E3 Equipment Energy Efficiency

2010 Residential Lighting Report

April 2013

A joint initiative of Australian, State and Territory and New Zealand Governments.

Executive summary

Background

This report documents the results of the first comprehensive lighting audit of the residential sector, which was commissioned in 2010 by the Department of Climate Change and Energy Efficiency. To date, not a great deal is known about Australia's lighting energy consumption, or the lighting technologies that make up the stock of lights. It has been estimated that lighting in homes consumes between 8% and 15% of the average household electricity budget, although this can differ depending on the makeup of the installed lighting technologies and user behaviour.

The Australian Bureau of Statistics publication ABS 4602 contains some very basic information about the number of fluorescent lights in homes, but no information on the details of where they are located or their power. Surveys of builders of new homes have also recorded the numbers and types of lights being installed in new homes. However other than the ABS publication, there has been no study that explicitly documents the lighting characteristics of older Australian homes. Understanding the stock of lighting is essential when proposing regulations that concern different lighting technologies and it also provides a good baseline which can be used to assess impacts of regulations and changes in technology.

In 2007, Australia announced a phase-out of the sale of incandescent lamps, with the intention of increasing the general efficacy of the installed lighting stock of Australian homes. This phase-out is being implemented through the introduction of minimum energy performance standards for a range of lighting technologies. Therefore, benchmarking residential lighting efficiency is an important step in assessing program impacts.

This survey provides quantitative data concerning lighting and provides the first sound basis for estimating the efficiency potential of residential lighting in Australia. It gives a comprehensive picture of what types of lighting technology householders like to install in different rooms, as well as the power of lamps they like to use. This data will help policy makers better understand not only the installed residential lighting stock, but also householder attitudes and user behaviour, to allow program improvements and enable better targeting of resources.

Study Objectives

This is the first intrusive residential survey undertaken to quantify the lighting characteristics of Australian households. This survey was primarily concerned with quantification of the stock of lamps currently installed in households and the documentation of their characteristics. The results from this intrusive survey will greatly assist in providing a basis for a preliminary assessment of the energy efficiency potential of employing improved lighting technologies.

The general objectives of this survey were to:

- document the characteristics (lamp type and technology, lamp shape, fitting type, motion sensor function, dimmer function, cap type, transformer type, power) of all lamps found in a house;
- identify behavioural trends in the use of each lamp found;
- measure and document the lighting for each room type in a house;
- identify forms of lighting that are of particular concern (now and in the future) when considering potential usage patterns, lamp power and ownership trends; and
- provide a solid benchmark of residential lighting characteristics and to provide a sound basis from which to evaluate the impact of future proposed lighting regulations.

Project Scope and Methodology

This intrusive survey covered some 150 houses, including 43 houses in Queensland (Brisbane), 36 houses in New South Wales (Newcastle and Sydney), and 71 houses in Victoria (Melbourne and Gippsland). Fieldwork was undertaken in the period October 2010 to March 2011. Lighting characteristics were identified in the field, the data was recorded and later validated then analysed for this report.

The demographic makeup of the final chosen sample was as close as possible to the ideal sample, (when compared to the 2006 Census breakdown), with some exceptions. These included a skew towards higher incomes, under-representation of single member and one-parent households, and an increased proportion of 25–34 year olds. The main impact of these exceptions would be a possible bias towards larger size houses, which may result in a skew towards a larger number of lights per household.

Key Results

Around 7200 individual lamps were documented in the 2010 lighting survey, with houses found to have an average of 48 lamps, each with an average rated power of 42 Watts. This included fixed lighting as well as plug load lighting such as table lamps and desk lamps. There were on average 15.4 rooms per house, with a total floor area of 158 m^2 (including some outdoor spaces – 139.2 m^2 of indoor rooms). The number of lamps per m^2 was 0.3, and the lamp power density was 13 Watts/m^2 (including some outdoor spaces – about 10 Watts/m^2 for indoor rooms, 8.5 Watts/m^2 of this due to fixed lamps). Finally, an estimate of the overall lighting level was found to be 230 Lumens/m^2 (Lux) in living areas (the majority of this due to fixed lamps – 206 Lux) if all lamps were on, with values of 182 Lux in sleeping areas and 293 Lux in indoor-other areas. This is the first firm quantitative data for the residential sector in Australia. These figures allow a picture to be created concerning the basic power and illumination levels of lighting in Australian houses.

For lamp technologies, the findings are also very interesting. The most common lamp type in a house was found to be halogen, at around 34% of the share of all lamps – 25% as low voltage lamps and 9% as mains voltage lamps. Each low voltage halogen lamp was found to have an average power of almost 44 Watts (around 28% share of the total lamp Watts found in a house), while each mains voltage lamp was found to have an average power of almost 75 Watts (almost 15% share of the total lamp Watts found in a house). Compact fluorescent lamps were found to be the next most common lighting technology, with a 30% share. In this case, each lamp was found to have an average power of almost 14 Watts (around a 10% share of the total lamp Watts found in a house). The other major lighting technology was found to be incandescent lamps, with a 22% share and an average power of around 73 Watts each (38% of the total Watts found in a house). Linear fluorescent lamps had a share of around 9% of all lamps, at an average of 33 Watts each (7% of the total Watts). These findings paint a stark picture, with relatively inefficient technologies contributing to the majority share of the lighting stock found in the average house.

The technology that contributed the highest share of Lumens (light) for the average house was found to be linear fluorescent, with a 27% share of total Lumens (at an assumed 90 Lumens/Watt[1]). Compact fluorescent lamps were next with a 23% share (assumed 55 Lumens/Watt). While, incandescent lamps were found to have a 19% share of total Lumens (at 12 Lumens/Watt), low voltage halogens a 19% share (17 Lumens/Watt) and finally mains voltage halogens, a 10% share (at 16 Lumens/Watt).

The majority of lamps in the average Australian house were fixed lamps, at almost 41 per house (85% of all lamps). Of these, 29% (12 lamps) were compact fluorescent, 27% were low voltage halogen (11 lamps), 21% (9 lamps) incandescent, and around 10% (4 lamps) were linear fluorescent. Finally, around 9% of all lamps (almost 4 lamps per house) were found to be mains voltage halogen.

There were about 7 plug lamps in the average Australian house, or 15% of all lamps. Most plug lamps were found to be compact fluorescent, with around a 40% share (3 lamps per house), while 29% of lamps were incandescent (2 lamps). Around 13% of lamps (1 lamp) were plug low voltage halogen lamps, and 7% (0.5 lamps) were mains voltage halogen. Only 3% (0.2 lamps per house) were found to be linear fluorescent.

Usage data, as reported by the householder, was also collected for each lamp recorded in the survey. This painted a more optimistic picture as it showed that incandescent lamps were generally installed in areas with lower usage while compact fluorescent lamps and linear fluorescents were located in areas with higher usage. These usage levels are somewhat anecdotal and more research is required to calibrate these survey responses to actual behaviour with respect to lighting.

Conclusions

Lighting is a complex issue, with householder habits and attitudes, lighting configuration and lamp technology all having a large impact on the potential to reduce lighting energy consumption. Lighting in the home is used for many reasons and purposes, and the requirements and lighting desires vary from user to user. Anecdotally, the

[1] The higher the amount of Lumens/Watt, the more effective the lighting source is at converting energy into useful light (efficacy).

general knowledge and understanding concerning lighting technologies and choices also varies greatly at a householder level, and this adds another layer of complexity in attempts to increase the efficiency of installed lighting stock.

Although some forms of incandescent lamps have been phased out, the installed stock of this technology is still quite high (22% of lamps in the average house), although these tend to be in lower usage areas. It is encouraging to see that the ownership of compact fluorescent lamps is reasonably high (especially in higher usage areas). However, it is concerning to see that halogen lamps also have a high ownership and many of these have high usage levels. Low voltage halogen lighting installed as flush mounted downlights appear to have become a very popular technology for installation, especially within newer homes. This form of lighting has numerous downsides with poor efficacy, potential fire risks and its impact on the effectiveness of ceiling insulation.

This survey gives a comprehensive picture of lighting in households by room type, as well as the power and technology of lamps. Retrofitting of lighting to increase overall efficiency levels is not a straight forward task, in part due to householder attitudes, knowledge levels and the lack of inter-changeability of some lamp types. The question of retrofitting lighting to increase general efficiency is a difficult one, and not as straight forward as a swap of an incandescent with a compact fluorescent lamp. There is no doubt that some houses have the potential to lower their electricity bills through the installation of a greater number of compact fluorescent lamps, but on the whole, incandescent lamps are found in areas of the house with lower use characteristics.

There may be significant opportunities for energy savings by retrofitting lower wattage extra low voltage halogen lamps, as technological developments mean 35 Watt Infra-Red Coated (IRC) lamps are available to replace standard 50 Watt lamps without reducing light levels. Retrofitting extra low voltage halogen lighting with fluorescent alternatives is a difficult task, as currently there are limited options available to householders without requiring a renovation of the room’s ceiling (due to holes in the plaster). LED lighting has the potential to fill this void, although it hasn’t been installed in numbers high enough to indicate widespread acceptance of the technology. There is still a rapid evolution of LED technology in progress in terms of efficacy and quality.

In overall terms, it would appear that there is the potential to increase total lighting efficiency by at least three fold in many houses that currently have lower efficiency systems. Less efficient homes have an overall average efficacy of around 15 Lumens/Watt (especially larger homes) while many of the most efficient homes have already achieved a practical overall average efficacy of nearly 60 Lumens/Watt.

In summary, the intrusive residential survey has provided valuable insight into the various complexities of residential lighting. The information enclosed will support policy makers as they carefully introduce lighting policy to support energy efficient practices in lighting.

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
CFL	Compact Fluorescent Lamp
DCCEE	Department of Climate Change and Energy Efficiency
E3	Equipment Energy Efficiency Committee
EES	Energy Efficient Strategies
K/L	Kitchen Living
LED	Light Emitting Diode
LFL	Linear Fluorescent Lamp
m^2	Square metres of floor area
MCE	Ministerial Council on Energy
MEPS	Minimum Energy Performance Standards
SK	Separate Kitchen
SL	Separate Living
W	Watts

1. Introduction

1.1 Background

This report documents the results of the first intrusive lighting study, commissioned in 2010. Prior to this study, not a great deal was known about Australian's lighting energy consumption, or the lighting technologies that contribute to it. It is estimated that lighting in homes consumes between 8% and 15% of the average household electricity budget, although this will differ depending on the makeup of the installed lighting technologies and user behaviour (EES, 2008).

The Australian Bureau of Statistics publication *ABS 4602 – Environmental Issues; Energy Use and Conservation*, contains some very basic information about the number of fluorescent lights (ie total fluorescent lighting, not split between linear and compact types) in homes, but no information on the details of where they are located or their power (ABS, 2008). Other than this ABS publication, there has been no study that explicitly documents the lighting characteristics of Australian homes. Understanding the stock of lighting is essential when proposing regulations concerning different lighting technologies and it also provides a good baseline which can be used to assess impacts of regulations and changes in technology.

In 2007, Australia announced a phase-out on the sale of incandescent lamps, with the intention of increasing the general efficiency of the installed lighting stock of Australian homes (Beletich, 2007). However, Australia has been working to improve the efficiency of lighting through the introduction of minimum energy performance standards (MEPS) for lighting products since 2001. MEPS have been introduced for a range of lighting technologies, including:

- ballasts for fluorescent lamps (GWA, 2001);
- linear fluorescent lamps (Ellis, 2003);
- compact fluorescent lamps (MCE, 2009);
- transformers and electronic step-down converters for electronic low voltage lamps (MCE, 2009); and
- incandescent lamps (Beletich, 2007).

It is expected that compact fluorescent lamps will increase in penetration as the installed stock of incandescent lamps decreases (due to the phase-out). This is expected to drive lighting energy consumption downwards in the short term. But in spite of technology and MEPS introductions, lighting energy consumption is projected to increase over the coming years. This is primarily driven by increasing installation of quartz halogen lighting and increasing household numbers (EES, 2008).

This survey fills a gap in the understanding and data concerning the stock of installed lighting technologies and provides the first sound basis for estimating the overall efficiency potential of residential lighting products. It will give a comprehensive picture of what types of lighting householders like to install in different rooms, as well as the power of lamps they use (and therefore installed lumen levels). The data will help policy makers better understand not only the installed residential lighting stock, but also householder attitudes and user behaviour, to allow program improvements and enable better targeting of resources.

1.2 Study Objectives

This report documents the first national audit of residential lighting characteristics in Australian households. This survey was primarily concerned with quantification of the stock of lamps currently installed in households and the documentation of their characteristics. The results attained from this intrusive survey will greatly assist in providing a basis for a preliminary assessment of the energy efficiency potential of improved lighting technologies.

The general objectives of this survey were to:

- document the characteristics (lamp type and technology, lamp shape, fitting type, motion sensor function, dimmer function, cap type, transformer type, power) of all lamps found in a house;
- identify behavioural trends in the use of each lamp found;

- measure and document each room type found in a house;
- identify lighting types that are particularly interesting (now and in the future) when considering their potential usage patterns, lamp power and ownership trends; and
- provide a solid benchmark of lighting characteristics and to provide a sound basis from which to evaluate the impact of future proposed lighting regulations.

1.3 Project Tasks and Outputs

This report documents the findings of the 2010 intrusive lighting survey. The intrusive survey covered some 150 houses including 43 houses in Queensland (Brisbane), 36 houses in New South Wales (Sydney and Newcastle), and 71 houses in Victoria (Melbourne and Gippsland). Field work was undertaken in the period September 2010 to March 2011. A total of 7200 individual lamps were recorded during the survey. Lighting characteristics were identified in the field with the assistance of field identification manuals, the data was recorded and later validated. Further discussion concerning the field identification manuals used in the study can be found in Appendix Four.

At the same time, a survey of appliances and equipment was also undertaken in the same houses, primarily to determine the low power mode characteristics of these products in order to quantify standby power. The results of this work are reported in a separate study (EES, 2011).

1.4 Acknowledgements

This report and part of the analysis was prepared by Jack Brown and Lloyd Harrington of Energy Efficient Strategies. The majority of the analysis was prepared by Robert Harrington of Energy Efficient Strategies. Field measurements were carried out by Jack Brown and Robert Harrington of Energy Efficient Strategies. Matthew Blacker of WorthIT provided programming assistance in the creation of the online demographic survey and recruitment tool. Steve Coyne and Megan O'Loughlin of Light Naturally, and Steve Beletich of Beletich & Associates provided assistance in the preparation of an analysis plan, measurement procedures, data validation and comments on the report. Dianne Glass of Energy Efficient Strategies assisted with report formatting.

The authors would like to thank the 150 participating householders that volunteered their time and residence for the survey, as well as all other householders that volunteered for the study but were not selected for participation.

The authors would also like to thank the individuals and organisations that assisted in promoting interest in the project. These include EnergyAustralia, Origin Energy, the CSIRO, the Port of Brisbane, and Warringah Shire Council.

Members of Department of Climate Change and Energy Efficiency (DCCEE) and the E3 Committee are also thanked for their guidance throughout the project.

2. Methodology

2.1 Methodology Overview

The lighting survey required the collection of an extensive range of data and information concerning the lighting in homes. This data was recorded using a spreadsheet, and in many cases used specific validation rules depending on the lamp technology or shape selected. The field researchers were experienced in luminaire and lamp identification, and it was rare that issues arose with these elements of the data collection (see Appendix One for further discussion).

The following list of data was required for each lamp recorded:

- Room ID;
- Switch number;
- Room type;
- Lamp connection type;
- Dimmer function;
- Motion sensor function;
- Fitting type;
- Lamp technology;
- Lamp shape;
- Lamp cap type;
- Lamp transformer type;
- Lamp power; and
- Any comments or notes.

The householder was also asked the general level of usage for each lamp found (outlined in Section 6.1).

The following sections outline the specific considerations and rules concerning classification of both rooms and lamps. Further discussion concerning the survey measurement methods and issues can be found in Appendix One.

2.2 Classification of Rooms

Upon entering a room, the first step was to correctly identify the space and note its characteristics. A laser tape was used to accurately calculate the floor area of the room, with the final measurement noted in the data collection spreadsheet[2]. A room ID was also assigned (according to the order that rooms were entered).

Room identification during the field research was undertaken according to the following list of rules:

- Bathroom: contains a shower and/or bath (may contain a toilet);
- Bedroom: contains a bed and/or is clearly intended as a space for a bed;
- Dining: contains a table and/or chairs;
- Foyer-inside: used as an entryway to the house, but has different dimensions to any hallway;
- Garage: used for car storage and/or as a work space;
- Hallway: used primarily as a passageway to other rooms;
- Kitchen: contains cooking appliances and/or refrigerator and/or sink and/or pantry space;
- Kitchen/Living: a continuous space that is a combination of both a kitchen and lounge or living-other;
- Laundry: contains a washing machine and/or clothes dryer and/or spaces clearly intended for the installation of these appliance types;
- Living-other: may contain a lounge suite and/or similar chairs and/or home entertainment equipment, but is additional to the main Lounge space;

[2] The measure is usable floor area – it does not include cavities, wall thickness, hidden spaces (like built in wardrobes) or other inaccessible areas. External spaces do not usually have a floor area. The floor area from building plans is usually slightly larger – based on a few examples, up to about 5% more.

- Lounge: contains a lounge suite and/or similar chairs and/or home entertainment equipment;
- Other-inside: a space that is inside the house that does not meet the criteria for any other internal space listed;
- Other-outside: a space that is outside the house that does not meet the criteria for any other external space listed;
- Outside-general: a space that is external to the house and is neither a garage or veranda and doesn't have an obvious and defined use (ie shed – which would be identified as Other-outside);
- Pantry: used as a space for storing food and/or kitchen appliances;
- Storage Room: a space used only for storing items (not suitable for other uses);
- Study: contains a working space with a computer and/or desk and/or home office equipment;
- Toilet: contains a toilet, but does not contain a shower/bath (may contain a sink);
- Verandah: an area covered by roofing that is clearly attached to the house, may be used as an external entryway to the house (there may be more than one veranda for a house, although only spaces that have installed lighting are noted);
- Walk-in Robe: used as a space for storing clothes that includes hanging and/or shelving for clothes (needs to be large enough to walk in).

These rules enabled a simple identification system of room types. A number of difficulties were encountered though, with the most significant involving the differentiation of open living areas (kitchen/living areas). The general rule was if there was a clear structural divide in the space (ie a part wall) the room was split into the respective spaces. The assumption was that householders would use lights for one space or the other, not both. In an open living area that had no partition, it was assumed that lights in one space would be used to illuminate the other space (eg kitchen lights on while watching television, etc). As can be imagined, this differentiation has the possibility of being arbitrary, although identification was generally confirmed by the householder during questions and feedback.

The other room naming and identification issue involved 'unusual' spaces (eg under house laundries) or multi-purpose rooms. Each was dealt with on a case by case basis. Generally, the 'dominant' space type was selected and a note was made in the data collection sheet.

In the analysis of the collected data, room types (and therefore data) were aggregated into the following classifications:

- **Indoor-other**: Bathroom, Foyer-inside, Hallway, Laundry, Other-inside, Pantry, Storage Room, Toilet, Walk-in Robe;
- **Living**: Dining, Kitchen, Kitchen/Living, Lounge, Living-other;
- **Outdoor**: Garage, Other-outside, Outside-general, Verandah;
- **Sleeping**: Bedroom, Study;

This was undertaken to increase the ease of analysis by room type. A cross tab of lighting type for all individual room types recorded would be too fine to draw useful conclusions (as there would be too few room and lights for many of the room types). However, the raw data has been retained so that more detailed analysis might be undertaken as required. A more detailed breakdown of living area types is included in Appendix Three.

2.3 Classification of Lamps

Lamp classification followed a series of steps, governed by experience, within the requirements of speed and accuracy. These basic steps are detailed below.

Fitting and Connection Classification

The first step in lamp classification was to identify the fitting in which the lamp was installed. Fitting types have a major influence on the type of lamp technology, the globe shape and cap that can be installed, and the options for lamp retrofit. Lamp fitting types fall into a range of categories, as outlined in Table 1 below. While identification for most fitting types is relatively self-evident, there are similarities between a number of fittings that can complicate this process. The key examples are desk and table lamps, and wall and uplights.

Table 1: Fitting and Connection Type Classification and Identification Notes Summary

Fitting Type	Connection Type	Identification Notes
Batten Holder	Fixed	A bare fitting, normally fixed directly to the ceiling. Only the lamp holder and lamp will be present. May have more than one lamp.
Batten Holder with Shade	Fixed	A bare fitting, normally fixed directly to the ceiling, with the lamp surrounded with a shade – this may be solid, translucent or opaque. May have more than one lamp.
Combination Heat/Light Unit	Fixed	Normally found in bathrooms, may comprise of two or more heating lamps, usually also includes a lighting lamp.
Desk Lamp	Plug	A multi-purpose task lamp, may have swivels, hinges or flex to allow repositioning of the lamp spot. May have a lamp shade or reflector. Differentiated from a table lamp through appearance – task orientated rather than decorative. May have more than one lamp (rare).
Downlight/Flush Mounted	Fixed	Recessed and installed flush with the ceiling surface. May have a swivel or gimbal to change lamp spot direction.
Fixed Floor Light	Fixed	Recessed and installed flush with the floor surface. Normally include a hard opaque or translucent cover to protect the lamp from damage.
Floodlight/External Spotlight	Fixed/Plug	Installed outside the house, may be directional through the use of a hinge, swivel or gimbal. May have more than one lamp, normally high power.
Floor/Standard Lamp	Plug	May be decorative or task orientated, may have swivels, hinges or flex to allow repositioning of lamp spot. May have lamp shade or reflector. Total fitting length disallows placement on a table or desk. May have more than one lamp.
Garden Light	Fixed/Plug	Installed outside the house, decorative rather than task orientated. May provide light for movement a night, not intended for task lighting.
Indoor Spotlight	Fixed	Not installed flush, found on both the ceiling and wall. May be directional through the use of a hinge, swivel or gimbal. May have more than one lamp.
Linear Fluorescent	Fixed/Plug	Rare fitting, normally uses a plug connection. May be found as a fish tank light or movable fitting. May have a lamp shade and/or cover.
Nightlight	Plug	Intended for ambience, may provide some utility, although only enough for movement at night rather than tasks. May have a sensor, light gauge or timer. May be coloured.
Other	Fixed/Plug	Generally specialised task lighting – example is a handheld work light. Does not meet the criteria for any other fitting category.
Oyster	Fixed	Batten holder with cover (any material) where the lamp is completely enclosed. Ceiling mounted only, may have more than one lamp.
Pool Light	Fixed	Any lamp installed in a pool, under the water surface.
Rangehood	Fixed/Plug	Installed over stoves in kitchens, normally also includes a fan function. May have more than one lamp.
Suspended	Fixed	Any type of hanging fitting, lamp may be bare, shaded or fully enclosed. May have more than one lamp.
Table Lamp	Plug	A decorative lamp, generally fixed spot. Lamp may be bare, enclosed or have a shade. Differentiated from a desk lamp through appearance – decorative rather than task orientated. May have more than one lamp.
Uplight	Fixed	Wall mounted fitting that is positioned so that the lamp spot is directed up towards the ceiling.
Wall Light	Fixed	Wall mounted only, lamp may be bare, enclosed (or installed flush) or have a shade. Non directional, may be internal or external.
Novelty Light	Plug	Decorative rather than task orientated – examples include fibre optic lights, lava lamps, Christmas lights, fairy lights (not included in the lighting audit or this report).
Sky Light	NA	Opening through the ceiling allowing natural light to enter, may include mirrors or a tube to increase focus. Obviously does not use energy, but does provide useable light and was included in the data collection because of this reason. May alter the characteristics of other lamps installed in the space (not included in the lighting audit or this report).

Connection type was an important factor to identify, as it denotes whether the lamp can be disconnected from the mains and/or moved. Plug fittings obviously provide a larger degree of user flexibility in terms of providing useful (task) lighting and changing the ambience, intensity, energy consumption or mood of lighting in a space. Plug fittings allow householders to configure the lighting in a space to suit their personal preference, without the need to undertake any resource intensive changes to the fixed lighting.

Lamp Technology Classification

Once the fitting type was established, the second step was to identify and document the lamp technology. Understanding the prevalence of different lamp technologies was one of the key issues in the audits and this report.

Different technologies have different energy profiles, and therefore the overall lighting efficiency of a house will vary.

Technologies fall into a range of types as outlined in Table 2. Note that 'Other' and 'Cannot Identify' are also valid choices for many of the following categories. Validation rules were used when inputting data into the data collection sheets, meaning that incorrect cap or transformer types weren't able to be selected for non-applicable technologies.

In the analysis of data for the majority of the report, lamp technology was divided into general categories: incandescent; halogen (mains voltage non-reflector, mains voltage reflector and extra low voltage reflector lamps); compact fluorescent (integral ballast and separate ballast); linear fluorescent (including circular fluorescent lamps); LED; and unknown.

Detailed results by technology are given in Section 5 where there is some breakdown of the halogen categories into extra low voltage and mains voltage halogen lamps. Here, the percentage of installation of that lamp technology in that fitting of all technologies is given. The percentage of those lamps that correspond to a particular cap type for that fitting are also given.

Table 2: Technology Type Cap and Transformer Identification Notes

Technology Type	Cap Type	Trans-former Type	Identification Notes
Incandescent – mains voltage	E14, E27, B15, B22, GU10	NA	No halogen capsule – large filament. Ignore outer envelope, as this can be many shapes. If frosted envelope such that burner cannot be seen, assume incandescent – mains voltage.
Halogen – mains voltage	E14, E27, B15, GU10	NA	Look for small halogen capsule at centre of lamp. Ignore outer envelope, as this can be many shapes.
Halogen – extra low voltage[3] (usually 12 V)	GU/GX5.3, G4	Magnetic, Electronic	Look for small halogen capsule at centre of lamp. Lamps marked as "12 V" or connected to transformer (lamp age can also give some indication on transformer type).
Compact Fluorescent – integral ballast	E14, E27, B15, B22, GU10	NA	Look for fluorescent tube (FB*).
Compact Fluorescent – separate ballast	2-Pin, 4-Pin	NA	Note pin cap (single cap) (FS*).
Linear Fluorescent	G5, G13	NA	Double ended cap (FD *), electronic or ferromagnetic ballast, T12, T8 or T5 lamps.
Circular Fluorescent	G10q	NA	Double ended cap (double cap) (FDC *).
LED	E14, E27, B15, B22, GU10, GU/GX5.3	NA	Typically has a cluster of diodes.
Heat Lamp	E27	NA	Typically very large.

