a no cost lighting audit and refit. Discounting the 10 businesses identified as vacant or closing, 88% of the viable businesses agreed to the lighting audit component and 81% accepted the audit and implementation. The lighting audit saved, on average, about a third of the lighting energy consumption, with lighting comprising an average of 22% of the bill.

Energy and cost savings

Specific to the individual lighting technologies, the replacement of low voltage halogen downlights with more efficient alternatives comprised over 40% of the total program savings at a simple payback of 3.5 years. A more competitive bidding process for both the lighting supply and install is estimated to reduce this to 2 to 3 years.

The replacement of tube fluorescent lights with more efficient alternatives was found to be both expensive at over 7 years simple payback and more complex with respect to the design of the retrofit and gaining acceptance from the business. The 3 sites which had rejected the implementation offer were primarily tube fluorescent lighting.

The replacement of lamps only offered a low payback of 3.3 years but was mainly replacing incandescent bulbs and so unlikely to represent a future opportunity due to the phase-out of incandescent bulbs by the Commonwealth Government.

Greenhouse savings

Greenhouse savings ranged from a low of $310 per tonne CO2-e per year for lamp only refits to $1,635 per tonne CO2-e per year for ballast only replacements. The retrofit of low voltage downlights offered the most attractive opportunity with over 40% of the program savings at an average rate of $600 per tonne CO2-e per year. Based upon projected costs from a larger scale program, supply and install costs are projected to be about $350-500 per tonne CO2-e per year.

With a lamp life of 5,000 hours (1-2 years) and a transformer life of 25,000 hours (7+ years), the life cycle greenhouse benefit is about $170 per tonne for actual costs and $100-140 per tonne for a larger scale program.

Demand savings

Demand savings ranged from a low of $1,260 per kW for lamp only refits to $5,950 kW for ballast only replacements. The retrofit of low voltage downlights offered the most attractive opportunity with over 40% of the program savings at an average rate of $2,325 per kW. Based upon projected costs from a larger scale program, supply and install costs are projected to be about $1,350-1,900 per kW.

Downlight technology

A total of 24 35 and 50 watt low voltage dichroic downlights were tested to determine the total light output and power draw from each lamp with. Three lamps were found to offer the most efficient replacement lamps for low voltage downlight replacements at about 19 lumens per watt. Typical downlights performed at 12-16 lumens per watt.

Some conclusions which could be drawn from the program are:

- Low voltage downlights offer the largest (41% of total) and best opportunity to save energy, demand, greenhouse and costs with lighting in the small businesses trialled.
- Fluorescent lighting retrofits comprise the second largest component (31%) of the available energy efficiency opportunities from lighting in the small businesses trialled, but at a higher cost and increased complexity.
- Lighting comprises about a quarter of the total energy use in the small businesses trialled.
- Overall lighting savings of a third are possible.
- Program success rates of 80% are viable where there is no cost for the offer, but do require significant marketing, acquisition and program management resources.

Recommendations from this study would be to:

- Trial a downlight replacement program to further explore the potential energy, cost, demand and greenhouse savings.
- Circulate findings to Government to assist in policy and program development.
- Trial the sensitivity of the program success rate with participant cost.