*Notes: * Codes as per IEC 61231: International lamp coding system (ILCOS).*

Table 3 shows the shape restrictions for different technologies and identification notes. Some shapes have a range of technologies that are applicable, complicating identification in the field. Although there are restrictions on the technologies that can use shapes, these are often very similar looking when installed in a fitting. A good example of this is the halogen reflector types. Fitting types can also cause the identification of technology shapes to be problematic – oyster fittings (complete coverage) are a good example of this. Validation rules were used when inputting data into the data collection sheets, meaning that incorrect shape types weren't able to be selected for non-applicable technologies.

[3] It is very difficult to ascertain the exact fitting type of this lamp technology when in the field. It is assumed that these cap types would have been used by the lamps audited.

Table 3: Technology Shape Restrictions and Identification Notes

Shape	Technology	Shape Notes
A-Shape	Incandescent – mains voltage, Halogen – mains voltage	Pear, tubular and mushroom shaped.
Fancy round	Incandescent – mains voltage, Halogen – mains voltage	Spherical shape, can be small or large.
Candle	Incandescent – mains voltage, Halogen – mains voltage	Lamp tapers to a point.
Reflector – R	Incandescent – mains voltage, Halogen – mains voltage	Includes MR (multi-faceted) reflector lamps.
Reflector - PAR	Incandescent – mains voltage, Halogen – mains voltage	Large diameter, thick quartz lens.
Pilot	Incandescent – mains voltage, Halogen – mains voltage	Small size.
Double ended	Halogen – mains voltage	Lamp is installed on fittings at both ends.
Reflector (Halogen – extra low voltage)	Halogen – extra low voltage	Specific technology shape.
Capsule	Halogen – extra low voltage	Pin type fitting installation.
Stick (Compact fluorescent)	Compact fluorescent	Specific technology shape.
Spiral (Compact fluorescent)	Compact fluorescent	Specific technology shape.
Covered (Compact fluorescent)	Compact fluorescent	Specific technology shape.
Reflector (Compact fluorescent)	Compact fluorescent	Directional light source.
Reflector (LED)	LED	Directional light source.
Non-reflector (LED)	LED	Multi-directional light source.

2.4 Assumed Efficacy Values by Technology

Efficacy is the amount of light emitted by a lamp, measured in Lumens, as a ratio of the Watts consumed to produce it. This is the only useful measure of lighting effectiveness and essentially 'replicates' the notion of efficiency (as found in appliances). The higher the Lumens/Watt, the higher the efficacy level of a particular lighting technology and the better it is at providing useful light for energy input.

For the purpose of this study, an assumed efficacy for each lighting technology was broadly assigned, based on typical values for the stock. It is acknowledged that the efficacy of individual lamps within a technology can vary, but there was no practical method available to this study for determination of true efficacy in the field as this is a complex measurement that can only be performed in a laboratory. Nor was it practical to attempt to match individual lamp models to the registration database, as many are not regulated and the lamp vintage cannot be easily be determined.

The assumed efficacy values by technology used for analysis were:

- Incandescent – 12 Lumens/Watt;
- Mains voltage halogen – 16 Lumens/Watt;
- Low voltage halogen – 17 Lumens/Watt;
- Compact fluorescent (integral ballast and separate ballast) – 55 Lumens/Watt;
- Linear fluorescent (including circular fluorescent) – 90 Lumens/Watt;
- LED – 60 Lumens/Watt;
- Unknown – 12 Lumens/Watt (assumed incandescent technology). This was only used for a very small number of lamps where the technology could not be established.

If the lamp was blown, not working or missing, then this was recorded as no lamp in the fitting (effectively a separate lamp type with no power consumption and no light output).

The details of heat lamps were recorded during the survey. These have been excluded from the overall audit results as they are considered to be heaters and not lamps. However, Section 8.3 does include some technical detail on the heat lamps that were found.

The effective amount of light that falls onto a horizontal surface on the floor (Lux – Lumens/m^2) was assumed to approximate as half of the total Lumen output for each lamp, calculated using the rated power and nominal efficacy values noted above (the reduced light output is due to luminaire losses, reflection and transmission onto other surfaces). While the practical Lumen output varies by technology and lamp shape or type, the assumed value gives a rough comparative illumination level for each room (in terms of Lux). The Lumen values reported in this study are the total light output for the assumed technology efficacies.

Where Lux values are reported for a particular room type, then this is the calculated Lux level as set out above assuming that all lights are on. Of course, this is somewhat higher than normal use, so typical Lux levels will be somewhat lower than the averages reported. While some outdoor spaces had a measured floor area, generally outdoor lights were higher power and most had no practical floor areas associated with them, so Lux values cannot be determined for these spaces. Therefore, all reported Lux values in this report exclude lights and spaces classified as outdoor type.

It should also be noted that where average values are reported in this study, then underlying these values is a range or distribution of values. For some parameters the distribution of values has been examined in some detail, but for many parameters no attempt has been made at characterising the shape and drivers for these distributions. This may be a fruitful area for further analysis.

2.5 Data Validation

All data was recorded electronically during the audit with a range of filters and validations built into the data collection instrument. Post survey data cleaning and validation was also undertaken on the dataset once the auditing was finished. This involved standardising each data component (lamp shape, cap type, etc) according to what the most probable entry should have been only where inconsistencies were found on review of the data (which were generally rare), as to fix any incorrect or missing data. Further validation was completed on lamp Wattage with the assistance of experts in the residential lighting field, who provided expected Wattage ranges according to technology, fitting and lamp shape. These assumptions were then implemented, and the dataset standardised. There were also a range of checks on total of number of lamps, Watts and Lumens in each of the standard room classifications to ensure that all records for all houses were included in the overall and house level analyses.

2.6 Demographics

The recruitment of households involved word of mouth, the circulation of emails and use of social media. Parties were asked to indicate their interest by completing an online demographic questionnaire, a total 228 individual responses were received. A breakdown of the 2006 Census was used to define an ideal sample and every attempt was made to ensure the demographic makeup of the sample was as close as possible to the ideal sample.

The final chosen sample provides a good representation of the Australian demographic, with the following exceptions:

- a high proportion of incomes above $88,000 pa, when considering the Census predominance of incomes below $62,000 pa;
- greatly increased proportion of the age group making up the years 25 to 34;
- single member and one parent households are under-represented, with a skew towards group member households;
- a bias towards households containing couples, both with and without children; and
- given the recruitment method, there is a chance of a higher than typical ownership of computers in the sample.

Of these demographic elements, household income would have the most impact on lighting characteristics. However, this impact tends to be indirect by influencing house size. Occupant age, family type and household size generally have a minimal impact on lighting characteristics and are more likely to influence lighting use. Therefore it can be surmised that the main impact of the demographic exceptions would be a possible bias towards larger size houses, which may result in a skew towards a larger number of lights per household. For more information, please see Appendix Two.

3. Overall Results

3.1 Key Findings

The two key findings for the survey were that the average house had 48 lamps each with an average power of 42 Watts. The average number of rooms per house was found to be 15.4, with a total floor area of a house being 158 m^2 (139 m^2 if only indoor rooms are considered). The number of lamps per m^2 for indoor areas was found to be 0.27, and the power density was almost 10 Watts/m^2 for indoor areas (fixed lamps contributed 8.3 Watts/m^2 to this total). The average Lux was found to be 230 for living areas, 182 for sleeping areas and 293 for indoor-other areas (based on total light output for all relevant light), with a weighted average of 230 Lux for all indoor areas (fixed lamps contributed 201 Lux to this total). These figures allow a picture to be created concerning the basic power and illumination levels of Australian houses (assuming all lights were on) and provide a benchmark of the lighting stock of Australian households in 2010/2011.

For lamp technologies, the findings are also very interesting. The most common lamp type in an average house was compact fluorescent, at around 30%. In this case, each lamp had an average power of almost 14 Watts (around a 10% share of the total Watts found in a house). Low voltage halogens had 25% share with an average power of 44 Watts per lamp (a 28% share of the total house). The other major lighting technology was found to be incandescent lamps, with a 22% share. Incandescent lamps had an average power of about 73 Watts each (38% of the total Watts found in a house). Main voltage halogen was found to have a 9% share with an average power of almost 75 Watts each (almost 15% share). Linear fluorescent lamps also had a share of around 9%, at an average of 33 Watts each (7% of the total Watts). These findings paint a stark picture, with relatively inefficient technologies contributing to the majority share of the lighting stock found in the average house.

The technology that contributed the highest share of the Lumens (total light output) for the average house was linear fluorescent, with a 27% share (assumed 90 Lumens/Watt). Compact fluorescent was next, with almost a 23% share (assumed 55 Lumens/Watt). Incandescent lamps had a 19% share (at 12 Lumens/Watt), as did low voltage halogens (17 Lumens/Watt). Finally, mains voltage halogens were found to have a 10% share (assumed 16 Lumens/Watt). This shows that the share of light output across the four major lighting technologies is more evenly spread than is reflected by the number of lights present by technology.

The majority of lamps in the average Australian house were fixed lamps, at almost 41 per house (85% of all lamps). Of these, 28% (12 lamps) were compact fluorescent, 27% were low voltage halogen (11 lamps), 21% (9 lamps) incandescent, and around 10% (4 lamps) were linear fluorescent. Finally, around 9% of all lamps (almost 4 lamps per house) were found to be mains voltage halogen.

There were about 7 plug lamps in the average Australian house, or 15% of all lamps. Most plug lamps were found to be compact fluorescent, with around a 40% share (3 lamps per house), while 28% of lamps were incandescent (2 lamps). Around 13% of lamps (1 lamp) were plug low voltage halogen lamps, and 7% (0.5 lamps) were mains voltage halogen. Only 3% (0.2 lamps per house) were found to be linear fluorescent.

In summary, comparatively inefficient technologies in fixed lighting points were found to be the dominate lighting in a typical Australian home. However, the share of total light output is more evenly spread across the four major lighting technologies.

3.2 Whole House Overview

The average number of lamps was 48 per house, which operate on an average number of 30 switches (less than 2 lamps per switch). The total power with all lights on was 2008 Watts per house. The average number of rooms per house was 15.5, with an average total floor area of 157 m^2 (including outdoor areas, 139 m^2 for indoor areas only). The average number of lamps per m^2 was 0.27 (indoor areas), with an average number of lamps per room found to be around 3. The average power density of all lamps was just under 10 Watts/m^2 (indoor areas). The average total light output per house was found to be almost 47,100 Lumens, which equated to around 230 Lux (for indoor areas only). These findings are shown in Table 4.

Table 4: Average House Summary – Key Characteristics

Average House	Average Per House
Number of Lamps	47.8
Number of Switches	29.8
Total Watts	2008
Number of Rooms	15.4 (12.4)*
Floor Area (m^2)	157.6 (139.2)
Lamps per m^2	(0.27)
Lamps per Room	(3.1)
Watts per Lamp	42.0
Power density (Watts/m^2)	(9.9)
Power density (Watts/m^2) - Fixed	(8.3)
Power density (Watts/m^2) - Plug	(1.6)
Lumens	47083
Lighting Levels (Lux)	(230)
Lighting Levels (Lux) – Fixed	(201)
Lighting Levels (Lux) – Plug	(29)

Note – brackets indicate indoor only.

Table 5 shows the breakdown of lighting in the major room types of the average house. The most prevalent room type in homes were 'indoor-other' rooms (remembering that this room type is an aggregation of several individual room types, including bathrooms, hallways and a range of other service areas that are used less frequently). This was followed by sleeping, outdoor and living room types. The room type with the largest floor area was found to be living, more than 15 m^2 larger than sleeping and 26 m^2 larger than indoor-other. Similarly, this difference is reflected in the share of floor area, with living accounting for almost 40% of the average house's floor area.

Living areas also had the largest number of lamps, but not the highest power density of lighting levels (Lux). Instead, indoor-other rooms had the highest power density at 12.2 Watts/m^2 as well as the highest Lux. Both of these aspects were only slightly more than living areas, while sleeping areas had both the lowest power density and lighting levels.

Living areas were found to have the highest average number of fixed lamps (14.3), followed by indoor-other, outdoor and sleeping. Almost the opposite was found for plug lamps, with sleeping areas found to have the highest average number (4.3 lamps), followed by living, outdoor and indoor-other.

Table 5: Average House Summary – Room Type Characteristics

Average by Room Type	Living	Sleeping	Indoor-other	Outdoor
Number of Rooms	2.7	3.5	6.1	3.1 *
Floor Area (m^2)	60.3	44.7	34.2	18.4 *
Share Floor Area	38.3%	28.4%	21.7%	11.7% *
Number of Lamps	16.3	11.1	10.8	9.7
Number of Fixed Lamps	14.3	6.8	10.4	9.2
Number of Plug Lamps	2.0	4.3	0.4	0.5
Power Density (Watts/m^2)	10.2	7.9	12.2	NA
Power Density (Watts/m^2) – Fixed	9.1	5.2	11.8	NA
Power Density (Watts/m^2) – Plug	1.1	2.7	0.4	NA
Lighting Levels (Lux)	230	182	293	NA

** Most outdoor lamp types are not associated with a space that has a measurable floor area, so these values are reported here for completeness.*

3.3 Technology Overview

Table 6 shows the lamp number and Watts by technology for the average house. Almost a third of all lamps in a house were found to be compact fluorescent (just over 14 lamps per house). This was 2.5 more units than low voltage lamps. Just under a quarter of lamps in a house were found to be incandescent, and around 9% (4.2 lamps) were linear fluorescent or mains voltage halogen. LED lamps only contributed to 1.4% of total installed stock.

Incandescent lamps had the highest power share (37%), and the second highest Watts per lamp (around 73 Watts). Mains voltage halogen lamps had the highest Watts per lamp (nearly 75 Watts), but only a 15% power share. Low voltage halogen lamps had a 28% share and an average of 44 Watts per lamp. Compact fluorescent lamps were nearly 10% of total household lamp power, at an average of almost 14 Watts per lamp. Linear fluorescent had a lower share than this (7%), but had an average of about 33 Watt per lamp. LED lamps made up only 0.2% share of total household Watts, with an average of just over 5 Watts per lamp.

Table 6: Average House Summary - Lamp Number and Watts by Technology

Average Per House	Incandescent*	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Number of Lamps	10.5	4.3	11.9	14.4	4.2	0.7
Number Share	22.0%	8.9%	24.8%	30.1%	8.9%	1.4%
Watts Total	755	294	558	195	142	4
Watts Share	37.6%	14.6%	27.8%	9.7%	7.0%	0.2%
Watts per Lamp	72.7	74.5	44.0	13.6	33.3	5.1

** Unknown and missing 'technologies' are included in the share numbers as incandescent lamps. These factors are reported separately in Sections 5.8 and 5.9.*

Table 7 shows the Lumen total and share by technology for the average house. The assumed Lumens/Watt have been included to help put the totals and share into some context. Linear fluorescent lamps had the highest Lumens share at around 27%. Compact fluorescent was second with a Lumens share of 23%. While low voltage halogen and incandescent lamps were the same with a 19% share each. Mains voltage halogen had a 10% Lumens share, and LED lamps only had a 0.4% share of total household Lumens.

Table 7: Average House Summary – Lumens by Technology

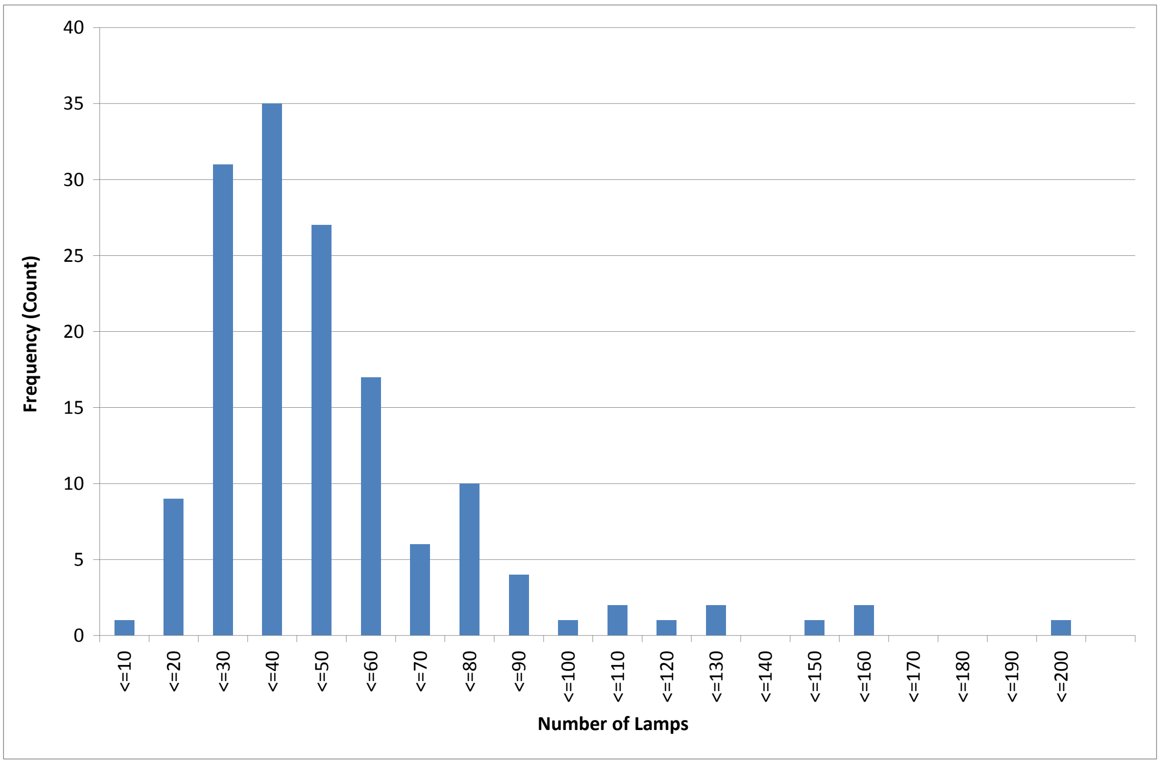
Average Per House	Incandescent*	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	9059	4704	8925	10742	12743	179
Lumens Share	19.2%	10.0%	19.0%	22.8%	27.1%	0.4%
Assumed Lumens/Watt	12	16	17	55	90	60

** Unknown and missing 'technologies' are included in the share numbers as incandescent, although these factors are reported separately in Sections 5.8 and 5.9.*

3.4 Frequency Distributions of Key Parameters

The average number of lamps per house (X axis), split into frequency bins, versus the number of houses within each bin, is shown in Figure 1. The most common number of lamps in houses was more than 30 and up to 40 lamps (about 23%, or 35 houses), with around 61% (92 houses) of houses having greater than 20 and up to 50 lamps. There was a wide range of total lamp numbers, with the highest total found to be over 190 lamps.

Figure 1: Distribution of Total Lamps per House for all Houses



Note: Includes lamps used in outdoor spaces.

Figure 2 shows the average number of rooms per house (indoor rooms only). The most common number of rooms per house was 10 (around 13% of all houses). The bulk of houses though had more rooms than this, with a large percentage having up to 14 rooms per house. The minimum number of rooms in a house was 3 (due to an open space living area in a flat), and the maximum was 27.

Figure 2: Distribution of Total Indoor Rooms for all Houses

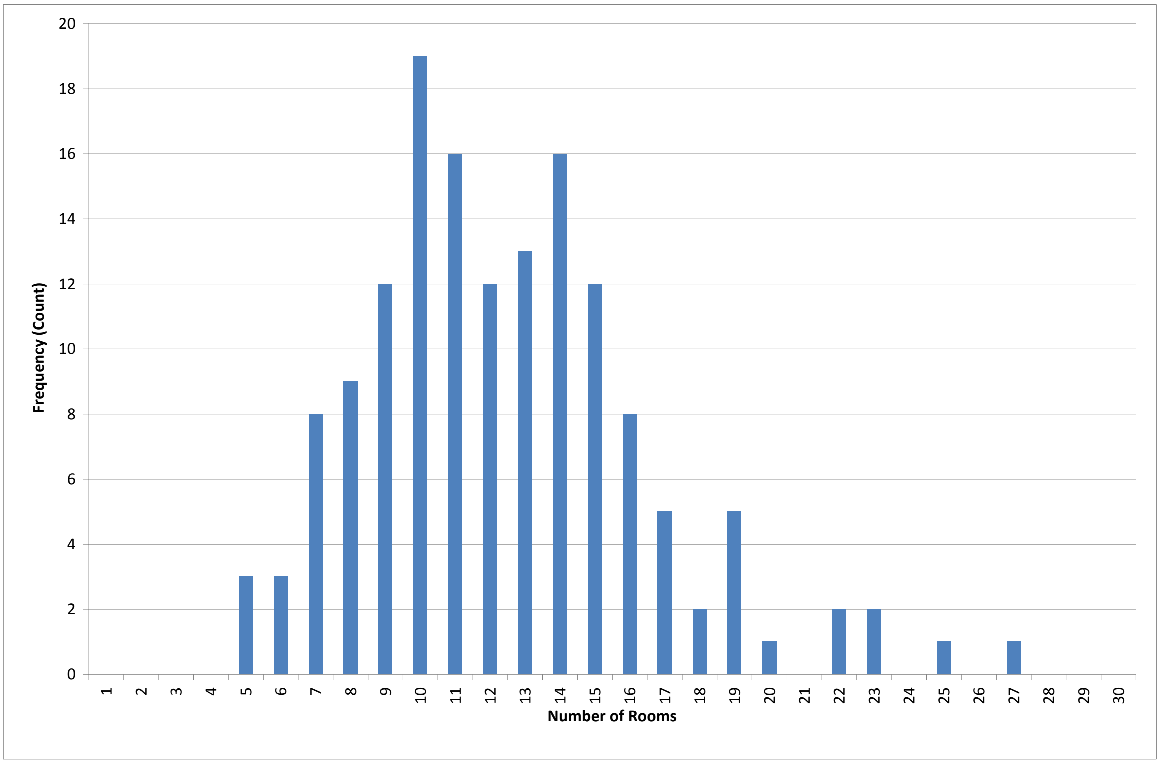


Figure 3 shows the average indoor floor area per house. The most common floor area (around 23% of houses) was greater than 76 m^2 and less than 100 m^2. A majority of houses had significantly larger floor areas than this range though. The minimum floor area was between greater than 25 m^2 and up to 50 m^2, and the maximum was up to 450 m^2.

Figure 3: Distribution of Total Indoor Floor Area (m^2) for all Houses

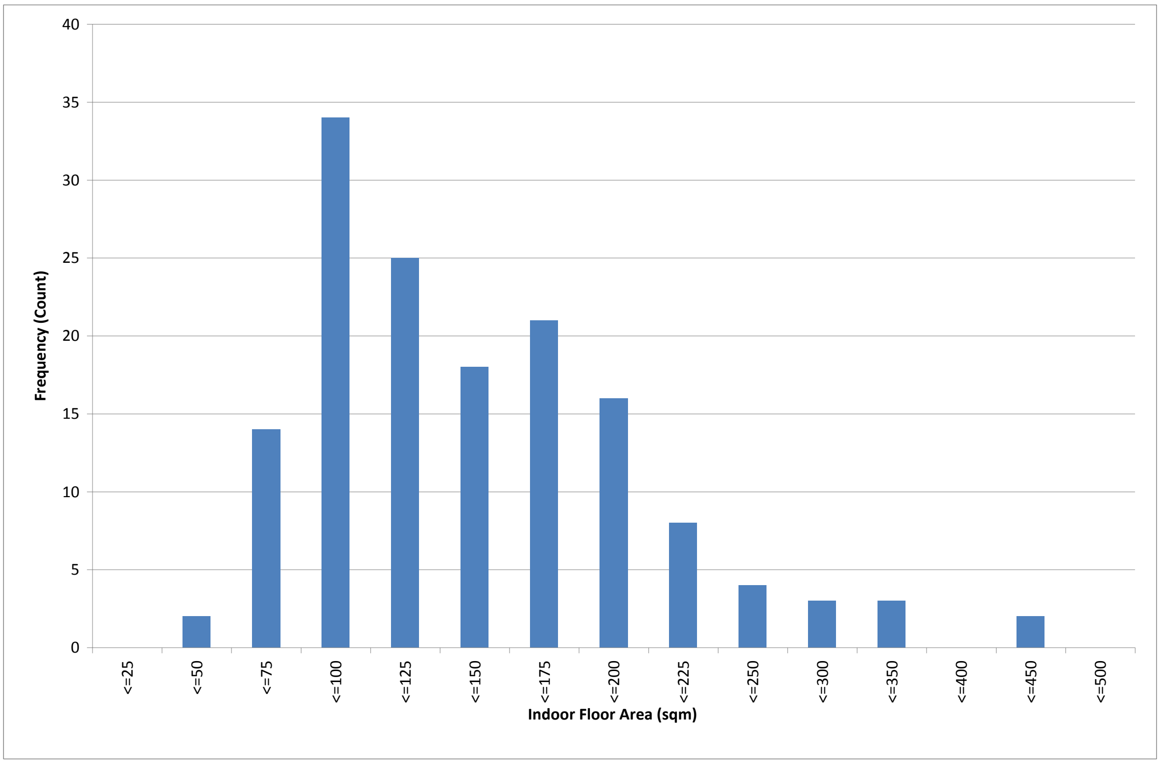


Figure 4 shows the average power density of lighting per m^2 for indoor spaces. The highest percentage of houses (around 28% houses) had an average of between 12 Watts/m^2 and 14 Watts/m^2. The rest of the houses were reasonably evenly split either side of this, with a minimum power density of 2 Watts/m^2 and a maximum of 26 Watts/m^2.

Figure 4: Distribution of Total Indoor Power Density (Watts/m²) for all Houses

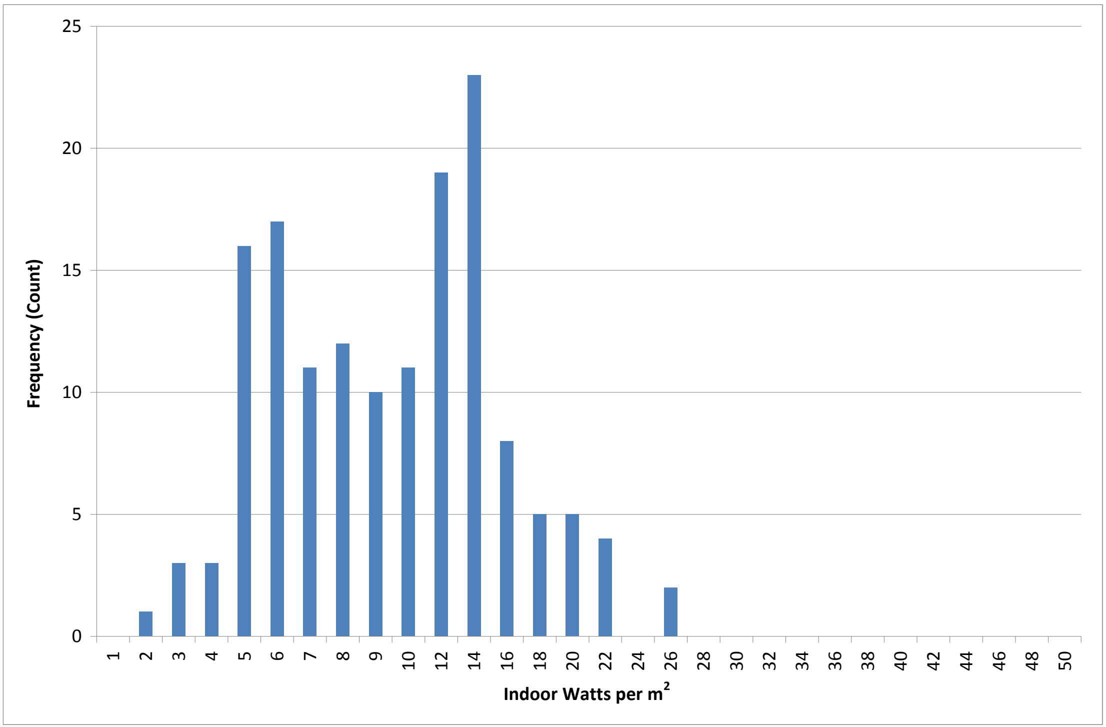
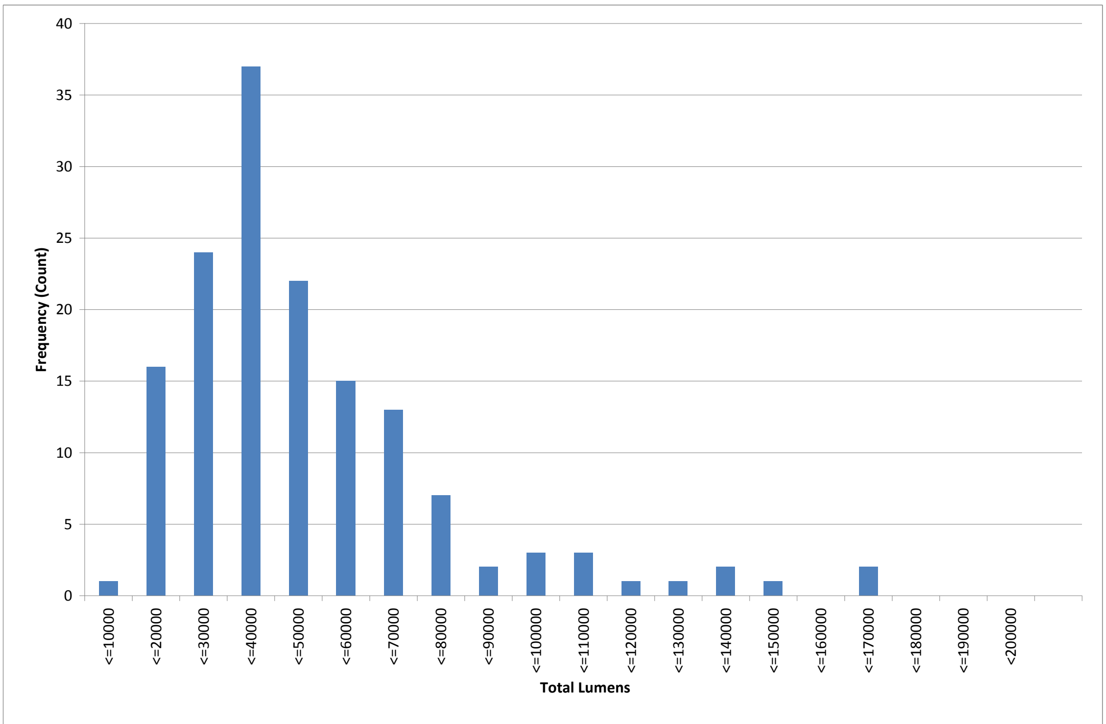


Figure 5 shows the range of Lumen totals in houses. Lighting in houses was found to have a large Lumen range, with the most common value found to be greater than 30,000 and up to 40,000 total Lumen output (around 25% of all houses) with all lights on. The minimum number of Lumens in a house was less than 10,000 and the maximum was up to 170,000 Lumens.

Figure 5: Distribution of Total Lumens for all Houses



Note: Includes lamps used in outdoor spaces.

One of the key drivers for total Watts and total Lumens will generally be floor area – larger houses tend to have more lights and therefore consume more energy and produce more light. This effect is illustrated in Figure 6 and Figure 7. There is clearly a large variation in Watts and Lumens for a given house size (shown by the regression lines shown in the previous figures). However, these figures do not show whether there is any significant range of average lighting efficacy at a household level.

Figure 6: Floor Area versus Total Watts – All Houses

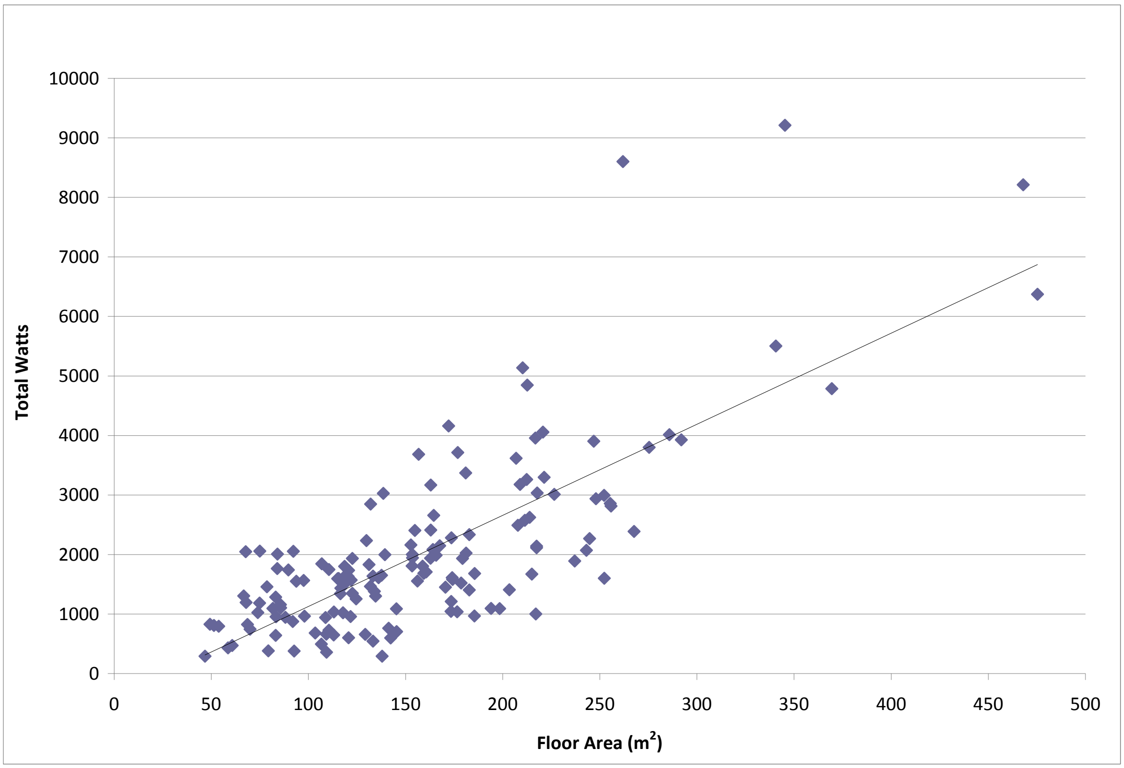
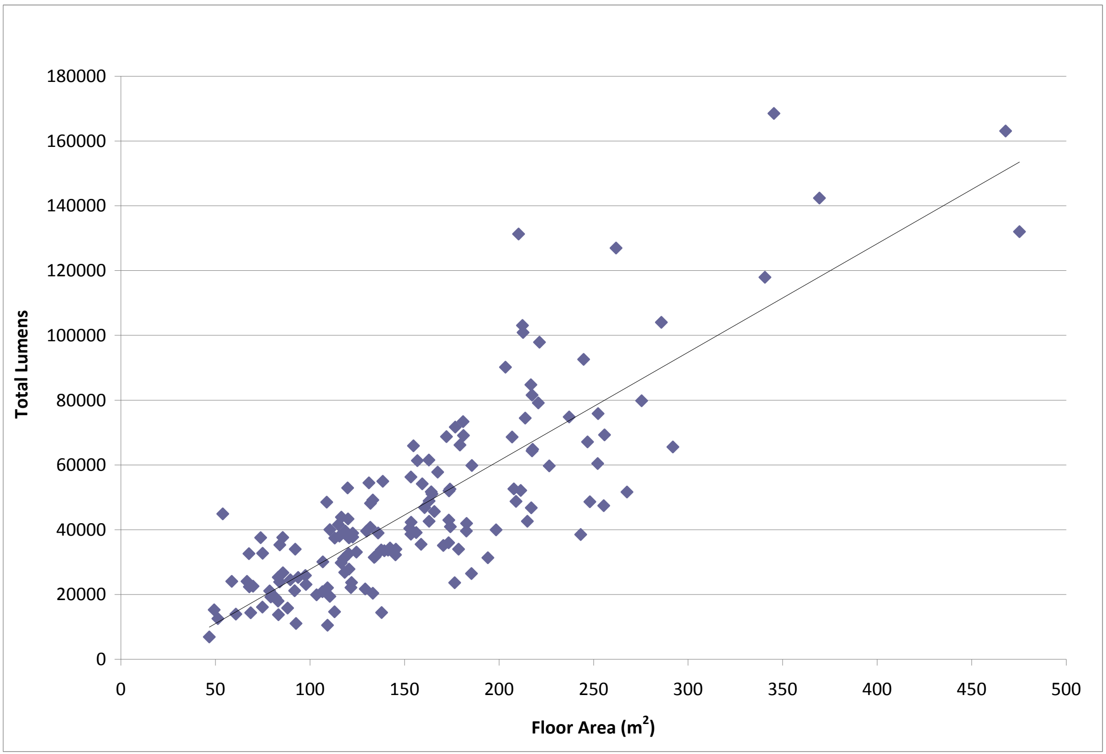


Figure 7: Floor Area versus Total Lumens – All Houses



An alternative way of looking at this data is to plot floor area versus total average Lumens/Watt for each house surveyed, as illustrated in Figure 8. This shows that larger houses tend to have a lower efficacy (15 to 30

Lumens/Watt total). Medium and small sized houses (between 50 m^2 and 250 m^2) have a wider range of average overall efficacy. This figure illustrates that the practical potential for improvement in average household lighting efficacy is more than 300%, from less than 15 Lumens/Watt in many houses to just over 60 Lumens/Watt (this higher efficacy level that has already been achieved by one house). Of course the energy used for lighting in the home will depend on which lights are used, their efficacy and their duration of use. However, there is no doubt that the lighting technologies available for installation in the home (as well as their placement in use) will have a major impact on overall lighting energy consumption. A house that has a very high overall lighting efficacy will most likely have lower total lighting energy consumption.

Figure 8: House Floor Area versus Total House Lighting Efficacy

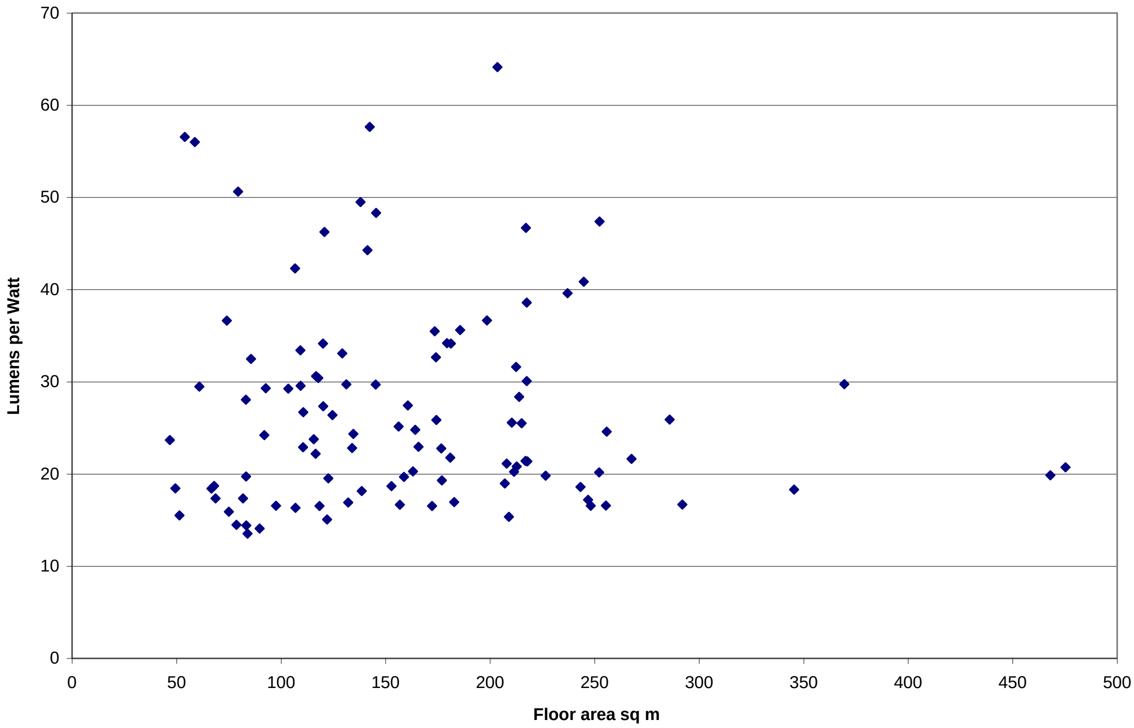
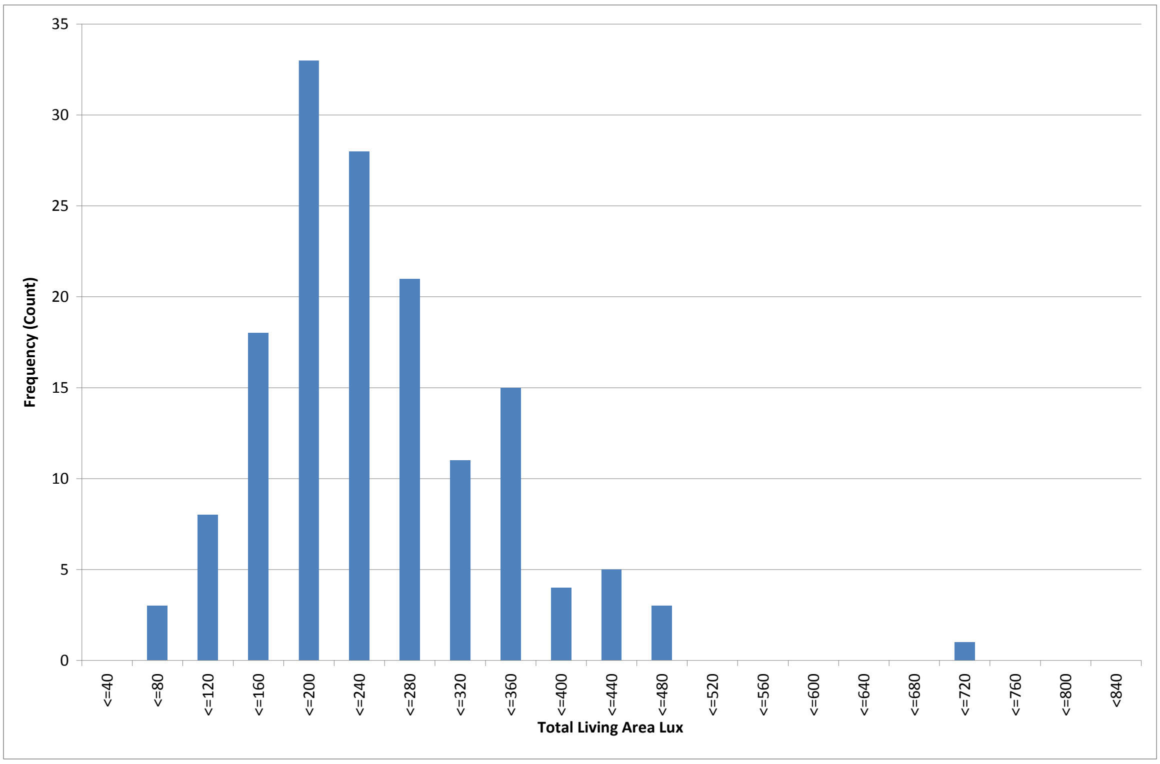


Figure 9 shows the Lux for living areas only[4]. The average Lux had a large range from greater than 40 up to 480 (one house had up to 720 Lux), although the lighting level for most living areas was in the range of more than 160 and up to 280 Lux. It is important to note that this is based on the total Lumen output of all lamps, assuming they are all on (which would rarely be the case in normal use). The lighting level on a horizontal surface (more typically the measure of useful light levels in a room) is estimated to be around half of these values (given directional losses and some losses via the luminaire, as set out in the methodology). So practical lighting levels in a home, given that all lamps are not on all the time, are probably in the range 80 to 200 Lux in most cases.

[4] Lighting levels in living areas are the most important in terms of total lighting. It is possible to calculate Lux distributions for other parts of the house, but values for sleeping and indoor-other rooms are less important in terms of usage level. It was not possible to calculate Lux for outdoor spaces.

Figure 9: Average House – Living Area Lumens/m² (Lux)



3.5 Fixed Lamps

Fixed lamps are defined as lamps that are permanently installed in the ceiling (normally), walls or floor of a house – these make up the majority of all lamps in an average home. Decisions concerning the placement, makeup, technology and mood of the fixed lighting are usually made at the design phase(s) of a house. This can be either when the house is first built or during a renovation. Lighting decisions made during these times make a massive impact on the effectiveness and overall energy consumption of a house's lighting system.

Table 8 shows the number of fixed lamps and share* for the average house. It can be seen that the lighting for a house is predominately comprised of fixed lamps (around 85%), this was almost 41 lamps per house on average (note that this includes missing lamps).

Table 8: Whole House Fixed Lamp Number and Share

Average by Room Type	Whole House
Fixed Lamp Numbers	40.7
Share of Fixed Lamps*	85.1%

** Share of all fixed and plug lamps found in the house.*

Table 9 shows the fixed lamp number and share for the average house by technology. It can be seen that the most common type of fixed lamp found in the average house was compact fluorescent, with just over a 28% share (around 12 lamps per house). Low voltage halogen lamps were the next most common, with almost a 27% share (about 11 lamps per house). Incandescent lamps had a slightly lower share at around 21% (almost 9 lamps per house) and linear fluorescent lamps had a just under a 10% share (4 lamps per house). Mains voltage halogen had a 9% share (almost 4 lamps), while LED lamps only had a 1% share (0.5 lamps), while lamps of an unknown technology had a 2.5% share (1 lamp per house).

Table 9: Whole House Fixed Lamp Number and Share by Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Lamp Numbers*	8.6	3.7	11.0	11.6	4.0	0.5	1.0
Fixed Lamp Share*	21.1%	9.2%	26.9%	28.4%	9.9%	1.1%	2.4%

** This does include missing lamps.*

3.6 Plug Lamps

Plug lamps are defined as lamps that are connected to a power point (general purpose outlet) and may be installed at any location around a house. They are generally placed on flat surfaces (ie tables, desks, floors) although they may also be found in a permanently installed form (but can still be disconnected from the mains – range hoods are a good example). Plug lamps can help to alter the light levels or mood of a space. Due to their flexibility, householders may use plug lamps to help alleviate poor fixed lighting design decisions (too much, not enough or not the right type of light) or to provide task lighting (eg for reading or on a desk). Plug lamps generally are able to have multiple forms of lamp technology installed (mostly incandescent, halogen or compact fluorescent) depending on cap type and design, although the configuration, connectors and available clearance can dictate the type of replacement lamps. This increases the ease of retrofitting choices of generic plugs such as bayonet (B22) and Edison screw (E27) types.

Table 10 shows the plug lamp number and share for the average house. It can be seen that plug lighting makes up only a minority share for a house (around 15%), this was found to be just over 7 lamps per house.

Table 10: Whole House Plug Lamp Number and Share

Average by Room Type	Whole House
Plug Lamp Numbers	7.1
Share of Plug Lamps*	14.9%

** Share of all fixed and plug lamps found in the house.*

Table 11 shows the plug lamp number and share for the average house by technology. It can be seen that the most common type of plug lamp found in the average house were compact fluorescent, with around a 40% total share (nearly 3 lamps per house). Incandescent lamps were the next most common, with just under a 27% total share (about 2 lamps per house). Low voltage halogen lamps had a lower total share at about 13% (1 lamp per house), with mains voltage halogen lamps having a 7% share (0.5 lamps). Linear fluorescent, LED and unknown lamps had a 3.0% or less total share.

Table 11: Whole House Plug Lamp Number and Share by Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Lamp Numbers*	1.9	0.5	0.9	2.8	0.2	0.2	0.1
Plug Lamp Share*	27.5%	7.1%	12.7%	39.9%	3.0%	3.0%	2.0%

** This does include missing lamps.*

3.7 Dimmers

Dimmers can be an important lighting control tool that householders use to adjust lamp brightness levels to their requirements. Dimmers reduce the power of the lamp and thereby similarly reduce the light intensity. Most operate by chopping the current waveform to the lamp using a thyristor – this technology only works on incandescent and quartz halogen technologies (resistance based lamps). Fluorescent technologies for dimming require specialised internal electronics. This generally means that most existing dimmers will not work with either compact fluorescent, linear fluorescent, or LED lamps, and are therefore unused by the householder in these cases.

Table 12 shows the average dimmer numbers by location and technology. An average of 4.4 dimmers were found per house, predominately in living areas (2.7 in the average house). Sleeping areas had an average of 1.1 dimmers per house, while indoor-other and outdoor areas were found to have less than 0.4 dimmers per house on average.

Dimmers were found most commonly on low voltage halogen lamps, at 2.8 per house. The majority of dimmers on these halogen lights were in living areas (just under 2 per house) and sleeping areas (although less than 1 per house). Low voltage halogen lamps in indoor-other and outdoor areas had dimmers, although they were less common (0.2 and 0.1 dimmers, respectively) than other areas.

Incandescent lamps were also found to have dimmers, although at far lower levels than low voltage halogen lamps (less than 1 per house and less than 0.5 for any room type), with mains voltage halogen lamps were found to have dimmers at similar levels. Compact fluorescent and LED lamps had dimmers, although these were rare at a household and individual room level.

Table 12: Average House Summary - Dimmer Location and Number by Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Incandescent	0.7	0.4	0.2	0.1	0.0
Mains Voltage Halogen	0.5	0.3	0.1	0.1	0.0
Low Voltage Halogen	2.8	1.8	0.7	0.2	0.1
Compact Fluorescent	0.2	0.2	0.1	0.0	0.0
Linear Fluorescent	0.0	0.0	0.0	0.0	0.0
LED	0.1	0.1	0.0	0.0	0.0
Total	4.3	2.8	1.1	0.4	0.1

4. Detailed Results by Room Type

Results are reported for the room aggregations as outlined in Section 2.2. It is important to understand not only the results for the whole house, but also for these individual room types, as key trends and findings may only become apparent after analysis has been completed for this level. Detailed results from the survey are split into several sections:

- Living rooms;
- Sleeping rooms;
- Indoor-other rooms; and
- Outdoors.

A range of characteristics are reported on for each room type, corresponding with the key interests concerning lighting:

- Numbers and electrical connection:
  - Lamp numbers;
  - Switch numbers;
  - Lamp numbers – fixed, plug;
  - Lamp share – fixed, plug.
- Room and area:
  - Number of rooms;
  - Floor area;
  - Room share;
  - Area share;
  - Lamps per m^2;
  - Lamps per room.
- Watts:
  - Total Watts;
  - Share Watts – fixed, plug;
  - Power Density (Watts/m^2);
  - Power Density (Watts/m^2) – fixed, plug.
- Lumens:
  - Lumens total;
  - Lumens – fixed, plug (total and share);
  - Lighting Levels (Lux – Lumens/m^2);
  - Lighting Levels (Lux – Lumens/m^2) – fixed, plug.

Further analysis of the living room findings can be found in Appendix Three, where it is split into three room types – separate kitchen (SK), kitchen/living (KL) and separate living.

4.1 Living

These are generally the high use areas of a house, and as such, are one of the most interesting areas in terms of lighting technologies and lighting levels. It is expected that householders would spend the largest amount of time in these areas, both during the day and evening hours. Unlike sleeping areas, living areas are focal points of household activity for the purposes of cooking, eating, entertainment and family activities. The living area is an aggregation of the:

- Dining;
- Kitchen;

- Lounge;
- Kitchen/Living; and
- Living-other.

The living area analysis presented here has been split into two sections – average values and frequency distributions – for different lamp and room characteristics.

4.1.1 Living Areas - Frequency Distribution of Key Parameters

Table 13 shows the lamp numbers and connection type for living areas. The average number of lamps was just over 16 per house, with 14.3 of these being fixed lamps (88%). Lamps in living areas were found on 8.2 switches, indicating more than 2 lamps were controlled by each switch.

Table 13: Living Room Summary – Numbers and Connection

Living Room	Average Per House
Number of Lamps	16.3
Number of Switches	8.2
Number of Fixed Lamps	14.3
Share of Fixed Lamps	88.0%
Number of Plug Lamps	2.0
Share of Plug Lamps	12.0%

Table 14 shows the room and area summary for living spaces. The average number of living rooms per house was almost 3, although this includes open space living areas as well. The average floor area per house was found to be 60 m^2, a sizeable proportion of the total space in a house. The share of all floor area shows this more clearly, as living areas made up almost 40% of the average house. There were around 6.0 lamps per room, with 0.3 lamps per m^2.

Table 14: Living Room Summary – Room and Area

Living Room	Average Per House
Number of Rooms	2.8
Floor Area (m^2)	60.3
Share of all Rooms	17.8%
Share of all Floor Area	38.3%
Lamps per m^2	0.3
Lamps per Room	5.9

Table 15 shows the living room summary for power consumption. Total Watts were 614 per house, with the majority of these due to fixed lamps (almost 90%). Plug lamps only contributed around 10% of the share of total Watts. The power density for living rooms was found to be just over 10 Watts/m^2. Again, most of this average was due to fixed lamps.

Table 15: Living Room Summary – Watts

Living Room	Average Per House
Total Watts	614.1
Share Watts – Fixed Lamps	89.5%
Share Watts – Plug Lamps	10.5%
Power Density (Watts/m^2)	10.2
Power Density (Watts/m^2) – Fixed Lamps	9.1
Power Density (Watts/m^2) – Plug Lamps	1.1

Table 16 shows the Lumen summary for living areas. The average Lumen output was just under 14,000, with 12,441 of this being due to fixed lamps (almost 90%). The average plug lamp Lumens was 1437 (around 11%). Lighting levels in living areas had an average of 230 Lux, with the majority of this (almost 210) being due to fixed lamps.

Table 16: Living Room Summary – Lumens

Living Room	Average Per House
Lumens	13878
Lumens – Fixed Lamps	12441
Lumens Share – Fixed Lamps	89.6%
Lumens – Plug Lamps	1437
Lumens Share – Plug Lamps	10.4%
Lighting Levels (Lux)	230
Lighting Levels (Lux) – Fixed Lamps	206
Lighting Levels (Lux) – Plug Lamps	24

4.1.2 Living Areas - Frequency Distribution of Key Parameters

Figure 10 shows the number of lamps (both fixed and plug) in the living areas of houses. The highest percentage of houses (around 17%), had more than 12 and up to 14 lamps. Although numbers ranged significantly, the majority of houses were found to have more than 6 and up to 20 lamps in living areas. A smaller number of houses had more than 34 lamps, the maximum as high as 78.

Figure 10: Distribution of Lamps in Living Areas for all Houses

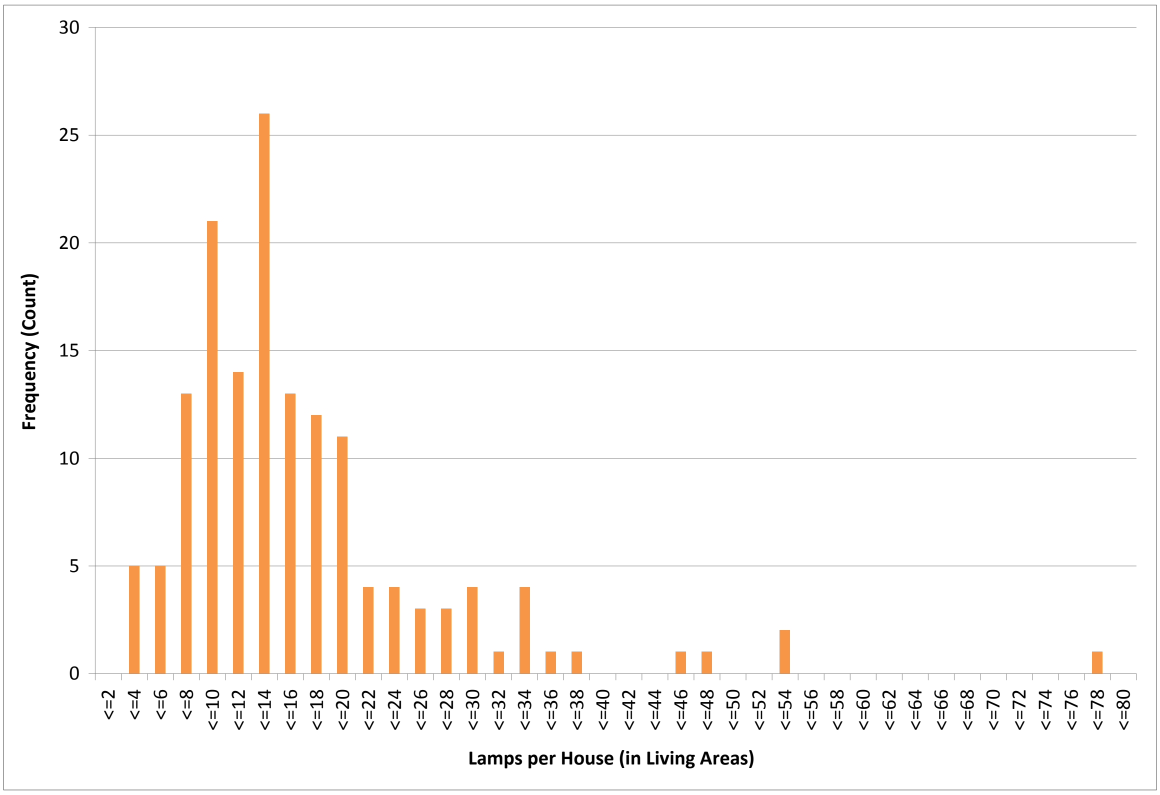


Figure 11 shows the number of fixed lamps found in living areas in houses. The highest percentage of houses (30%), were found to have between more than 6 and up to 10 fixed lamps. The bulk of houses had more than this, up to a maximum of 76, although it was uncommon to find houses with more than 30 fixed lamps in living areas.

Figure 11: Distribution of Fixed Lamps in Living Areas for all Houses

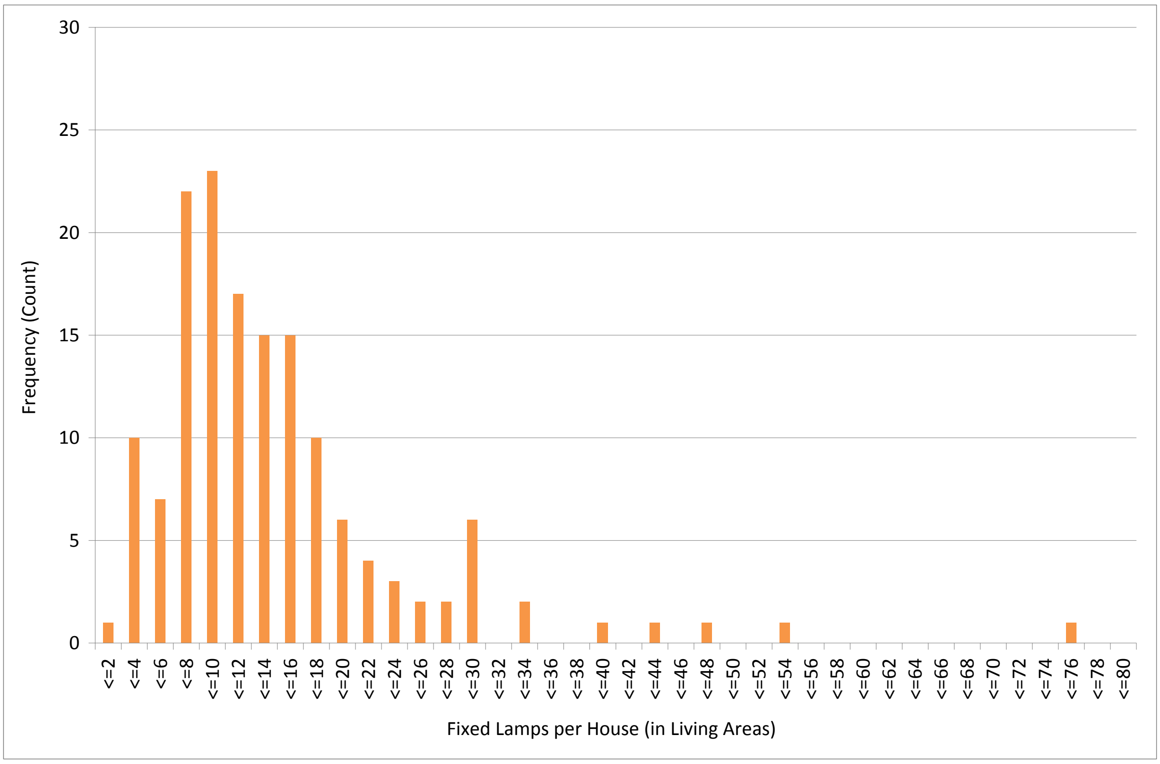


Figure 12 shows the number of plug lamps found in living areas in houses. Most houses (54%), had no or only 1 plug lamps. Another 20% of houses were found to have 2 plug lamps, with a smaller number having either 3 or 4. A small percentage of houses had between 5 and 9, and one house had 15 plug lamps in living areas.

Figure 12: Distribution of Plug-in Lamps in Living Areas for all Houses

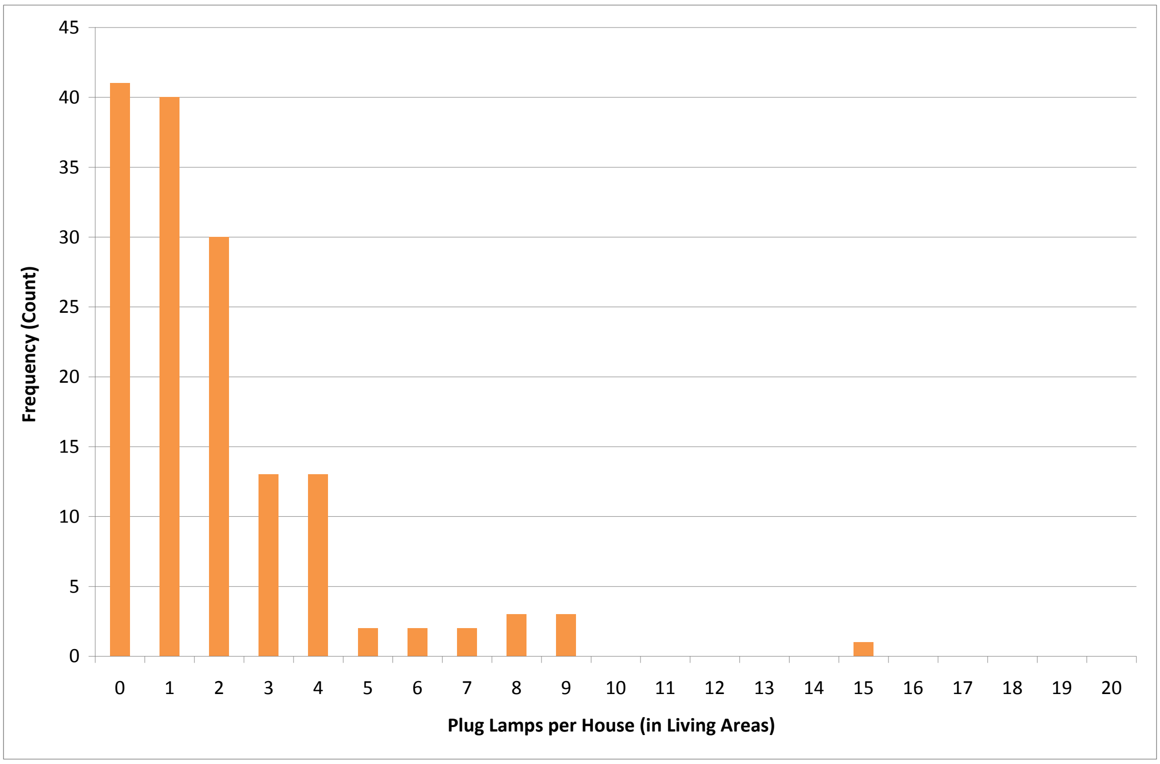


Figure 13 shows the number of living rooms per house. The largest number of houses (around 39%) were found to have 2 living areas (most probably a kitchen and a lounge). Almost 34% had 3 living areas, with a considerable number having 4. A far smaller number of houses had either 1 or 5 living areas.

Figure 13: Distribution of Living Rooms per House for all Houses

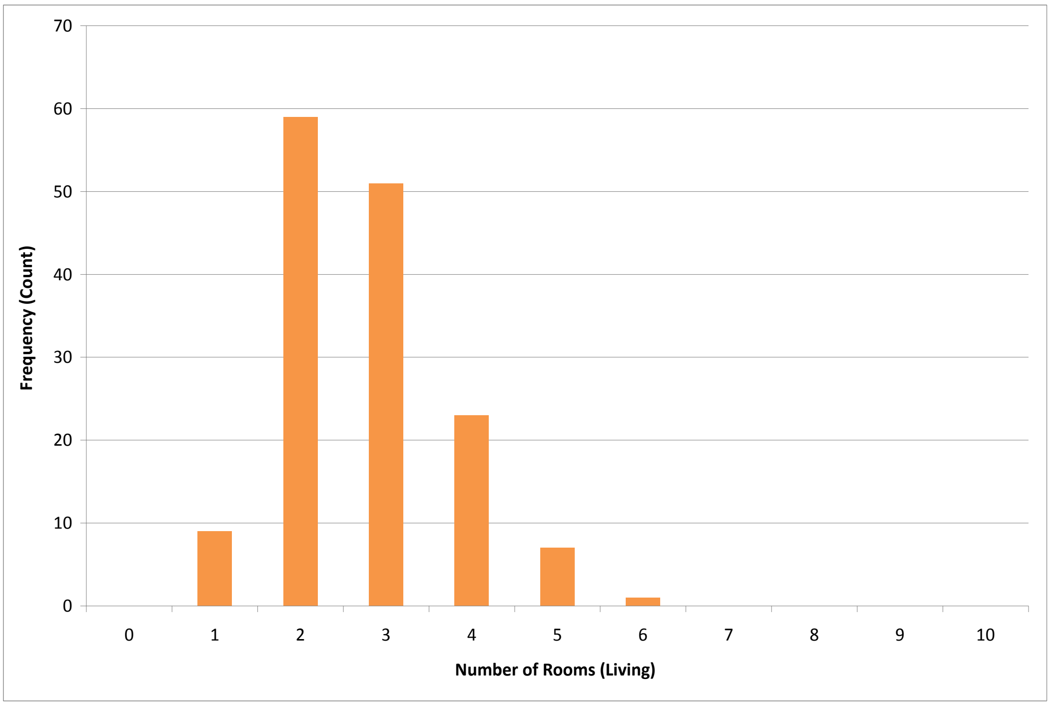


Figure 14 shows the average living room floor area per house. Almost 13% of houses (the highest percentage for a bin category) were found to have greater than 36 m² and up to 40 m² of floor area, although the bulk of houses had more than this. The minimum floor area was less than 20 m², and the maximum was found to be between 195–200 m² (exclusive).

Figure 14: Distribution of Living Area Floor Area (m²) for all Houses

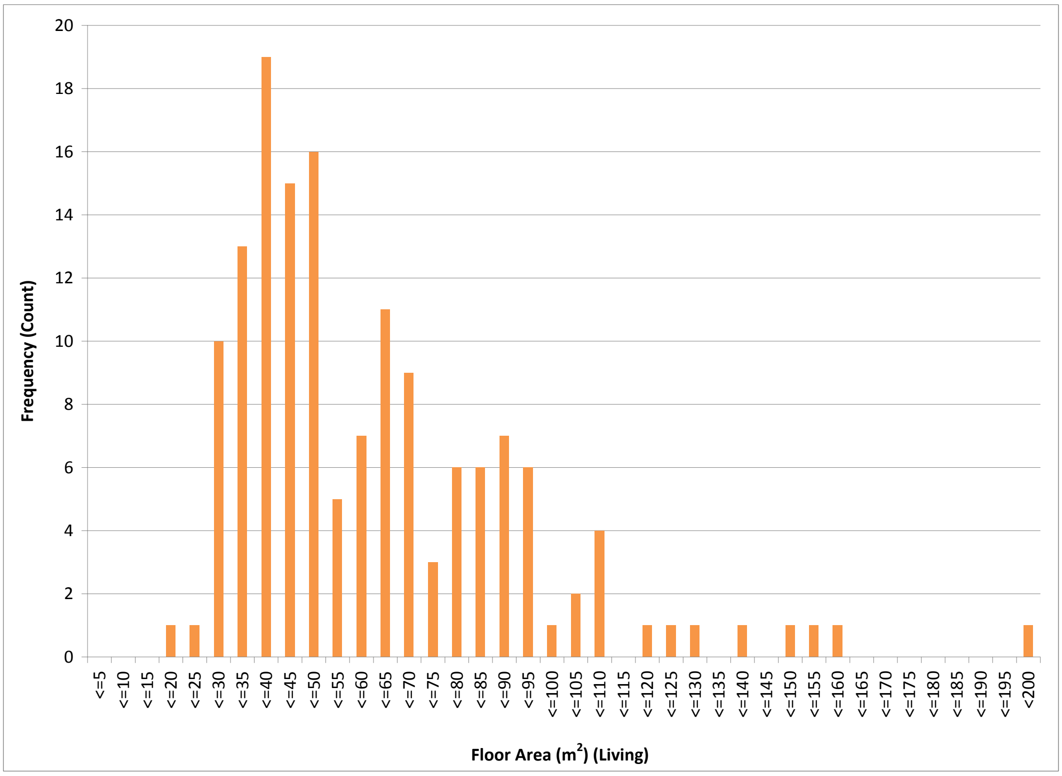


Figure 15 shows the average power density for living areas. Eighteen per cent of houses had an average of more than 4 Watts/m² and up to 6 Watts/m², although the bulk of houses had more than this – up to 14 Watts/m². A number of houses had a power density higher than this, with a maximum of 27 Watts/m² recorded. Some houses were found to have less than 4 Watts/m², down to a minimum of less than 2 Watts/m², although these were the minority.

Figure 15: Distribution of Living Area Power Density (Watts/m²) for all Houses

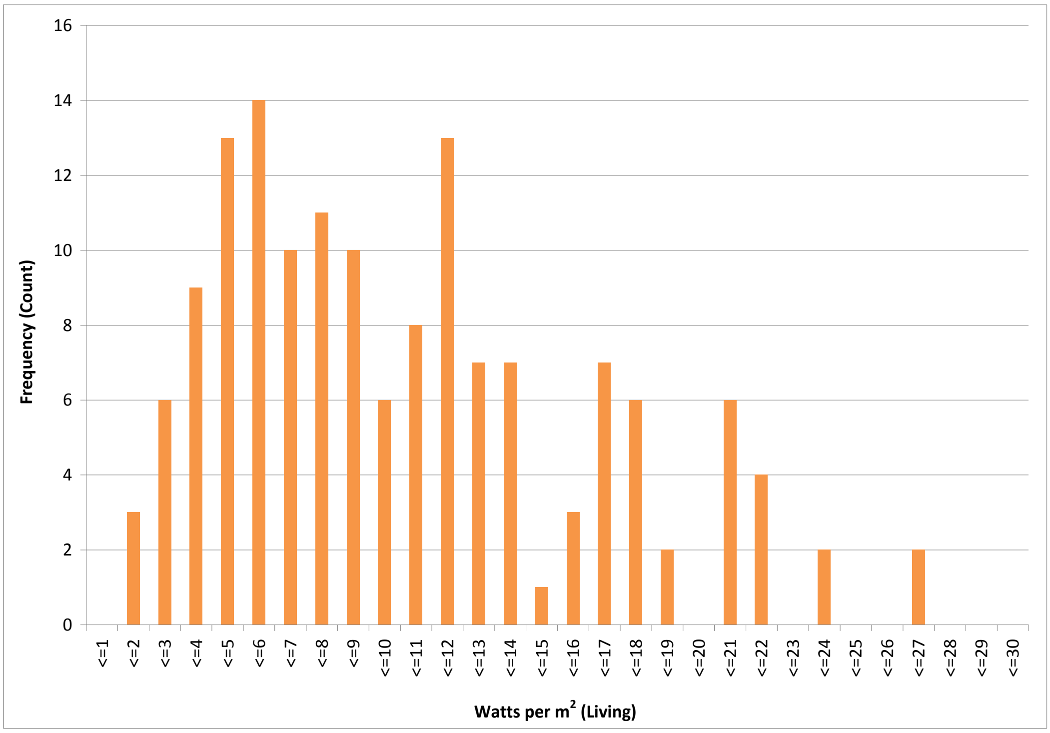


Figure 16 shows the range of Lumens totals of living spaces in houses. Eighteen per cent of houses (the highest percentage for a bin category) had greater than 8000 Lumens and up to 10,000 Lumens, with the bulk of houses having more than this. The minimum number of Lumens in living rooms in a house was less than 4000, with the maximum of up to 52,000 Lumens. However, it was rare for houses to have over 26,000 Lumens in living rooms.

Figure 16: Distribution of Living Area Total Lumens for all Houses

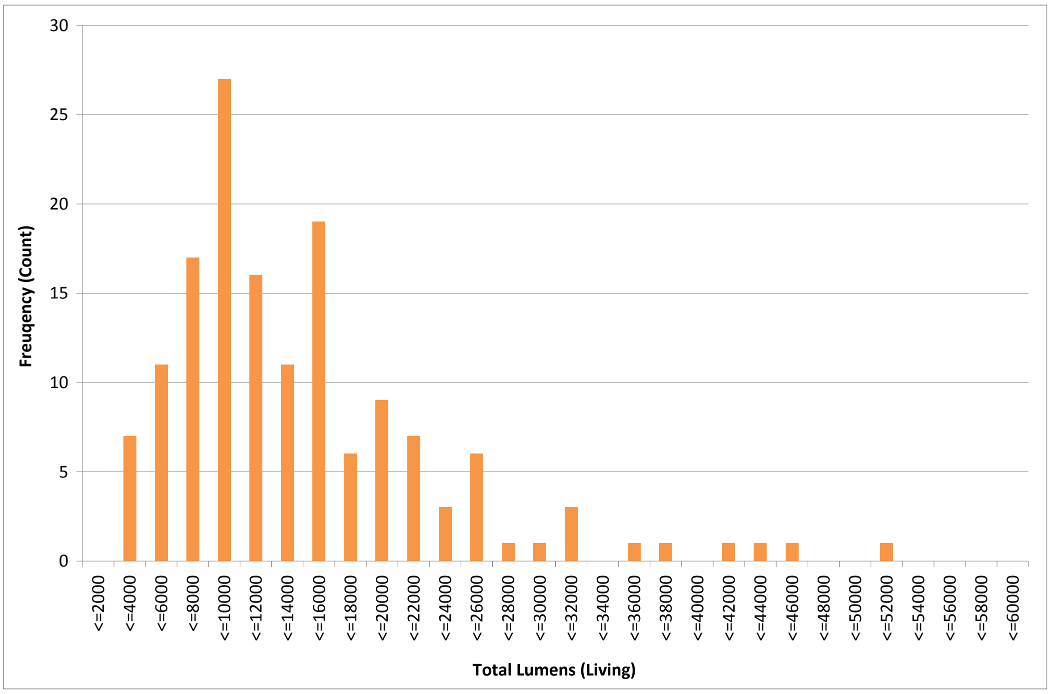
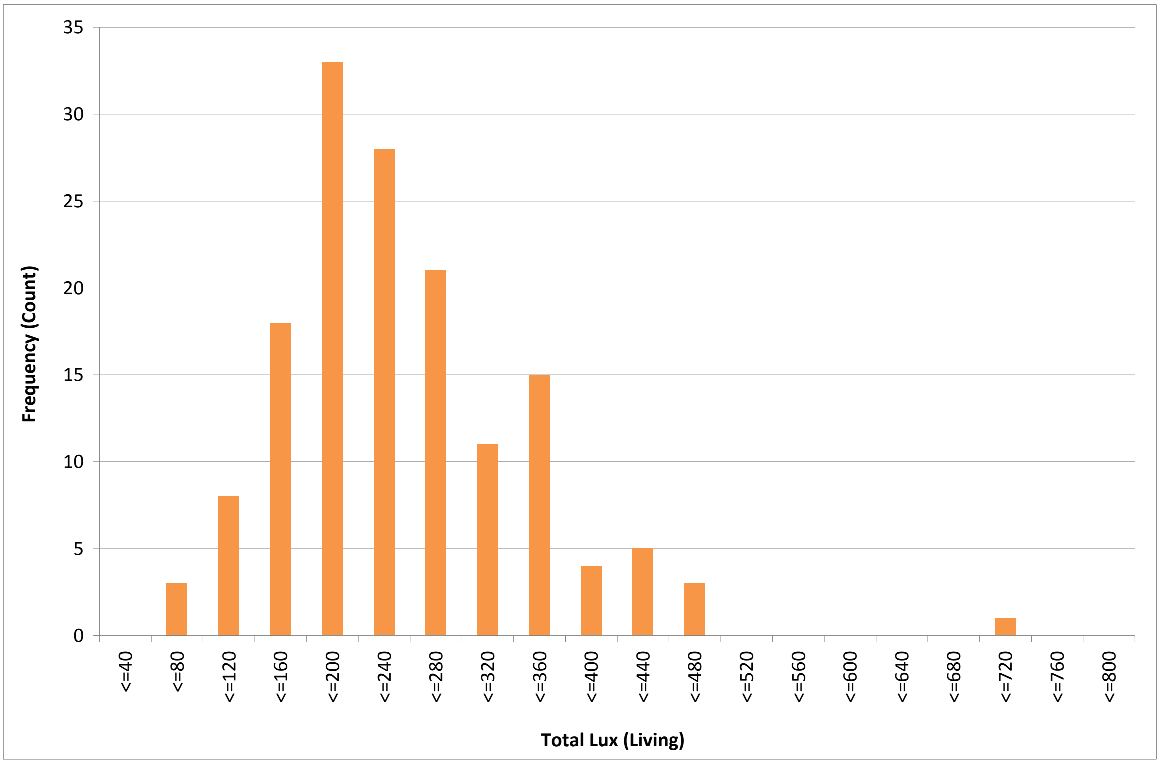


Figure 17 shows the lighting levels for the living spaces of houses. The majority of houses (22%) had an average Lux greater than 160 and up to 200, with around another 19% having up to 240 Lux. The minimum Lux for a house was greater than 40 but less than 80, and the maximum was found to be up to 720 Lux (a statistical outlier). The bulk of houses produced more than 120 Lux, ranging up to 360 Lux.

Figure 17: Distribution of Living Area Lighting Levels (Lux) for all Houses



4.2 Sleeping

It is expected that householders would spend a reasonably large amount of time in sleeping areas, although in differing periods of the day/night. The sleeping area is an aggregation of the:

- Bedroom; and
- Study (this was included as these spaces were assumed to have a similar interest and use profile as bedrooms).

Bedroom lighting use may differ from study lighting use, although it is not expected to affect the analysis as the prevalence of these rooms is fairly low.

Table 17 shows the lamp numbers and connection type for sleeping areas. The average number of lamps was found to be just over 11 per house, with almost 7 of these being fixed lamps (around 61%). These lights were found on 8.1 switches, indicating that less than 2 lamps were controlled by each switch (multiple lamp switches are probably for fixed lamps).

Table 17: Sleeping Rooms Summary – Numbers and Connection

Sleeping Rooms	Average Per House
Number of Lamps	11.1
Number of Switches	8.1
Number of Fixed Lamps	6.8
Share of Fixed Lamps	61.5%
Number of Plug Lamps	4.3
Share of Plug Lamps	38.5%

Table 18 shows the room and area summary for sleeping spaces. The average number of sleeping rooms per house was found to be 3.5 (almost 23% of all rooms). The average sleeping room floor area per house was 44.7 m^2, almost 30% of the average house. There were just over 3.0 lamps per room, with 0.3 lamps per m^2.

Table 18: Sleeping Room Summary – Room and Area

Sleeping Room	Average Per House
Number of Rooms	3.5
Floor Area (m^2)	44.7
Share of all Rooms	22.8%
Share of all Floor Area	28.4%
Lamps per m^2	0.3
Lamps per Room	3.1

Table 19 shows the sleeping room summary for Watts. Sleeping rooms had a total average of 354 Watts per house, with the majority of these due to fixed lamps (around 65%). The power density for sleeping rooms was found to be just under 8 Watts/m^2, with over 5 Watts/m^2 of this being due to fixed lamps.

Table 19: Sleeping Room Summary – Watts

Sleeping Room	Average Per House
Total Watts	354.0
Share Watts – Fixed Lamps	65.3%
Share Watts – Plug Lamps	34.7%
Power Density (Watts/m^2)	7.9
Power Density (Watts/m^2) – Fixed Lamps	5.2
Power Density (Watts/m^2) – Plug Lamps	2.7

Table 20 shows the Lumen summary for sleeping areas. The average Lumen output was around 8200, with almost 5824 of this being due to fixed lamps (around 71%). The average plug lamp Lumens were only around 2,300. Sleeping areas had a Lux of 182, with the majority of this (130 Lux or 71%) being due to fixed lamps.

Table 20: Sleeping Room Summary – Lumens

Sleeping Room	Average Per House
Lumens	8154
Lumens – Fixed Lamps	5824
Lumens Share – Fixed Lamps	71.4%
Lumens – Plug Lamps	2329
Lumens Share – Plug Lamps	28.6%
Lighting Level (Lux)	182
Lighting Level (Lux) – Fixed Lamps	130
Lighting Level (Lux) – Plug Lamps	52

4.3 Indoor-other

These are a collection of 'intermediate use' areas of a house, which for lighting may mean 'on/off' type use in many cases. It is not expected that there would be any pattern to this usage (time of day or otherwise), even by room type.

The indoor-other area is an aggregation of the:

- Bathroom;
- Foyer-inside;
- Hallway;
- Laundry;
- Pantry;
- Storage Room;

- Walk-in Robe;
- Toilet; and
- Other-inside.

This rather eclectic mix of rooms has been aggregated into one space, as it is expected that analysis at an individual room level (for any room type) would not provide useful or meaningful results. Compared to living or sleeping areas, these are normally small sized rooms, probably with a lower number of lamps per room and on average are likely to have fairly low usage.

Table 21 shows the lamp numbers and connection type for indoor-other areas. The average number of lamps was just under 11 per house, with around 10.4 of these being fixed lamps (around 96%), and just under 0.5 being plug lamps. These lights were found on just over 8 switches, indicating that just less than 2 lamps on average were controlled by each switch.

Table 21: Indoor-Other Room Summary – Numbers and Connection

Indoor-other Room	Average Per House
Number of Lamps	10.8
Number of Switches	8.4
Number of Fixed Lamps	10.4
Share of Fixed Lamps	96.3%
Number of Plug Lamps	0.4
Share of Plug Lamps	3.7%

Table 22 shows the room and area summary for indoor-other spaces. On average there were 6 indoor-other rooms per house, with a total average floor area of around 34 m^2. The share of all rooms was almost 40%, with the share of floor area found to make up just over 20% of the average house. There were less than 2 lamps per room, with 0.3 lamps per m^2.

Table 22: Indoor-Other Summary – Room and Area

Indoor-other Room	Average Per House
Number of Rooms	6.1
Floor Area (m^2)	34.2
Share of all Rooms	39.6%
Share of all Floor Area	21.7%
Lamps per m^2	0.3
Lamps per Room	1.8

Table 23 shows the indoor-other room summary for Watts. Total Watts were 416 per house, with the majority of these due to fixed lamps (just under 97%). Indoor-other rooms had just over 12 Watts/m^2, with almost all of this being due to fixed lamps.

Table 23: Indoor-Other Room Summary - Watts

Indoor-other Room	Average Per House
Total Watts	416
Share Watts – Fixed Lamps	96.7%
Share Watts – Plug Lamps	3.3%
Power Density (Watts/m^2)	12.2
Power Density (Watts/m^2) – Fixed Lamps	11.8
Power Density (Watts/m^2) – Plug Lamps	0.4

Table 24 shows the Lumen summary for indoor-other areas. The average Lumens was around 10,000, with over 9700 of this being due to fixed lamps (around 97%). The average plug lamp Lumens were found to be only 291. Indoor-other areas had a Lux of 293, with the majority of this being due to fixed lamps.

Table 24: Indoor-Other Room Summary - Lumens

Indoor-other Room	Average Per House
Lumens	10,029
Lumens – Fixed Lamps	9,738
Lumens Share – Fixed Lamps	97.1%
Lumens – Plug Lamps	291
Lumens Share – Plug Lamps	2.9%
Lighting Levels (Lux)	293
Lighting Levels (Lux) – Fixed Lamps	285
Lighting Levels (Lux) – Plug Lamps	9

4.4 Outdoor

These are a collection of probably rare and intermediate use areas of a house, which for lighting may mean either 'on/off' type use (including through sensors), or infrequent use in many cases. The outside area is an aggregation of:

- Garage;
- Other-outside;
- Outside-general; and
- Verandah.

Table 25 shows the lamp numbers and connection type for outdoor areas. The average number of lamps was 9.7 per house, with around 9 of these being fixed lamps (just over 95%). Outdoor area lights were found on 5.2 switches, indicating that less than 2 lamps were controlled by each switch.

Table 25: Outdoor Area Summary – Numbers and Connection

Outdoor	Average Per House
Number of Lamps	9.7
Number of Switches	5.2
Number of Fixed Lamps	9.2
Share of Fixed Lamps	95.1%
Number of Plug Lamps	0.5
Share of Plug Lamps	4.9%

Table 26 shows the room and area summary for outdoor spaces. There was an average of 3 outdoor 'rooms' (distinct areas in which lamps were located) per house. The average floor area per house was about 18 m^2 (garages, some sheds and under house areas). The share of all floor area for outdoor areas was almost 12% of the average house. However, most outdoor spaces do not have a floor area as such, so this value needs to be treated with some caution. There were just over 3 lamps per room, with 0.5 lamps per m^2.

Table 26: Outdoor Area Summary – Room and Area

Outdoor	Average Per House
Number of "Rooms" (Outdoor Spaces)	3.1 *
Floor Area (m^2)	18.4 *
Share of all Rooms	19.8%
Share of all Floor Area	11.7%
Lamps per m^2	0.5
Lamps per Room	3.2

*Note: * This only includes outdoor spaces that had at least 1 light. Most outdoor spaces do not have defined boundaries and cannot have a floor area allocated in this analysis.*

Table 27 shows the outdoor area summary for Watts. Outdoor areas had an average total Watts of just over 624 per house, with the majority due to fixed lamps (almost 95%). The power density for outdoor areas was just over 32 Watts/m^2, with nearly all of this being due to fixed lamps (plug lamps only contributing 1.9 Watts/m^2).

Table 27: Outdoor Area Summary - Watts

Outdoor	Average Per House
Total Watts	624.7
Share Watts – Fixed Lamps	94.4%
Share Watts – Plug Lamps	5.6%
Power Density (Watts/m²)	34.0
Power Density (Watts/m²) – Fixed Lamps	32.1
Power Density (Watts/m²) – Plug Lamps	1.9

Table 28 shows the Lumen summary for outdoor areas. The average Lumens was around 15,000, with over 14,000 of this being due to fixed lamps (around 95%). The average plug lamp Lumens were found to be around 700. Outdoor areas had an average 818 Lux, with the majority of this being due to fixed lamps.

Table 28: Outdoor Area Summary - Lumens

Outdoor	Average Per House
Lumens	15022
Lumens – Fixed Lamps	14321
Lumens Share – Fixed Lamps	95.3%
Lumens – Plug Lamps	701
Lumens Share – Plug Lamps	4.7%
Lighting Levels (Lux)	818
Lighting Levels (Lux) – Fixed Lamps	779
Lighting Levels (Lux) – Plug Lamps	38

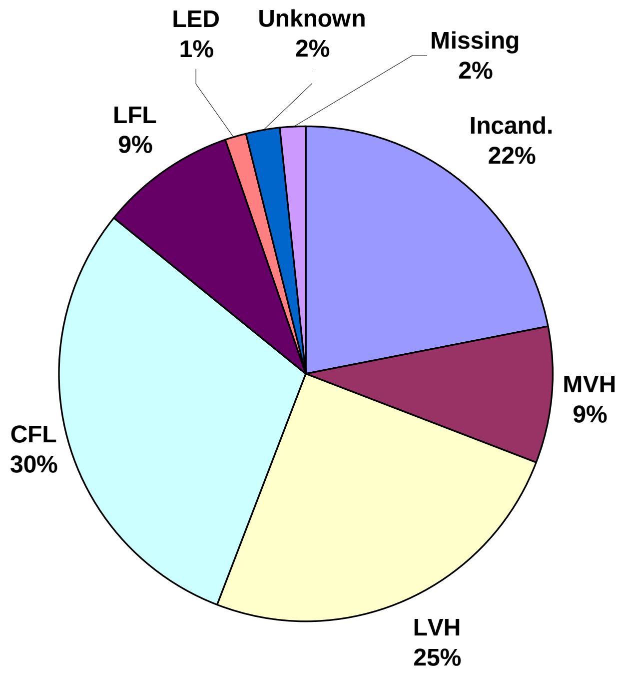
The results for this space type are influenced by the prevalence of higher power incandescent and quartz halogen (mains voltage) spotlights.

5. Detailed Results by Technology

The mix of lamp technology has a massive influence on the lighting energy consumption of a house. Different technologies have differing efficacy levels and sometimes different dominant fitting types. Both of these factors impact on the ability to retrofit when attempting to increase the general efficiency of lighting. They also impact on the ability of the householder to alter the lighting makeup or mood of their house.

Figure 18 shows the technology share of the average house. As can be seen, around 30% of lamps were compact fluorescent and about a quarter low voltage halogen or incandescent. Linear fluorescent and mains voltage halogen lamps both made up 9% of the technology share, and 1% were LEDs. Four per cent of lamps were either unknown or missing.

Figure 18: Average House – Technology Share (number of lights)



Note: CFL = compact fluorescent lamp. LFL = linear fluorescent lamp. MVH = mains voltage halogen. LVH = low voltage halogen.

5.1 Incandescent

Incandescent lamps are the original technology for producing light using electricity. They produce light by heating a metal (tungsten) filament to a high temperature until it glows. In terms of the general conversion of energy to light, this technology is poor due to the high amount of heat produced by the process. Australian Governments have introduced measures to phase out incandescent as a lighting technology, where feasible, for this reason.

Table 29 shows the findings for incandescent lamps, by household area. Incandescent lamps were just under a quarter of all lamps in houses, with almost 11 lamps per house. They were found to contribute around 38% of the Watts in a house, with an average of just under 73 Watts per lamp.

Incandescent lamps were found in high numbers in all parts of the house, contributing to almost a third of lamps in outdoor spaces. In indoor-other areas, almost a quarter of lamps were found to be incandescent, while in sleeping areas just under 20% were incandescent. For living areas, 16.5% of lamps were incandescent.

Incandescent lamps were found to be responsible for 53% of the total power in outdoor areas, which is certainly driven by external spotlights. This is confirmed by an average power of just over 110 Watts per lamp (external spotlights such as PAR lamps, are commonly around 150 Watts).

For sleeping areas, incandescent lamps contributed almost a third of total power, while for living areas, they were found to be responsible for just over a fifth of total power. The average power per lamp for these areas was very similar, at around 50 Watts. This is because lower power incandescent lamps (ie 40 Watts) are still reasonably common in table lamps on beside tables.

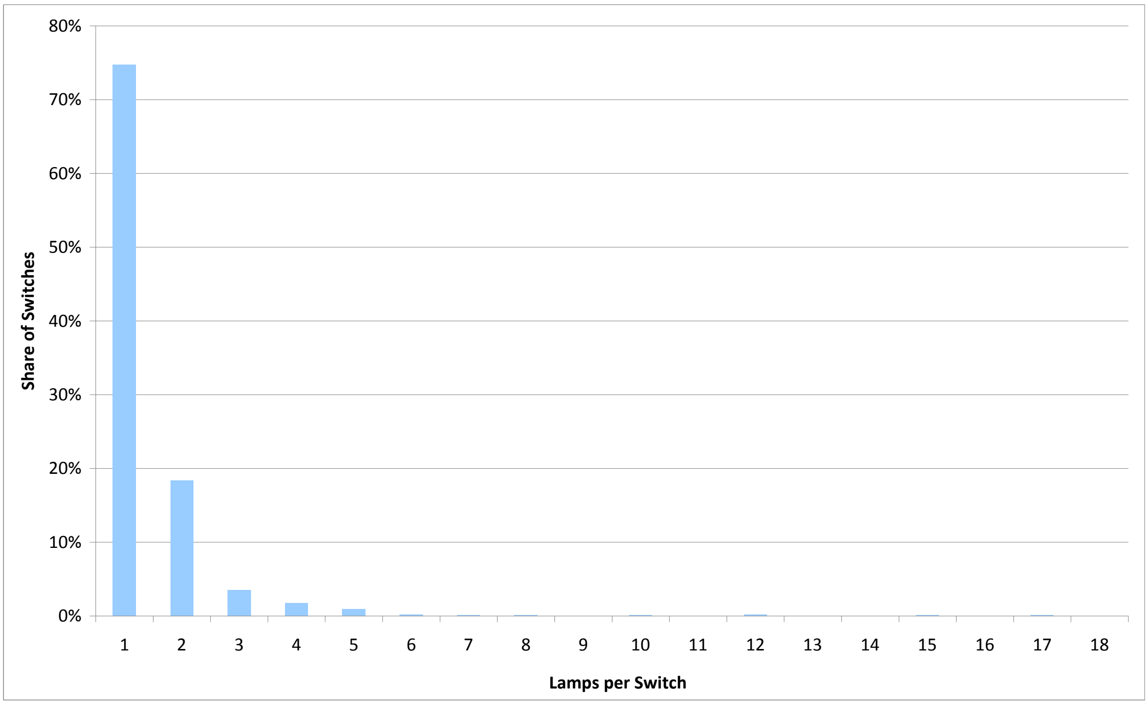
Table 29: Detailed Results – Incandescent Technology

Average Per House	Whole house	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	10.6	2.7	2.2	2.6	3.1
Number Share*	22.0%	16.5%	19.6%	23.8%	32.2%
Watts Total	755.0	144.0	113.0	167.0	331.0
Watts Share*	37.6%	23.5%	31.9%	40.1%	53.0%
Watts per Lamp	72.7	49.1	49.8	70.1	112.4

** This is as a share of all technologies*

Figure 19 shows the number of incandescent lamps found per switch. The majority of switches had only one incandescent lamp (around 74%), with almost 20% of switches found to have two incandescent lamps. A small number of switches had between 3 and 6 incandescent lamps.

Figure 19: Number Incandescent Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

5.1.1 Incandescent Fitting and Cap Types

Table 30 to Table 33 show the fitting and cap type details for incandescent lamps. The following points give a brief explanation of what is shown in each table. More information on fitting types is given in Section 2.3.

Key for Fitting and Cap Type Table Heading Explanation (for all lamp technologies)

- Fitting Type/Cap Type: this column lists the fitting type that the lamp was found in.
- Per cent of All Lamp Techs: this column lists the percentage of installation of that lamp technology in that fitting of all technologies, and in brackets the raw number of lamps found (ie 36% of fixed lamps found in Batten Holders were incandescent, equalling 126 individual lamps).

- Cap Type Columns: these columns list the cap types that that were applicable for that lamp technology. Cell entries show the percentage of lamps that corresponded to a particular fitting and cap type (ie 1% of Batten Holder fixed incandescent lamps had a B15 cap).

Key for Fitting and Cap Type Average Wattage Table Heading Explanation (for all lamp technologies)

- Fitting Type/Cap Type: this column lists the fitting type that the lamp was found in.
- All Lamp Techs Average W: this column lists the average Wattage of all lamp technologies for that fitting.
- Cap Type Columns: these columns list the cap types that that were applicable for that lamp technology. Cell entries show the average Wattage of lamps that corresponded to a particular fitting and cap type.

Table 30 shows the fitting and cap type details for incandescent fixed lamps. The key findings to note are:

- 57% of all floodlight/external spotlight lamp fittings were fixed incandescent lamps, with 100% of these having an E27 cap;
- 27% of all suspended lamp fittings were fixed incandescent lamps, with 77% of these having a B22 cap; and
- 37% of all wall light lamp fittings were fixed incandescent lamps, with 58% of these having a B22 cap.

Table 30: Incandescent Fixed Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	Cannot Identify	B15	B22	E14	E27
Batten Holder	36% (126)		1%	93%		6%
Batten Holder with Shade	21% (25)			100%		
Combination Heat/Light Lamp	73% (82)			1%		99%
Downlight/Flush Mounted	6% (103)					100%
Floodlight/External Spotlight	57% (196)					100%
Garden Light	63% (32)			72%		28%
Indoor Spotlight	20% (79)			8%	1%	91%
Oyster	30% (151)	28%		46%		26%
Rangehood	61% (99)	10%	90%			
Suspended	27% (203)	7%	9%	77%	4%	3%
Uplight	20% (5)					100%
Wall Light	37% (184)	5%	18%	58%	7%	12%

Table 31 shows the fitting and cap type average Wattage details for incandescent fixed lamps. The key findings to note are:

- the average Wattage for floodlight/external spotlight lamp fittings was 82 Watts, fixed incandescent lamps with an E27 cap had an average of 150 Watts;
- the average Wattage for suspended lamp fittings was 43 Watts, fixed incandescent lamps with a B22 cap had an average of 56 Watts;
- the average Wattage for wall light lamp fittings was 40 Watts, fixed incandescent lamps with a B22 cap had an average of 68 Watts.

Table 31: Incandescent Fixed Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	Cannot Identify (Avg W)	B15 (Avg W)	B22 (Avg W)	E14 (Avg W)	E27 (Avg W)
Batten Holder	44.6		60.0	68.8		71.3
Batten Holder with Shade	46.4			74.0		
Combination Heat/Light Lamp	45.8			75.0		80.9
Downlight/Flush Mounted	53.3					77.8
Floodlight/External Spotlight	82.5					150.0
Garden Light	36.2			72.4		63.3
Indoor Spotlight	45.4			75.0	60.0	69.0
Oyster	55.4	56.0		67.3		59.4
Rangehood	27.8	40.0	39.6			
Suspended	43.4	54.6	40.0	55.8	40.0	49.3
Uplight	66.1					60.0
Wall Light	39.9	42.0	32.3	68.0	50.0	72.0

Table 32 shows the fitting and cap type details for incandescent plug lamps. The key findings to note are:

- 38% of table lamp fittings were plug incandescent lamps, with 58% of these having a B22 cap;
- 20% of all desk lamp fittings were plug incandescent lamps, with 45% of these having a B22 cap;
- 26% of all floor/standard lamp fittings were plug incandescent lamps, with 33% of these having an E27 cap.

Table 32: Incandescent Plug Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	Cannot Identify	B15	B22	E14	E27
Desk Lamp	20% (54)		11%	45%	20%	24%
Floodlight/External Spotlight	51% (21)					100%
Floor/Standard Lamp	26% (49)		14%	22%	31%	33%
Nightlight	75% (9)	12%	44%		44%	
Other	25% (3)					100%
Rangehood	50% (2)		100%			
Table Lamp	38% (147)	3%	17%	58%	18%	4%

Table 33 shows the fitting and cap type average Wattage details for incandescent plug lamps. The key findings to note are:

- the average Wattage for table lamp fittings was 32 Watts, plug incandescent lamps with a B22 cap had an average of 50 Watts;
- the average Wattage for desk lamp fittings was 31 Watts, plug incandescent lamps with an E27 cap had an average of 55 Watts;
- the average Wattage for floor/standard lamp fittings was 52 Watts, plug incandescent lamps with a B22 cap had an average of 69 Watts.

Table 33: Incandescent Plug Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	Cannot Identify (Avg W)	B15 (Avg W)	B22 (Avg W)	E14 (Avg W)	E27 (Avg W)
Desk Lamp	30.9		29.2	50.3	32.7	55.0
Floodlight/External Spotlight	110.1					150.0
Floor/Standard Lamp	51.8		37.9	68.6	39.3	62.8
Nightlight	11.1	20.0	8.0		5.8	
Other	24.6					51.7
Rangehood	45.0		40.0			
Table Lamp	31.9	37.0	34.6	50.5	35.9	43.3

Findings and discussion concerning incandescent lamps can be found in Section 5.7.

5.2 Halogen

Halogen lamps produce light by heating a metal filament to a high temperature until it glows (similar to incandescent lamps), although they also contain a small amount of halogen gas to increase lifetime and operating temperature (and therefore intensity). Halogen lamps are also similar to incandescent lamps in that electrical energy to light conversion is relatively poor due to the amount of heat produced. However, halogen lamps are slightly more efficient.

Many householders appear to hold misconceptions concerning halogen lamps, specifically low voltage types – the misunderstanding being that 'extra low voltage' means low energy. A recent Victorian lighting survey (Appliances and Lighting Quantum, Sustainability Victoria, June 2010) found that 63% of those surveyed believed low voltage halogens were the most efficient form of lighting, compared with 38% for compact fluorescent lighting.

Halogen lamps in the form of low voltage downlights have become very much more prevalent in Australian households in recent times. The flush mounting (ie insertion into the ceiling cavity) has been known to interact with ceiling insulation (if this has been incorrectly installed over the top of the fitting) causing house fires due to the amount of heat produced. Similarly, if installed correctly, the insulation levels of the ceiling space are reduced by the gaps left for these downlight fittings. In essence, there are many issues connected to halogen lamps installed in houses, not the least of which is their energy profile.

This section outlines the findings for both mains voltage and low voltage halogen lamps.

Table 34 shows the findings for mains voltage halogen lamps, by household area. Mains voltage halogen lamps made up 9% of all lamps in houses, with just over 4 per house. They were found to contribute almost 15% of the power found in a house, with an average of 74.5 Watts per lamp. This per lamp power finding is driven by external floodlight, as these generally have a power of around 100 Watts.

Mains voltage halogen lamps were found in even numbers in all parts of the house, contributing just over 15% of lamps in outdoor spaces and around 8% in both sleeping and living spaces. In indoor-other areas, mains voltage halogens were 7.5% of the total number of lamps.

For living areas, mains voltage halogen lamps contributed 14% in terms of power share, with an average of just over 65 Watts per lamp. They were found to be responsible for around 11% of the total power in sleeping areas. The average power was around 61 Watts.

In indoor-other areas, the average power was 58.2 Watts, with an 11% power share. It is in outdoor areas that mains voltage halogen lamps contributed the most, 21% of total power. The average power per lamp for outdoor areas was just over 92 Watts, certainly driven by external spotlights.

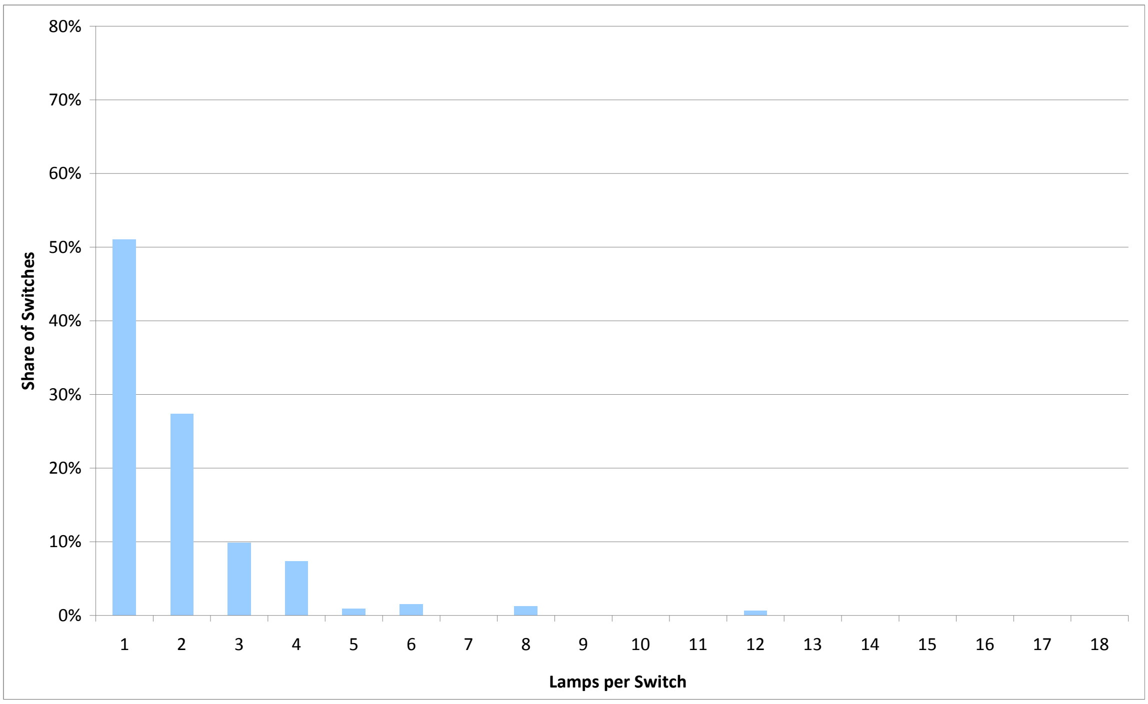
Table 34: Detailed Results – Mains Voltage Halogen Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	4.3	1.4	0.6	0.8	1.5
Number Share*	8.9%	8.4%	5.4%	7.5%	15.2%
Watts Total	294.0	83.0	38.0	41.0	132.0
Watts Share*	14.6%	13.5%	10.7%	9.9%	21.2%
Watts per Lamp	74.5	65.4	61.3	58.2	92.2

** This is a share of all technologies*

Figure 20 shows the number of mains voltage halogen lamps found per switch. The highest percentage of switches had only one mains voltage halogen lamp (51%). Just under 30% of switches were found to have two mains voltage halogen lamps, while about 10% and 6% of switches had three or four lamps, respectively. A small number of switches had between five and twelve mains voltage halogen lamps.

Figure 20: Number Mains Voltage Halogen Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

Table 35 shows the findings for low voltage halogen lamps, by household area. Low voltage halogen lamps made up a quarter of all lamps in houses, with almost 12 per house. They were found to contribute almost 28% of the power found in a house, with an average of 44.0 Watts per lamp. This per lamp power finding is certainly driven by downlights, as these generally have a power of around 50 Watts (note this does not include any transformer power losses).

Like incandescent lamps, low voltage halogen lamps were found in high numbers in all parts of the house (with exception of outdoor areas), contributing over 36% of lamps in living spaces, 25% in sleeping and around 22% in indoor-other spaces. In outdoor areas, low voltage halogens were around 9% of the total number of lamps.

For living areas, low voltage halogen lamps were dominant in terms of power share (nearly 46%) – this is most certainly primarily driven by the ownership of downlights. This is confirmed by an average power of around 47 Watts per lamp. They were also found to be responsible for over 34% of the total power in sleeping areas. The average power was around 38 Watts, a combination of both downlights and lower power lamps installed in bedside table lamps.

In indoor-other areas, the average power was 48.0 Watts, which like other areas, is certainly driven by downlights. For outdoor areas, low voltage halogen lamps contributed almost 7% of total power, while for indoor-other areas, they were found to be responsible for almost 28%. The average power per lamp for outdoor areas was just over 47 Watts, once again driven by downlights.

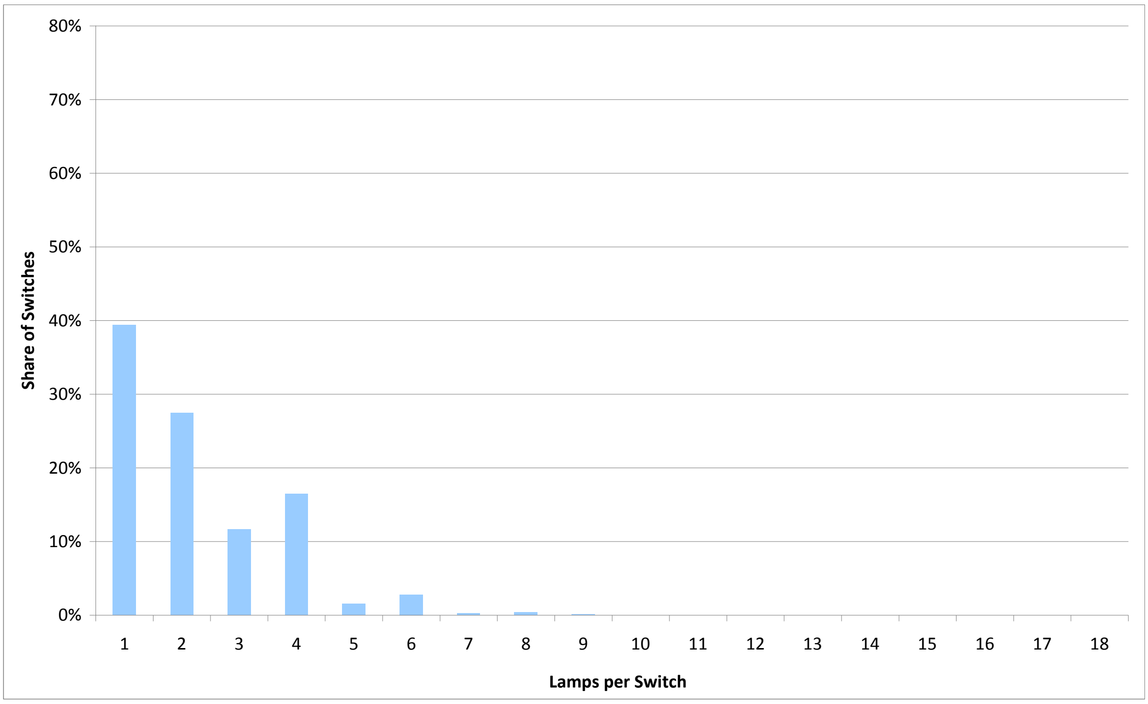
Table 35: Detailed Results – Low Voltage Halogen Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	11.9	5.9	2.7	2.4	0.9
Number Share*	24.8%	36.2%	24.7%	22.0%	8.9%
Watts Total	558.0	281.0	120.0	115.0	42.0
Watts Share*	27.8%	45.7%	34.0%	27.7%	6.7%
Watts per Lamp	44.0	47.1	37.8	48.0	47.4

** This is a share of all technologies*

Figure 21 shows the number of low voltage halogen lamps found per switch. The highest percentage of switches had only one halogen lamp (39%). Just over 25% of switches were found to have two halogen lamps, while about 11% and 16% of switches had three or four lamps, respectively. A small number of switches had five or six low voltage halogen lamps.

Figure 21: Number Low Voltage Halogen Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

5.2.1 Mains Voltage Halogen Fitting and Cap Types

Table 36 to Table 39 show the fitting and cap type details for mains voltage halogen lamps. Note – more information on fitting types is given in Section 2.3.

Table 36 shows the fitting and cap type details for mains voltage halogen fixed lamps. The key findings to note are:

- 45% of all indoor spotlight lamp fittings were fixed mains voltage halogen lamps, with 96% of these having an GU10 cap;
- 38% of floodlight/external spotlight fittings were fixed mains voltage halogen lamps, with 71% of these having a E27 cap and 29% having a GU/GX5.3 cap;
- 20% of all wall light lamp fittings were fixed mains voltage halogen lamps, with 54% of these having a GU10 cap, 40% a GU/GX5.3 cap, and 6% a B22 cap.

Table 36: Mains Voltage Halogen Fixed Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	B22	E27	GU10	GU/GX5.3	Other
Batton Holder	4% (15)	60%				40%
Batton Holder with Shade	3% (4)					100%
Floodlight/External Spotlight	38% (132)		71%		29%	
Garden Light	24% (12)			67%	33%	
Indoor Spotlight	45% (180)		1%	96%	3%	
Oyster	2% (10)	20%	10%		70%	
Pool Light	60% (3)			67%	33%	
Rangehood	8% (13)			85%	15%	
Suspended	10% (77)	21%		8%	71%	
Uplight	44% (11)				100%	
Wall Light	20% (98)	6%		54%	40%	

Table 37 shows the fitting and cap type average Wattage details mains voltage halogen fixed lamps. The key findings to note are:

- the average Wattage for indoor spotlight lamp fittings was 45 Watts, fixed mains voltage halogen lamps with an E27 cap had an average of 42 Watts, an average of 50 Watts for GU10 caps, and 70 Watts for GU/GX5.3 caps;
- the average Wattage for floodlight/external spotlight fittings was 83 Watts, fixed mains voltage halogen lamps with an E27 cap had an average of 100 Watts, and 132 Watts for a GU/GX5.3 cap;
- the average Wattage for wall light lamp fittings was 40 Watts, fixed mains voltage halogen lamps with a B22 cap had an average of 39 Watts, GU10 caps an average of 38 Watts, and GU/GX5.3 caps an average of 52 Watts.

Table 37: Mains Voltage Halogen Fixed Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	B22 (Avg W)	E27 (Avg W)	GU10 (Avg W)	GU/GX5.3 (Avg W)	Other (Avg W)
Batton Holder	44.6	51.3				50.0
Batton Holder with Shade	46.4					50.0
Floodlight/External Spotlight	82.5		100.0		131.6	
Garden Light	36.2			50.0	20.0	
Indoor Spotlight	45.4		42.0	50.0	70.0	
Oyster	55.4	57.0	42.0		114.3	
Pool Light	50.0			50.0	50.0	
Rangehood	27.8			22.7	20.0	
Suspended	43.4	52.1		50.0	58.2	
Uplight	66.1				140.9	
Wall Light	39.9	39.2		37.8	51.8	

Table 38 shows the fitting and cap type details for mains voltage halogen plug lamps. The key findings to note are:

- 100% of mains voltage plug floodlight/external spotlights had a G4 cap;
- 5% of desk lamp fittings were plug mains voltage halogen lamps;
- 15% of all floor/standard lamp fittings were plug mains voltage halogen lamps.

Table 38: Mains Voltage Halogen Plug Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	B15	B22	E14	E27	GU10	G4
Desk Lamp	5% (14)		21%	14%	21%	14%	30%
Floodlight/External Spotlight	44% (18)						100%
Floor/Standard Lamp	15% (29)		7%	3%	3%	17%	70%
Table Lamp	3% (13)	8%	54%	23%	15%		

Table 39 shows the fitting and cap type average Wattage details for mains voltage halogen plug lamps. The key findings to note are:

- the average Wattage for floodlight/external spotlight fittings was 110 Watts, plug mains voltage halogen lamps with a G4 cap had an average of 172 Watts;
- the average Wattage for floor/standard lamp fittings was 52 Watts, plug mains voltage halogen lamps with a B22 cap had an average of 49 Watts, an E14 cap 28 Watts, an E27 cap 42 Watts, a GU10 cap 50 Watts, and a G4 cap had an average of 43 Watts.

Table 39: Mains Voltage Halogen Plug Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	B15 (Avg W)	B22 (Avg W)	E14 (Avg W)	E27 (Avg W)	GU10 (Avg W)	G4 (Avg W)
Desk Lamp	30.9		45.7	34.0	41.3	35.0	27.5
Floodlight/External Spotlight	110.0						172.2
Floor/Standard Lamp	51.8		49.0	28.0	42.0	50.0	122.5
Table Lamp	31.9	42.0	36.9	28.0	46.0		

5.2.2 Low Voltage Halogen Fitting and Cap Types

Table 40 to Table 43 show the fitting and cap type details for low voltage halogen lamps. Note – more information on fitting types is given in Section 2.3.

Table 40 shows the fitting and cap type details for low voltage halogen fixed lamps. The key findings to note are:

- almost all low voltage halogen fixed lamps had a GU/GX5.3 cap;
- 79% of downlight/flush mounted fittings were low voltage halogens;
- 14% of indoor spotlight lamp fittings were fixed mains voltage halogen lamps, with 37% of these having a GU10 cap and 63% having a GU/GX5.3 cap.

Table 40: Low Voltage Halogen Fixed Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	GU10	GU/GX5.3
Downlight/Flush Mounted	79% (1475)		100%
Fixed Floor Light	100% (4)		100%
Floodlight/External Spotlight	1% (3)		100%
Garden Light	12% (6)		100%
Indoor Spotlight	14% (56)	37%	63%
Pool Light	40% (2)		100%
Rangehood	22% (35)		100%
Uplight	24% (6)		100%
Wall Light	11% (53)	4%	96%

Table 41 shows the fitting and cap type average Wattage details for low voltage halogen fixed lamps. The key findings to note are:

- the average Wattage for downlight/flush mounted fittings was 53 Watts, fixed low voltage halogen downlight/flush mounted halogen lamps with a GU/GX5.3 cap had an average of 49 Watts;
- the average Wattage for indoor spotlight lamp fittings was 45 Watts, fixed low voltage halogen lamps with either a GU10 cap or a GU/GX5.3 cap had an average of 50 Watts.

Table 41: Low Voltage Halogen Fixed Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	GU10 (Avg W)	GU/GX5.3 (Avg W)
Downlight/Flush Mounted	53.3		48.8
Fixed Floor Light	50.0		50.0
Floodlight/External Spotlight	82.5		50.0
Garden Light	36.2		20.0
Indoor Spotlight	45.4	50.0	49.6
Pool Light	50.0		50.0
Rangehood	27.		38.0
Uplight	66.1		50.0
Wall Light	39.9	20.0	43.2

Table 42 shows the fitting and cap type details for low voltage halogen plug lamps. The key finding to note is that 41% of desk lamp fittings were plug low voltage halogen lamps, with 100% of these having a other cap.

Table 42: Low Voltage Halogen Plug Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	Other
Desk Lamp	41% (109)	100%
Floor/Standard Lamp	8% (15)	100%

Table 43 shows the fitting and cap type average Wattage details for low voltage halogen plug lamps. The key finding to note is that the average Wattage for desk lamp fittings was 31 Watts, plug low voltage halogen lamps with an other cap had an average of 30 Watts;

Table 43: Low Voltage Halogen Plug Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	Other (Avg W)
Desk Lamp	30.9	30.0
Floor/Standard Lamp	51.8	43.0

Findings and discussion concerning extra low and mains voltage halogen lamps can be found in Section 5.7.

5.3 Compact Fluorescent

Compact fluorescent lamps, colloquially known as 'energy saving lights', use standard fluorescent technology. Compact fluorescent lamps have both electrical connections at one end (so called 'single ended' lamps, which have at least several, and sometimes many, bends in the tube), while linear fluorescent lamps have electrical connections at each end (so called 'double-ended' lamps, usually straight tubes, but they can be circular). Fluorescent lamps use an electric discharge to excite mercury vapour atoms inside a tube, which in turn emit ultraviolet light. The light interacts with the surface of the tube which is coated with a phosphorescent substance, causing it to fluoresce, and thereby creating visible light. Unlike incandescent and halogen lamps, this physical reaction is substantially more efficient at converting electricity to light.

Fluorescent lamps can produce different colours of light to more traditional incandescent lamp technologies depending on the phosphor recipe used to coat the tube ('cool whites' and 'warm yellows'), and may take a little bit of time to fully warm up. The light distribution may also be different, depending on the tube configuration and lamp orientation.

Householder attitudes differ on these lamps – some are very happy with the light, while others dislike the technology or light given. Anecdotally, reasons for these attitudes vary, but it is thought that poor quality early models and consumer inexperience selecting the right compact fluorescent lamp for their needs, contributed significantly to negative experiences. Data on user attitudes was not collected as part of this study.

Compact fluorescent lamps have much lower power use compared to both incandescent and halogen lamps (lower running costs), and therefore generally have lower associated CO_2 emissions. They also have increased lifetimes.

Due to these reasons, there has been a push by both energy retailers and government (at all levels) to increase household ownership and installation of compact fluorescent lamps.

Table 44 shows the findings for compact fluorescent lamps, by household area. Compact fluorescent lamps were found to make up 30% of all lamps in houses, with over 14 per house. They contributed around 9.5% of the lighting power found in a house, with an average of just under 14 Watts per lamp. This average is made up of individual lamps ranging from 5 to 25 Watts.

Like incandescent lamps, compact fluorescent lamps were found in high numbers in all parts of the house, contributing 41% of lamps in sleeping spaces and 29% in living spaces. In indoor-other areas, around 33% of lamps were compact fluorescent, while for outdoor areas they were found to have only a 16% share.

In sleeping, living and indoor-other areas, compact fluorescent lamps had over a 10% share in terms of power (16.3%, 10.5% and 12.0%, respectively). Compact fluorescent lamps had an average power of 13–14 Watts, per lamp in these areas. For outdoor areas, compact fluorescent lamps were responsible for only 3.7% of power, with an average power of just under 15 Watts.

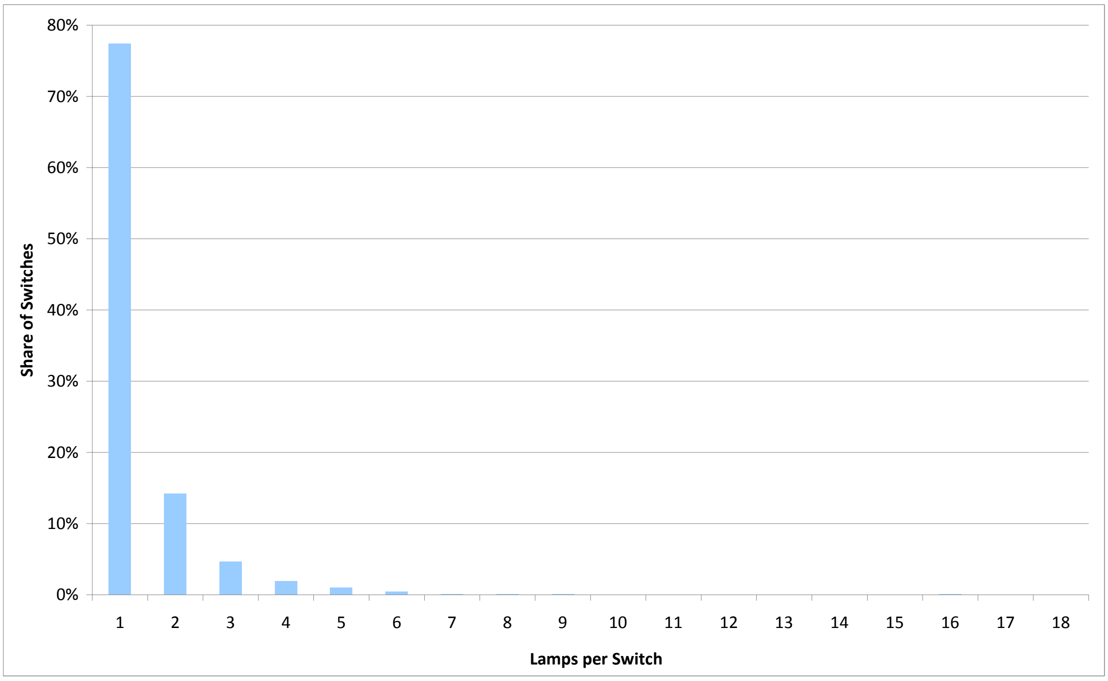
Table 44: Detailed Results – Compact Fluorescent Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	14.4	4.7	4.5	3.6	1.6
Number Share*	30.1%	29.0%	41.0%	33.1%	16.0%
Watts Total	195.0	64.0	58.0	50.0	23.0
Watts Share*	9.7%	10.5%	16.3%	12.0%	3.7%
Watts per Lamp	13.6	13.7	12.9	13.9	14.9

** This is a share of all technologies*

Figure 22 shows the number of compact fluorescent lamps found per switch. The majority of switches (78%) had only one compact fluorescent lamp with about 13% of switches found to have two compact fluorescent lamps. A small number of switches had between three and six compact fluorescent lamps.

Figure 22: Number Compact Fluorescent Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

5.3.1 Compact Fluorescent Fitting and Cap Types

Table 45 to Table 48 show the fitting and cap type details for compact fluorescent integral ballast fixed lamps (note that compact fluorescent lamps with separate ballasts are not included due to their low sample number). Note – more information on fitting types is given in Section 2.3.

Table 45 shows the fitting and cap type details for compact fluorescent integral ballast fixed lamps. The key findings to note are:

- 62% of suspended lamp fittings were fixed compact fluorescent integral ballast lamps, with 69% of these having a B22 cap;
- 68% of oyster lamp fittings were fixed compact fluorescent integral ballast lamps, with 33% of these having an E27 cap;
- 15% of all downlight/flush mounted lamp fittings were fixed compact fluorescent integral ballast lamps, with 72% of these having an E27 cap.

Table 45: Integral Ballast Compact Fluorescent Fixed Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	Cannot Identify	B15	B22	E14	E27	GU10
Batten Holder	60% (210)			94%		6%	
Batten Holder with Shade	75% (89)		6%	92%		2%	
Combination Heat/Light Lamp	26% (29)	7%		3%		90%	
Downlight/Flush Mounted	15% (286)	6%				72%	22%
Floodlight/External Spotlight	4% (13)			15%		85%	
Indoor Spotlight	22% (89)	3%		1%	3%	50%	43%
Oyster	68% (345)	48%		19%		33%	
Rangehood	9% (15)	20%	7%	27%	33%	13%	
Suspended	62% (460)	15%	1%	69%		15%	
Uplight	12% (3)			100%			
Wall Light	33% (165)	12%		74%	3%	11%	

Table 46 shows the fitting and cap type average Wattage details for compact fluorescent integral ballast fixed lamps. The key findings to note are:

- the average Wattage for suspended lamp fittings was 43 Watts, fixed compact fluorescent integral ballast lamps with a B22 cap had an average of 13 Watts;
- the average Wattage for oyster lamp fittings was 55 Watts, fixed compact fluorescent integral ballast lamps with an E27 cap had an average of 14 Watts;
- the average Wattage for downlight/flush mounted lamp fittings was 53 Watts, fixed compact fluorescent integral ballast lamps with an E27 cap had an average of 16 Watts.

Table 46: Integral Ballast Compact Fluorescent Fixed Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	Cannot Identify (Avg W)	B15 (Avg W)	B22 (Avg W)	E14 (Avg W)	E27 (Avg W)	GU10 (Avg W)
Batten Holder	44.6			13.8		17.7	
Batten Holder with Shade	46.4		11.0	15.6		15.0	
Combination Heat/Light Lamp	45.8	14.5		11.0		14.6	
Downlight/Flush Mounted	53.3	18.0				15.5	10.6
Floodlight/External Spotlight	82.5			18.0		21.4	
Indoor Spotlight	45.4	5.0		14.0	8.0	14.3	10.6
Oyster	55.4	14.0		14.7		13.5	
Rangehood	27.8	10.3	15.0	14.3	7.6	15.0	
Suspended	43.4	14.5	9.5	13.4		14.7	
Uplight	66.1			13.7			
Wall Light	39.9	14.4		14.4	8.0	13.3	

Table 47 shows the fitting and cap type details for compact fluorescent integral ballast plug lamps. The key findings to note are:

- 58% of table lamp fittings were plug compact fluorescent integral ballast lamps, with 78% of these having a B22 cap;

- 51% of floor/standard lamp fittings were plug compact fluorescent integral ballast lamps, with 57% of these having a B22 cap;
- 33% of all desk lamp fittings were plug compact fluorescent integral ballast lamps, with 53% of these having an B22 cap.

Table 47: Integral Ballast Compact Fluorescent Plug Lamps – Fitting and Cap Type

Fitting Type/Cap Type	% of All Lamp Techs	Cannot Identify	B15	B22	E14	E27	GU10	Other
Desk Lamp	33% (87)			53%	21%	22%	1%	3%
Floor/Standard Lamp	51% (96)			57%	14%	29%		
Table Lamp	58% (220)	1%		78%	11%	10%		

Table 48 shows the fitting and cap type average Wattage details for compact fluorescent integral ballast plug lamps. The key findings to note are:

- the average Wattage for all table lamp fittings was 32 Watts, plug compact fluorescent integral ballast lamps with a B22 cap had an average of 12 Watts;
- the average Wattage for floor/standard lamp fittings was 52 Watts, plug compact fluorescent integral ballast lamps with a B22 cap had an average of 13 Watts;
- the average Wattage for desk lamp fittings was 31 Watts, plug compact fluorescent integral ballast lamps with a B22 cap had an average of 13 Watts.

Table 48: Integral Ballast Compact Fluorescent Plug Lamps – Fitting and Cap Type Average Wattage

Fitting Type/Cap Type	All Lamp Techs (Avg W)	Cannot Identify (Avg W)	B15 (Avg W)	B22 (Avg W)	E14 (Avg W)	E27 (Avg W)	GU10 (Avg W)	Other (Avg W)
Desk Lamp	30.9			13.0	7.6	13.6	11.0	9.0
Floor/Standard Lamp	51.8			12.5	8.0	13.1		
Table Lamp	31.9	12.0		12.1	8.5	12.6		

Findings and discussion concerning integral ballast compact fluorescent lamps can be found in Section 5.7.

5.4 Linear Fluorescent

Linear fluorescent lamps, colloquially known as 'tubes', work in the same manner as compact fluorescent lamps. Similar to these lamps, they are also much better at the general conversion of energy to light, due to the low amount of heat produced (currently better than all other domestic technologies). For this study, linear (straight) and circular double ended lamps were classified as linear fluorescents.

The technology has been in service for a long time, and historically they were widely used in kitchens and living areas, although they are less common in newer homes. Linear fluorescents are widely used in commercial settings. Linear fluorescent lamps tend to produce a white light compared to an incandescent lamp, which householders can view as 'harsh', although warm white models are now common. This technology appears to be more often installed in spaces where task lighting rather than mood lighting is required (kitchens and garages are good examples).

Table 49 shows the findings for linear fluorescent lamps, by household area. Linear fluorescent lamps made up almost 9% of all lamps in houses – just over 4 lamps per house. They were found to contribute 7% of the total power found in a house, with an average of around 33 Watts per lamp. This per lamp power finding is comprised of circular and linear type lamps (about 15% of all linear fluorescent lamps were circular).

Table 49: Detailed Results - Linear Fluorescent Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	4.2	0.9	0.3	0.9	2.1
Number Share*	8.9%	5.5%	3.0%	8.3%	21.7%
Watts Total	142.0	29.0	10.0	29.0	74.0
Watts Share*	7.0%	4.7%	2.8%	6.9%	11.9%
Watts per Lamp	33.3	31.3	27.3	31.2	35.5

** This is a share of all technologies*

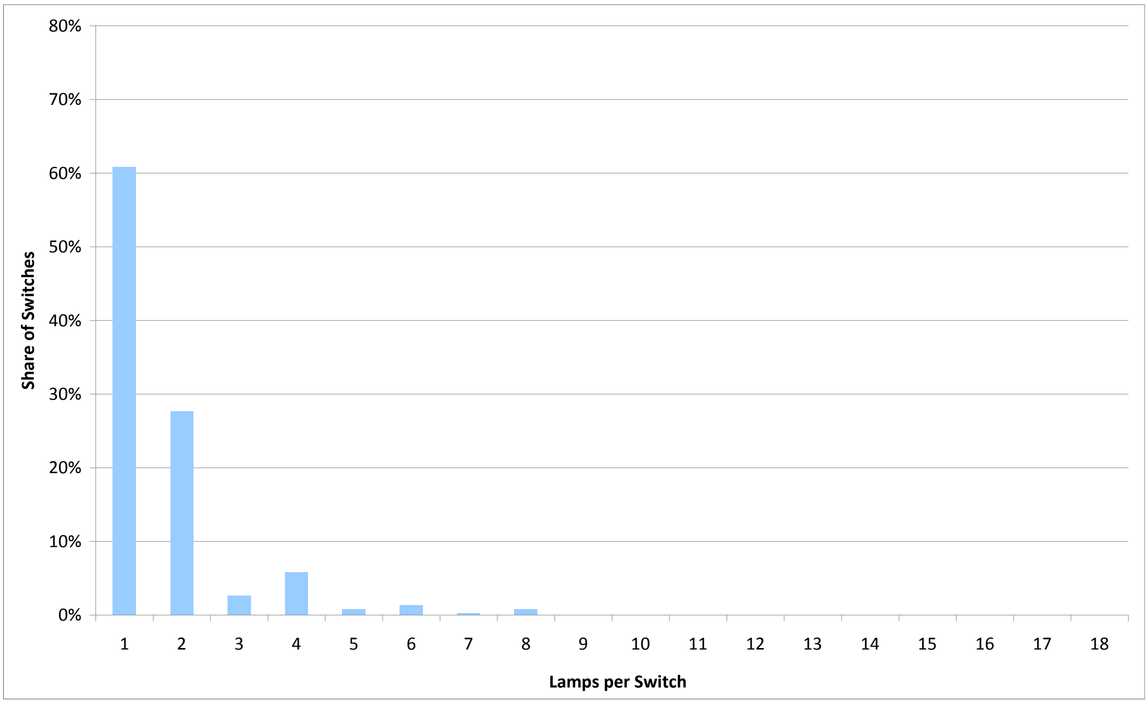
Linear fluorescent lamps made up less than 10% of total lamps in all parts of the house, except in outdoor areas where they were found to be almost 22% of lamps (most likely due to their prevalence in garages). In other-indoor areas, around 8.5% of lamps were linear fluorescent, while for living areas they had a 5.5% share and in sleeping areas a 3% share.

Once again, it was only in outdoor areas that linear fluorescent lamps had an over 10% share in terms of power. In outdoor areas linear fluorescent lamps were found to have an average power of 35.5 Watts. Indoor-other areas had an average power of around 31 Watts and a 6.9% share.

For living and sleeping areas, linear fluorescent lamps contributed 4.7% and 2.8% of total Watts, respectively. The average power per lamp for living areas was around 31 Watts, while for sleeping areas the average power was found to be just over 27 Watts.

Figure 23 shows the number of linear fluorescent lamps found per switch. The majority of switches (around 60%) had only one linear fluorescent lamp, with almost 30% of switches found to have two linear fluorescent lamps. A small number of switches had between three and eight linear fluorescent lamps.

Figure 23: Number Linear Fluorescent Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

5.5 LED

LED lamps are relative new comers to lighting in the residential sector. Historically, this technology has been used for signalling (ie in appliances – mode lights) and have tended to be red, yellow or green in colour, rather than as a pure white light source. LED lamps that are realistic alternatives to other types of general domestic lighting, are just becoming available. There is currently a wide variation in quality and efficiency of products available, with efficiencies ranging from similar to incandescent lamps (very inefficient) to similar to compact fluorescent lamps (quite efficient). At this stage, most good LED lamps are relatively expensive (general service light especially – downlights less so) and many are outside the average householder's price range. LED lighting may be the technology of the future, and has the ability to reduce overall lighting energy and financial costs; however, improvements are still required in many facets before it will have wide use in a residential context. The technology is going through rapid developments (both in terms of efficacy improvements and price reductions), so it is a matter of "watch this space".

Table 50 shows the findings for LED lamps by household area. LED lamps made up 1.4% of all lamps in houses, with an average of 0.7 per house. They were found to contribute only 0.2% of the Watts found in a house, with an average of just over 5 Watts per lamp. This per lamp power finding is comprised of a number of different types of LED lamp, including fixed lamp types and small LED nightlights (with very low power).

LED lamps were found in very small numbers in all parts of the house, contributing between 1–2% of lamps in each room type. The power share for LED lamps was incredibly small, with no area have more than a 0.3% share. Living spaces had an average of 5.4 Watts per lamp, while in outdoor spaces it was just under 8.3 Watts per lamp. Sleeping areas were found to have an average Watts per lamp of almost 4.5, while for other-indoor it was slightly over 3.5.

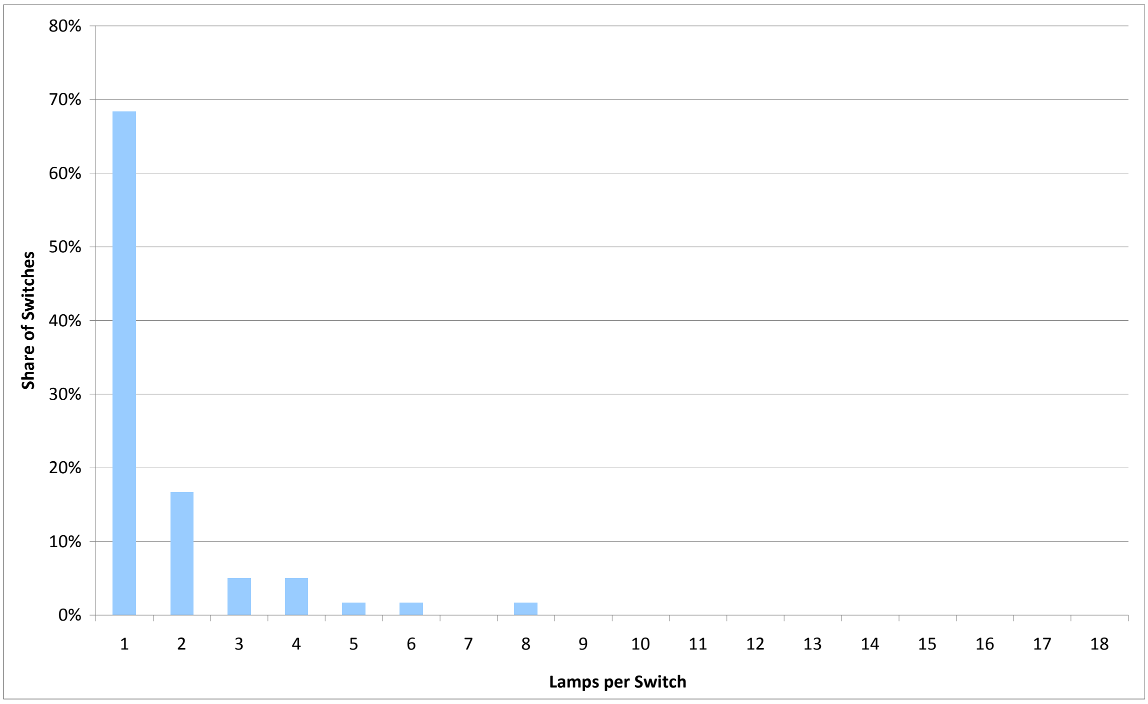
Table 50: Detailed Results – LED Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	0.7	0.2	0.1	0.2	0.11
Number Share*	1.4%	1.5%	1.2%	1.8%	1.1%
Watts Total	4.0	1.7	0.5	1.1	0.7
Watts Share*	0.2%	0.3%	0.1%	0.3%	0.1%
Watts per Lamp	5.1	5.4	4.4	3.6	8.3

** This is a share of all technologies*

Figure 24 shows the number of LED lamps found per switch. The majority of switches (around 70%) had only one LED lamp, with about 17% of switches found to have two LED lamps. A small number of switches had between three and eight LED lamps.

Figure 24: Number LED Lamps per Switch



Note: Includes all lamps in the house. Exclude switches with mixed technologies – see Section 8.1.

5.6 Distribution of Light Output by Lamp Technology

Efficacy is the amount of light emitted by a lamp, measured in Lumens, as a ratio of the Watts consumed to produce it. This is the only useful measure of lighting energy characteristics and essentially 'replicates' the notion of efficiency (as found in appliances).

Table 51 shows the overall range of light production (Lumens) for the average house, by lamp technology. The highest share was for linear fluorescent lamps, with the Lumens share of 27%. Compact fluorescent lamps were just under a 23% share. Incandescent and low voltage halogen lamps had a Lumen share of around 19%, while mains voltage halogen lamps had a share of 10%. LED lamps had the lowest share by a significant amount, with only a 0.4% share. Care is required in the interpretation of these values as the results are not weighted for usage factors which vary considerably by space types and by individual lamp.

Table 51: Distribution of Light Output by Lamp Technology – Whole House

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	9059	4704	8925	10742	12743	179.4
Lumens Share*	19.2%	10.0%	19.0%	22.8%	27.1%	0.4%
Assumed Lighting Levels (Lumens/Watt)	12	16	17	55	90	60

** Note that unknown and missing 'technologies' are included in the share numbers. These factors are reported separately in Sections 5.8 and 5.9.*

Table 52 shows the range of light production for living areas, by lamp technology. The highest Lumens share was found for low voltage halogen lamps, at just over 32%. Compact fluorescent lamps were found to have the next highest Lumen share at over 25%. Linear fluorescent lamps had just under a 19% share, while incandescent lamps were just under a 13% share. Mains voltage halogen lamps had a 9.5% share. LED lamps had the lowest share at around a 0.5% share of total Lumens produced.

Table 52: Distribution of Light Output by Lamp Technology – Living

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	1730	1325	4492	3544	2575	71
Lumens Share*	12.5%	9.5%	32.4%	25.5%	18.6%	0.5%
Assumed Lighting Levels (Lumens/Watt)	12	16	17	55	90	60

** Note that unknown and missing 'technologies' are included in the share numbers. These factors are reported separately in Sections 5.8 and 5.9.*

Table 53 shows the range of light production amounts by technology, for sleeping areas. The highest Lumens share was compact fluorescent lamps, at 39%. Low voltage halogen lamps had the next highest Lumen share at almost 24%. Incandescent lamps were just under a 17% share, while linear fluorescent lamps were found to have just under an 11% share. Mains voltage halogen lamps had a 7.4% share. LED lamps had the lowest share, with 0.3% of total Lumens produced.

Table 53: Distribution of Light Output by Technology - Sleeping

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	1355	606	1924	3181	886	23
Lumens Share*	16.6%	7.4%	23.6%	39.0%	10.9%	0.3%
Assumed Lighting Levels (Lumens/Watt)	12	16	17	55	90	45

** Note that unknown and missing 'technologies' are included in the share numbers. These factors are reported separately in Sections 5.8 and 5.9.*

Table 54 shows the range of light production amounts by technology, for indoor-other areas. The highest share was compact fluorescent lamps, which produced just over 27% of Lumens in indoor-other areas. Linear fluorescent lamps were the next highest Lumen share at around 26%. Incandescent lamps were just under a 20% share, while low voltage halogen lamps were just over a 18% share. Mains voltage halogen lamps had a 6.6% share. LED lamps had the lowest share, with 0.5% of total Lumens in indoor-other areas.

Table 54: Distribution of Light Output by Technology – Indoor-other

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	1999	658	1844	2732	2588	51
Lumens Share*	19.9%	6.6%	18.4%	27.2%	25.8%	0.5%
Assumed Lighting Levels (Lumens/Watt)	12	16	17	55	90	45

** Note that unknown and missing 'technologies' are included in the share numbers. These factors are reported separately in Sections 5.8 and 5.9.*

Table 55 shows the range of light production amounts by technology, for outdoor areas. The highest Lumens share was found for linear fluorescent lamps, at almost 45%. Incandescent lamps had the next highest Lumen share with just over 26%. Mains voltage halogen lamps were a 14% share, while compact fluorescent lamps were just under a 9% share. Low voltage halogen lamps had a 4.4% share. LED lamps had the lowest share, with 0.2%.

Table 55: Distribution of Light Output by Technology - Outdoor

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Lumens Total	3975	2115	666	1286	6693	34
Lumens Share*	26.5%	14.1%	4.4%	8.6%	44.6%	0.2%
Assumed Lighting Levels (Lumens/Watt)	12	16	17	55	90	45

** Note that unknown and missing 'technologies' are included in the share numbers. These factors are reported separately in Sections 5.8 and 5.9.*

5.7 Share of Bayonet and Edison Lamp Caps by Technology Type

The lamp cap is what keeps the lamp in the light fitting, it is also provides the connection with the electricity supply. Understanding lamp cap types is most important when considering retrofit options for lighting in homes. For standard lamps, there are two main types: bayonet (twin pins set on opposite sides of the cap base, where the light is pushed in and turned 90 degrees to lock it in place – more prevalent in Australia) and Edison Screw type (spiral base which is screwed into the fitting). Generally, there are four standard cap types of interest:

- B15 (bayonet 15 mm) – these are small caps, common in some fitting types like rangehoods, and desk and table lamps;
- B22 (bayonet 22 mm) – one of the most commonly found cap types found in homes, many standard light fittings and batten holders;
- E14 (Edison screw 14 mm or mini-ES) – found in similar fittings to B15 capped lamps (except rangehoods);
- E27 (Edison screw 27 mm standard) – fairly common in standard light fittings and some batten holders; and
- Cannot Identify – not all cap types were able to be identified while in the field.

Table 56 shows cap types by area. For the whole house, the cap type with the highest share was B22, at around 47% (11.7 lamps per house). E27 caps were the next most common with a share of just over 34% (8.6 lamps per house). Cap types that couldn't be identified had nearly a 10% share (2.4 lamps), while B15 caps were just over a 5% share (1.3 lamps). E14 caps had the lowest share at 4% (1 lamp per house).

For living areas, the B22 cap was again the highest share (43%). Similar to the whole house, E27 caps were the next highest share at around 33%. B15 caps were found to have just over an 11% share, while unidentified caps were around a 9% share. The cap type with the smallest share was E14 (around 4%).

The B22 cap was most common in sleeping areas, at just under 51%. E27 caps were found to have around a 24% share, while unidentified caps were around 11%. Lamps with an E14 cap were just over a 10% share in sleeping areas, while B15 caps had around a 4% share.

In indoor-other areas, B22 was again found to have the most common cap type (49%) and E27 caps were next most common with a one third share. Unidentified caps were found around 13% of the time. B15 and E14 caps had reasonably small shares, 4% and 1.5% respectively.

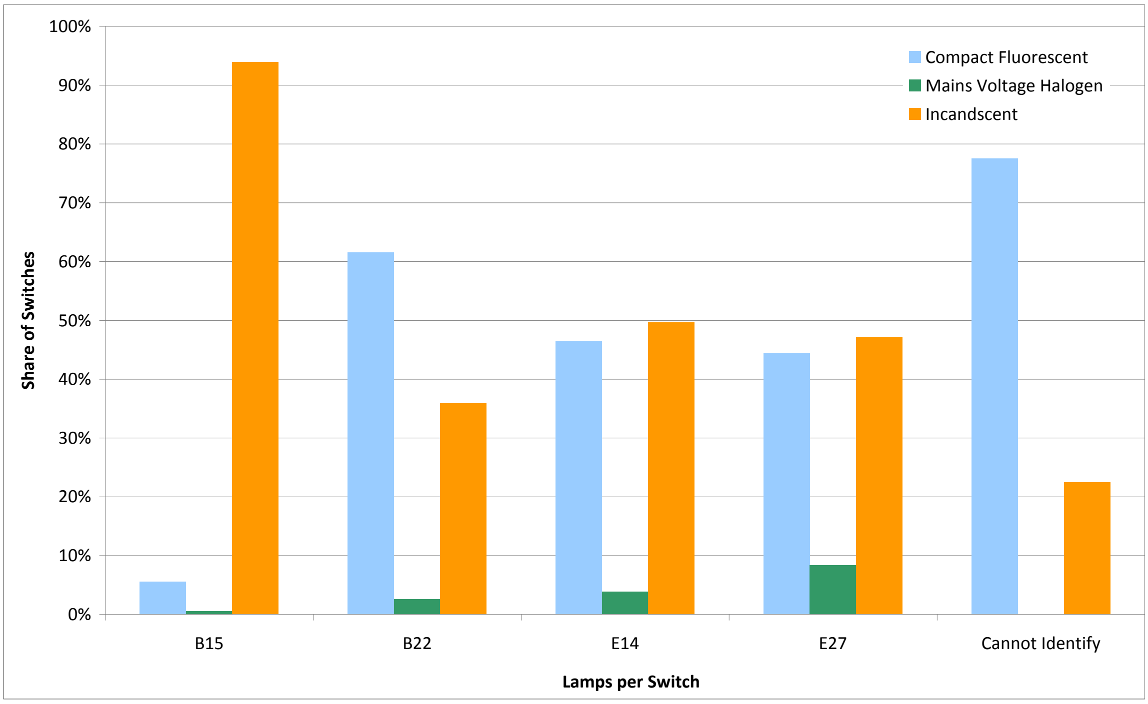
E27 and B22 were the most common cap types found in outdoor areas, with around a 51% and 43% share, respectively. Unidentified caps had the third largest share with just under 5%. E14 and B15 cap shares were again small at 0.6% and 0.3%, respectively.

Table 56: Cap Type Share by Space

Average Per House	Whole house	Living	Sleeping	Indoor-other	Outdoor
B15 Lamp Numbers	1.3	0.8	0.3	0.2	0.0
B15 Share	5.2%	11.2%	4.1%	3.9%	0.3%
B22 Lamp Numbers	11.7	3.0	3.4	3.0	2.3
B22 Share	46.7%	43.2%	50.9%	49.0%	43.4%
E14 Lamp Numbers	1.0	0.3	0.7	0.1	0.0
E14 Share	4.2%	3.6%	10.2%	1.4%	0.6%
E27 Lamp Numbers	8.6	2.3	1.6	2.0	2.7
E27 Share	34.3%	32.7%	23.9%	33.0%	51.1%
Cannot Identify Lamp Numbers	2.4	0.7	0.7	0.8	0.2
Cannot Identify Share	9.6%	9.4%	10.9%	12.7%	4.7%

Figure 25 shows the findings for cap type by technology, as a share. It can be seen that the lamp technology with the majority of B15 caps was incandescent (over 90%). These lamps are most commonly seen as the lighting in rangehood appliances. The only other lamp technology that is found installed in these appliances are mains voltage halogen lamps. A small share of compact fluorescent lamps were also found to have the B15 cap size, although this was only around 5%.

Figure 25: Cap Type by Technology - Share



For the B22 cap size, compact fluorescent lamps had the highest share, at around 60%. This cap size is most common for non-oyster type ceiling fittings (ie batten holder, suspended, etc). Incandescent lamps were around a 37% share, while mains voltage halogen lamps had the smallest share at around 3%.

E14 caps were the most common for incandescent lamps, with around a 50% share. Compact fluorescent lamps were not far behind with around a 46% share, while mains voltage halogen lamps had only about a 4% share. This cap size is often found in table and desk lamps, which are common in bedrooms and studies.

The E27 cap size was most common in incandescent lamps, which had around a 47% share. Similar to E14 caps, compact fluorescent lamps were not far behind with about a 44% share. Mains voltage halogen lamps were found in this cap size with around a 9% share. E27 caps were common in oyster type fittings as the lamp was often installed horizontally, meaning screwing the lamp was easier than having to push and turn. External spotlights were also often found with E27 fittings.

Compact fluorescent lamps were the technology type with the highest 'cannot identify' cap share (around 78%), with incandescent lamps unidentified around 22% of the time. Oyster fittings and lamps in hard to reach areas (high ceilings, above stairs and similar) were difficult to audit and were therefore where cap type was normally unidentified.

These findings help to indicate the change in lighting stock since incandescent lamps were phased out. As can be seen in the above figure, incandescent lamps are still very common in houses, when compared to replacement technologies that use the same cap type. The exception could be with B22 caps, where compact fluorescent lamps have much higher count (almost double). Compact fluorescent lamps have similar shares in all cap types with the exception of B15 and B22. Mains voltage halogen lamps are still relatively rare for all cap types. Even in the cap type where they are most common (E27), halogen lamps still have a less than 10% share.

5.8 Unidentified Lamps

Unidentifiable lamps were unfortunately an unavoidable occurrence within the constraints of the field research for the study. Fittings that completely cover the lamp (ie oyster) and that are opaque mask the lamp technology and shape. Unidentified (or unknown) lamps with a fixed connection were assumed to be a 60 Watt incandescent and those with a plug connection were assumed to be a 40 Watt incandescent. Both these were chosen as they were seen as a conservative choices (ie the 'worst case' in terms of efficacy), whereas the use of a compact fluorescent or halogen type would probably have higher efficacy.

Table 57 shows the findings for unknown lamp technologies, by household area. These lamps were found to make up 2.3% of all lamps in houses, or just over 1 lamp per house. They contributed 3.0% of the Watts found in a house, with an average of 54 Watts per lamp.

Unidentified lamps were found in small numbers in all parts of the house, contributing 3.7% of lamps in outdoor spaces, 2.5% in sleeping areas, 2.2% of lamps in indoor-other areas and 1.5% in living areas.

The power share for lamps was similarly small. Sleeping spaces were found to have the largest share of power, at just over 4% and with an average of almost 50 Watts per lamp. Outdoor areas had a 3.4% share, at an average of 60 Watts per lamp. Indoor-other areas had a 3.2% share, with an average of almost 57 Watts per lamp. For living spaces, the share was 2%, with an average power per lamp of just over 48 Watts.

Table 57: Detailed Results – Unknown Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	1.1	0.2	0.3	0.2	0.35
Number Share*	2.3%	1.5%	2.5%	2.2%	3.7%
Watts Total	61	12	15	13	21
Watts Share*	3.0%	1.9%	4.2%	3.2%	3.4%
Watts per Lamp	54.0	48.6	49.7	56.7	60.0

** This is a share of all technologies*

Table 58 shows the distribution of power by area, for unidentified lamps. For the average house, the Lumens share of unidentified lamps was 1.6%. Sleeping areas had the highest share of unidentified lamps, with a 2.2% share. All other areas were found to have a lower share than this, with outdoor areas having a 1.7% share, living areas a 1% share and indoor-other areas a 1.6% share.

Table 58: Distribution of Power by Area – Unknown Technology

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Lumens Total	730	141	177	158	254
Lumens Share*	1.6%	1.0%	2.2%	1.6%	1.7%
Assumed Lighting Levels (Lumens/Watt)	12.0	12.0	12.0	12.0	12.0

** This is a share of all technologies*

5.9 Number of Lamps with Blown or No Lamp

It wasn't unusual to find fittings in houses with blown or no lamp installed. There is a probable mix of reasons for this to occur:

- householders intended to change the lamp, but hadn't got around to it;
- the lamp was in an area where light wasn't needed and therefore a lamp hadn't been installed or replaced;
- the fitting was in storage (plug types – desk and table lamps); or
- the fitting was a multi-lamp array, and the householders had made a conscious decision not to install all lamps (due to energy, light requirements or other reasons).

Table 59 shows the findings for missing or blown lamps by number and space. There was just under 1 missing or blown lamp on average per house, equating to 1.6% of all lamps in a house. Sleeping areas were where the highest amount of missing or blown lamps were found, at just over 2.5%. Living areas were the next highest at 1.4%, while indoor-other and outdoor spaces had just over 1% missing or blown lamps for the average house.

Table 59: Missing or Blown Lamp - Number and Space

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	0.8	0.22	0.29	0.13	0.12
Number Share*	1.6%	1.4%	2.7%	1.3%	1.2%

** Share of all technologies.*

6. Usage Related Data

6.1 Overview of Questions

User behaviour is the largest driver of energy consumption in lighting – after all, if a light is switched off, it isn't using any energy. Unfortunately, investigating and understanding user behaviour is an incredibility difficult task. The simplest approach is to ask householders questions and then make assumptions based on their answers. Caution should be used in interpreting this information though, as householders may answer questions in a fashion that is either incorrect or misleading (they may be unsure how much they use lights, they may not use certain lights themselves and therefore do not understand patterns of use, they may understand that the questionnaire is about energy and want to appear to be environmentally conscious, etc). In spite of these shortcomings, behavioural questions may give some indication of usage, which is better than knowing nothing. Ideally, it may be possible to calibrate such usage questionnaires with direct end use measurement data from some homes in order to get a better understanding of typical lighting usage patterns.

For this survey, householders were asked a general usage question for each lamp that was found in a house during the audit. One of four qualitative responses was allowed:

- Frequent long – lamp used for a number of hours a day (example given was a kitchen or main living area light);
- Frequent short – lamp used for short periods throughout a day (example given was a bathroom or toilet light);
- Occasionally – lamp used a number of times during a week, no limit on time period, just that it wasn't used every day (example given was a study or spare room); or
- Rarely – lamp not used very often, maybe a couple of times a month (example given was an outside light in a low use area).

Obviously, these responses won't be able to give an exact usage profile, but they do give a feel for how much a lamp is switched on and off, and length of use periods.

6.2 Whole House – Usage by Technology Type

Table 60 shows the usage characteristics by technology for the average house (note that these figures only cover 60% of houses for this survey, as the decision to include usage questions for all lights was not made until quite a number of houses had already been audited). Low voltage halogen and compact fluorescent lamps had a generally even spread across usage levels (ranging from 16% to 32%). Incandescent and mains voltage halogen lamps tended to be in lower usage areas, as were linear fluorescent (linear fluorescents are more prevalent in garages, for example). The usage patterns for incandescent and compact fluorescent lamps suggest that the weighted energy consumption for lighting may not be as poor as the count by lamp type would initially suggest.

Table 60: Average House Summary – Usage Characteristics

Average Per House*	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long	10% (1.0)	19% (0.8)	26% (3.3)	32% (5.0)	15% (0.6)	29% (0.2)	14% (0.1)
Frequent Short	23% (2.4)	16% (0.7)	29% (3.7)	25% (4.0)	22% (0.8)	39% (0.3)	25% (0.2)
Occasionally	20% (2.1)	29% (1.3)	16% (2.1)	21% (3.3)	34% (1.3)	6% (0.0)	24% (0.2)
Rare	47% (4.7)	37% (1.6)	29% (3.6)	22% (3.6)	30% (1.1)	26% (0.2)	37% (0.3)

** For houses where usage questions were asked – N = 87*

6.3 Sub-room Type – Usage by Technology Type

6.3.1 Living Usage

Table 61 shows the usage characteristics by technology for the living areas of an average house. It can be seen that low voltage halogen lamps have a range of usages, with the largest number of frequent long use responses (expected due to the high ownership of this lamp type). Compact fluorescent lamps are also used a lot for frequent long periods. Incandescent lamps had the highest number (although highest percentage for a lamp technology) of rare use responses, indicating that they were installed in fittings that didn't have high amounts of use. Linear fluorescent and LED technologies have lower usage characteristics (in terms of numbers) than other technology types, although linear fluorescent lamps tended to be used for frequent long periods. Mains voltage halogen lamps had an even range of usages, although less frequent short usages (a pattern noted for all technologies).

Table 61: Living Room Summary – Usage Characteristics

Average Per House*	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long	19% (0.46)	30% (0.47)	40% (2.47)	52% (2.64)	60% (0.38)	28% (0.09)	17% (0.01)
Frequent Short	9% (0.23)	12% (0.18)	21% (1.28)	8% (0.43)	9% (0.06)	21% (0.07)	17% (0.01)
Occasionally	17% (0. 41)	35% (0.54)	13% (0.82)	19% (0.97)	18% (0.11)	0% (0.00)	17% (0.01)
Rare	55% (1.37)	23% (0.36)	26% (1.61)	21% (1.06)	13% (0.08)	52% (0.17)	50% (0.03)

** For houses where usage questions were asked – N = 87*

6.3.2 Sleeping Usage

Table 62 shows the usage characteristics by technology for the sleeping areas of an average house. It can be seen that compact fluorescent lamps have a range of usages, with the largest number of frequent long use responses (expected due to the flexibility of this lamp type for both fixed and plug fittings). Low voltage halogen lamps are used for a range of usage periods, specifically frequent short and rarely. Incandescent lamps also had a range of responses. Mains voltage halogen, linear fluorescent and LED technologies have lower usage characteristics than other technology types in sleeping areas.

Table 62: Sleeping Room Summary – Usage Characteristics

Average Per House*	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long	19% (0.40)	24% (0.08)	18% (0.54)	30% (1.51)	14% (0.03)	54% (0.08)	20% (0.06)
Frequent Short	16% (0.33)	28% (0.09)	34% (1.02)	25% (1.23)	9% (0.02)	31% (0.05)	28% (0.08)
Occasionally	25% (0.53)	24% (0.08)	16% (0.49)	23% (1.17)	36% (0.09)	0% (0.00)	24% (0.07)
Rare	40% (0.82)	24% (0.08)	32% (0.95)	22% (1.09)	41% (0.10)	15% (0.02)	28% (0.08)

** For houses where usage questions were asked – N = 87*

6.3.3 Indoor-other Usage

Table 63 shows the usage characteristics by technology for the indoor-other areas of an average house. It can be seen that incandescent lamps have a range of usages, although with a lower number of frequent long use responses (interesting considering their characteristics in these spaces). Both halogen lamp types are also used for a range of usage periods, although low voltage halogens are primarily frequent short and rarely (similar percentages to incandescent lamps), whereas mains voltage halogen are occasionally and rarely. Compact fluorescent lamps also had a range of responses, including the highest number of frequent long responses, although they were primarily used for frequent short periods. Linear fluorescent and LED technologies have lower usage characteristics than other technology types.

Table 63: Indoor-Other Room Summary – Usage Characteristics

Average Per House*	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long	4% (0.09)	19% (0.17)	8% (0.21)	14% (0.56)	5% (0.03)	21% (0.05)	6% (0.01)
Frequent Short	44% (1.05)	15% (0.14)	45% (1.10)	54% (2.17)	44% (0.32)	68% (0.15)	63% (0.11)
Occasionally	19% (0.45)	28% (0.26)	18% (0.44)	16% (0.66)	27% (0.20)	0% (0.00)	0% (0.00)
Rare	33% (0.77)	38% (0.36)	29% (0.70)	15% (0. 62)	24% (0.17)	11% (0.02)	31% (0.06)

** For houses where usage questions were asked – N = 87*

6.3.4 Outdoor Usage

Table 64 shows the usage characteristics by technology for the outdoor areas of an average house. It can be seen that incandescent lamps have a range of usages, although with a very low number of frequent long use responses. This can be said for all technologies, as outdoor areas appear to be low use lighting areas (at least for long periods). Each of the technology types (except compact fluorescent and LED), was used for similar amounts of frequent short uses, and this trend was generally repeated for occasional and rare use responses. This would indicate that no single technology is preferred for use in the outdoor areas of houses.

Table 64: Outdoor Summary – Usage Characteristics

Average Per House*	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long	1% (0.02)	6% (0.10)	3% (0.03)	17% (0.30)	5% (0.11)	18% (0.02)	13% (0.03)
Frequent Short	24% (0.78)	18% (0.30)	28% (0.28)	11% (0.20)	19% (0.43)	45% (0.06)	0% (0.00)
Occasionally	21% (0.69)	25% (0.41)	32% (0.33)	28% (0.49)	41% (0.90)	36% (0.05)	42% (0.11)
Rare	54% (1.75)	51% (0.84)	37% (0.37)	45% (0.79)	35% (0.77)	0% (0.00)	46% (0.13)

** For houses where usage questions were asked – N = 87*

7. Fixed and Plug Lamps

7.1 Overview of Lamp Type Share – Whole House

Lighting in homes is made up of two primary types – fixed and plug. Fixed lamps are permanently installed in the ceiling (normally), walls or floor of a house and are connected to mains electricity (hardwired). Plug lamps are defined as lamps that can be moved and installed in any free power point. They are generally placed on flat surfaces (ie tables, desks, floors) although they may also be found in a permanently installed form (although still able to be disconnected from the mains).

Table 65 shows the fixed and plug lamp number and share by area for the whole house. It can be seen that the majority of lamps in houses are fixed (around 85%) and just under 15% of lamps in a house were found to be plug type. In living areas the majority of lamps were fixed, in similar proportion to that found for the whole house. Sleeping areas had around 60% fixed lamps, with plug lamps found to have around a 40% share. This was the highest plug share for any room type. Indoor-other and outdoor areas had similar ratios of both fixed and plug lamps, with fixed lamps having around a 96% share in indoor-other rooms and around 95% in outdoor rooms.

Table 65: Fixed and Plug Lamp Number and Share by Area

Average Per House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Fixed Lamps Number	40.7	14.3	6.8	10.4	9.2
Plug Lamp Number	7.1	2.0	4.3	0.4	0.5
Fixed Lamp Share	85.2%	88.0%	61.5%	96.3%	95.1%
Plug Lamp Share	14.8%	12.0%	38.5%	3.7%	4.9%

7.2 Prevalent Technologies for Fixed Lamps by Room Type

Fixed lamps are the dominant form of lighting found in a house. Decisions concerning the placement, makeup and mood of the fixed lighting of a house are usually made at the design phase(s) of a house. This can be either when the house is first built or during a renovation. Lighting decisions made during these times make a massive impact on the effectiveness and overall energy consumption of a house's lighting system.

Table 66 shows the whole house fixed lamp number and share by technology. It can be seen that the highest number of fixed lamps found in a house are compact fluorescent, with around a 28% share (just under 12 lamps per house). These were followed by low voltage halogen lamps at around 27% (11.0 lamps per house). Incandescent lamps had just over a 21% share (around 9 lamps per house), while linear fluorescent and mains voltage halogen lamps had just under a 10% share (4 lamps per house). LED and unknown lamps had less than a 3% share each.

Table 66: Whole House Fixed Lamp Number and Share by Technology

Whole House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Fixed Lamp Number*	8.6	3.7	11.0	11.6	4.0	0.5	1.0
Fixed Lamp Share	21.3%	9.3%	27.2%	28.7%	10.0%	1.1%	2.4%

** This doesn't include missing lamps.*

Table 67 shows the living area fixed lamp number and share by technology. It can be seen that the highest share was low voltage halogen lamps with 40% of lamps (around 6 lamps per house in living areas). Compact fluorescent lamps had around a 26% share (nearly 4 lamps). Incandescent lamps had a share of 16%, or about 2.5 lamps in living rooms per house. Mains voltage halogen lamps were around a 9% share (just over 1 lamp per house). Linear fluorescent lamps were around a 6% share (almost 1 lamp per house), and LED and unknown lamps had less than a 1.5% share each.

Table 67: Living Fixed Lamp Number and Share by Technology

Living	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Fixed Lamp Number*	2.3	1.2	5.7	3.8	0.8	0.2	0.2
Fixed Lamp Share	16.1%	8.5%	40.4%	26.4%	5.8%	1.5%	1.3%

** This doesn't include missing lamps.*

Table 68 shows the sleeping area fixed lamp number and share by technology. It can be seen that compact fluorescent lamps had the highest share in sleeping areas, at 41% (almost 3 lamps per house). Low voltage halogen lamps had around a 30% share for sleeping areas (2.0 lamps). For incandescent lamps, around a 15% share was found (1 lamp per house in sleeping areas). Mains voltage halogen lamps had around a 6% share (0.5 lamps per house). Linear fluorescent lamps were around a 4% share (0.3 lamps per house). Unknown lamps had around a 3% share, while LED lamps had less than a 1% share.

Table 68: Sleeping Fixed Lamp Number and Share by Technology

Sleeping	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Fixed Lamp Number*	1.0	0.4	2.0	2.8	0.3	0.03	0.2
Fixed Lamp Share	14.9%	5.6%	30.3%	41.5%	4.1%	0.4%	3.3%

** This doesn't include missing lamps.*

Table 69 shows the indoor-other area fixed lamp number and share by technology. It can be seen that, similar to sleeping areas, compact fluorescent lamps had the highest share at 34% (3.5 lamps per house). Incandescent lamps made up around 23% of lamps (2.4 lamps). Low voltage halogen lamps had about a 23% share, or 2.4 lamps per house in indoor-other areas. Linear fluorescent and mains voltage lamps had around an 8% share (nearly 1 lamp), while LED and unknown lamps were found to have a 2.0% or less share each.

Table 69: Indoor-other Fixed Lamp Number and Share by Technology

Indoor-other	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Fixed Lamp Number*	2.4	0.8	2.4	3.5	0.9	0.1	0.2
Fixed Lamp Share	23.6%	7.7%	22.9%	34.2%	8.5%	1.2%	2.0%

** This doesn't include missing lamps.*

Table 70 shows the outside area fixed lamp number and share by technology. It can be seen that the highest share of lamps found outdoors were incandescent, at around 31% or 3 lamps per house. Around 22% were linear fluorescent (2 lamps). Compact fluorescent lamps had around a 16% share (1.5 lamps), while mains voltage halogen lamps had a 15% share (1.4 lamps). Low voltage halogen lamps had just over a 9% share (1 lamps per house). LED lamps had just over a 1% share (0.1 lamps). Outdoor areas had the highest number of unknown fixed lamps in the average house, at just under a 4% share.

Table 70: Outside Fixed Lamp Number and Share by Technology

Outside	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Fixed Lamp Number*	2.9	1.4	0.9	1.5	2.1	0.1	0.4
Fixed Lamp Share	31.5%	15.1%	9.3%	16.4%	22.5%	1.2%	3.9%

** This doesn't include missing lamps.*

7.3 Prevalent Technologies for Plug Lamps by Room Type

Plug lamps can help to alter the light levels or mood of a space. Due to their flexibility, householders may use plug lamps to help alleviate poor fixed lighting design decisions (too much, not enough, or not the right type of light). Plug lamps generally are able to have multiple forms of lamp technology installed (incandescent, halogen or compact fluorescent) depending on cap type, an ability that many forms of fixed lighting does not have. This increases the ease of retrofitting choices.

Table 71 shows the whole house plug lamp number and share by technology. It can be seen that the most common type of plug lamp found in a house were compact fluorescent, with around a 42% share (2.8 lamps per house). These were followed by incandescent lamps at around 29% (nearly 2 lamps) and low voltage halogen lamps with just over a 13% share (1 lamp per house). Mains voltage halogen lamps had a 9% share (0.5 lamps per house). Linear fluorescent, LED and unknown lamps were found to have a 3% or less share each.

Table 71: Whole House Plug Lamp Number and Share by Technology

Whole House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Plug Lamp Number*	2.0	0.5	0.9	2.8	0.2	0.2	0.1
Plug Lamp Share	28.9%	9.3%	13.3%	41.9%	3.2%	3.2%	2.1%

** This doesn't include missing lamps.*

Table 72 shows the living area plug lamp number and share by technology. It can be seen that the highest share was again compact fluorescent lamps – accounting for over 50% of lamps found, equivalent to 1 lamp in living rooms per house. Incandescent lamps had around a 20% share (0.4 lamps), while both halogen lamp types had around a 9% share, or 0.2 lamps in living rooms per house. Linear fluorescent, LED and unknown lamps made up less than a 4% share each.

Table 72: Living Plug Lamp Number and Share by Technology

Living	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Plug Lamp Number*	0.4	0.2	0.2	1.0	0.1	0.0	0.1
Plug Lamp Share	21.4%	8.9%	9.3%	52.0%	3.9%	1.8%	2.8%

** This doesn't include missing lamps.*

Table 73 shows the sleeping area plug lamp number and share by technology. It can be seen that compact fluorescent lamps had the highest share in sleeping areas, at around 43% (almost 2 lamps per house). Incandescent lamps were found to have around a 29% share for sleeping areas, just over 1 lamp. For low voltage halogen lamps there was around a 17% share (just under 1 lamp in sleeping areas). Mains voltage halogen lamps had just over a 5% share (0.2 lamps per house), while linear fluorescent, LED and unknown lamps had a less than 3% share each.

Table 73: Sleeping Plug Lamp Number and Share by Technology

Sleeping	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Plug Lamp Number*	1.2	0.2	0.7	1.7	0.1	0.1	0.1
Plug Lamp Share	28.8%	5.4%	17.1%	43.0%	1.5%	2.6%	1.5%

** This doesn't include missing lamps.*

Table 74 shows the indoor-other area plug lamp number and share by technology. It can be seen that incandescent lamps were this time found to have the highest share at over a third share, or 0.1 lamps per house. Compact fluorescent lamps had a 17% share (0.1 lamps per house). LED lamps had around an 20% share (0.1 lamps). Mains and low voltage halogen, linear fluorescent and unknown lamps had a 10% or less share each.

Table 74: Indoor-other Plug Lamp Number and Share by Technology

Indoor-other	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Plug Lamp Number*	0.1	0.0	0.0	0.1	0.0	0.1	0.0
Plug Lamp Share	37.0%	5.6%	5.6%	16.7%	7.4%	20.4%	7.4%

- *This doesn't include missing lamps.*

Table 75 shows the outside area plug lamp number and share by technology. It can be seen that the highest share of lamps found outdoors were incandescent, with around a 53% (0.3 lamps per house) share. About 21%, or 0.1 lamps were mains voltage halogen. Compact and linear fluorescent lamps had around an 11% share (0.1 lamps) each. Low voltage halogen had a 3% share. No LED or unknown lamps were found in outdoor areas.

Table 75: Outside Plug Lamp Number and Share by Technology

Outside	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Plug Lamp Number*	0.3	0.1	0.0	0.1	0.1	0.0	0.0
Plug Lamp Share	52.9%	21.4%	2.9%	11.4%	11.4%	0.0%	0.0%

** This doesn't include missing lamps.*

8. Other Data

8.1 Number of Switches and Lamps per Switch

The quantity of switches in a house has an impact on lamp use and behaviour. Multiple lamps on single switches in a space will increase overall energy consumption, compared to the same lights on multiple switches (depending on how those lamps are used). This is especially important for high use areas like living spaces. Individual lamp switching enables the user to have greater flexibility, depending on their lighting requirements. High numbers of lamps on single switches seem to be more common for halogen downlights, compounding the energy impact of this technology.

Table 76 show the number of switches per lamp by space type. For the average house, around 30 switches were found for around 48 lamps, giving an average of 1.6 lamps per switch. Living areas had the highest number of lamps per switch at 2, with outdoor areas just under 2 lamps per switch. Indoor-other areas had 1.3 lamps per switch, while sleeping areas had 1.4 lamps per switch.

Table 76: Number of Switches per Lamp by Space Type

Average House	Whole House	Living	Sleeping	Indoor-other	Outdoor
Number of Lamps	47.8	16.3	11.1	10.8	9.7
Number of Switches	29.8	8.2	8.1	8.4	5.2
Lamps per Switch	1.6	2.0	1.4	1.3	1.9

Table 77 show the number of switches per lamp by technology. For the average house, the highest number of lamps per switch was found for low voltage halogen lamps at 2. Linear fluorescent and mains voltage halogen lamps were found to have 1.8 lamps per switch, while LED were 1.6. Incandescent and compact fluorescent both had 1.3 lamps per switch.

Table 77: Number of Switches per Lamp by Technology

Average House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED
Number of Lamps*	10.4	4.3	12.0	14.4	4.2	0.7
Number of Switches*	6.9	2.0	5.0	9.8	2.4	0.4
Lamps per Switch**	1.3	1.8	2.0	1.3	1.8	1.6

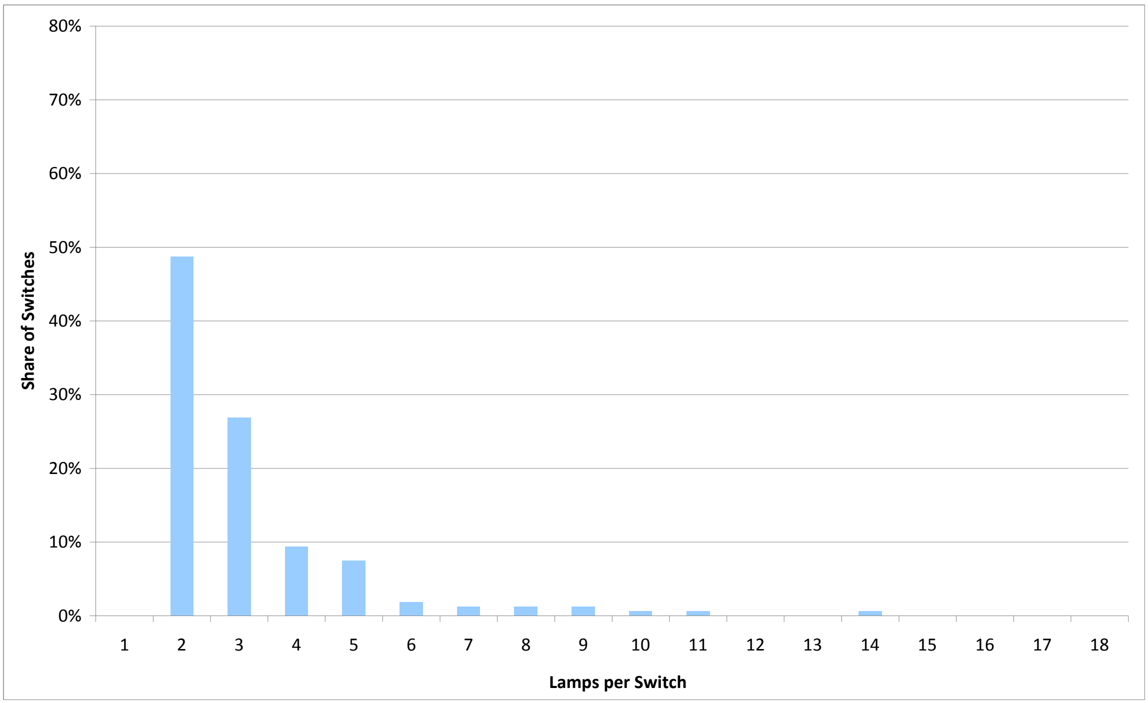
**Note – these figures do not include fittings with mixed, unknown or missing lamp technologies.*

***Note – switches with a mixed technology complicate the relationship of this figure with the numbers above it.*

Some switches were for 'mixed technology' fittings. A mixed technology fitting is a fitting that has different technologies switched by a single switch. A common case is where a householder has installed several lamp technologies in a multi-lamp chandler (usually suspended) fitting, or where they have replaced different lamps at different times and used whatever lamp was available.

Figure 26 shows the number of mixed technology lamps found per switch. The highest percentage of switches had two lamps of mixed technologies (around 50%). Around 27% of switches were found to have three mixed technology lamps. A smaller number of switches had between four and fourteen lamps of a mixed technology.

Figure 26: Number Mixed Technology Lamps per Switch



8.2 Motion Sensors

Motion sensors are generally installed on lights for security or ease of use reasons (rids the requirement to use a switch). As an external security measure they are quite common and are usually sold as a package with one or more lamps. They are rare on internal lamps, although may be found in areas like the pantry or toilet, where householders go regularly but for short periods.

Table 78 shows the share of motion sensors by area (for all lamps). Note that only two areas of the house have been reported on here (as well as the whole house), as motion sensors were only found in these two areas. For the whole house only 3.3% of lamps had a motion sensor (1.6 lamps per house). For indoor-other areas, only 0.4% of lamps had a motion sensor (less than 0.1 lamps per house), while for outdoor areas, 16% of lamps had a motion sensor (1.5 lamps per house). It would appear that motion sensors are a management tool that is not used that much by householders, even in an outdoor situation.

Table 78: Motion Sensors by Area

	Whole House	Indoor-other	Outdoor
Motion Sensor Lamp Number per House	1.6	0.1	1.5
Motion Sensor Share*	3.3%	0.4%	16.0%

** Reported for the full sample as overall lamp numbers are very low.*

Table 79 shows the share of motion sensors by lamp technology for lamps that were found to have a motion sensor. The majority of lamps with motion sensors were incandescent, with just over a 52% share. Almost 22% of lamps with a motion sensor were mains voltage halogen, and almost 10% were low voltage halogen. Around 10% of lamps with a motion sensor were compact fluorescent, while less than 2.5% of lamps with motion sensors were LED, linear fluorescent or unknown lamps

Table 79: Motion Sensors by Lamp Technology

	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Motion Sensor Lamp Number per House	0.83	0.35	0.15	0.16	0.03	0.03	0.04
Motion Sensor Share	52.5%	21.9%	9.7%	10.1%	1.7%	1.7%	2.5%

8.3 Heat Lamps

Heat lamps are normally found in bathrooms. They haven't been classified in this report as lights, as their main function is as a source of radiant heat. Usually there were two or four 275 Watt lamps installed in a fitting, often with a separate light source lamp installed at their centre (especially where four heat lamps were found). The light source lamp (where present) usually had a separate switch. Most heat lamps were switched in pairs of lamps. Anecdotally, these lights may be used as either a source of heat or light, dependant on user behaviour. As a heat source they are seasonal in use, with the highest use periods corresponding with the colder months.

A total of 71 out of 150 houses had heat lamps installed in bathrooms, and there were a total of 321 heat lamps recorded in the survey (an average of 2.1 for every house – all found in indoor-other areas, almost exclusively in bathrooms). On average, 2 heat lamps were found per switch (heat lamp switches only).

9. Conclusions

Lighting is a complex issue, with householder habits and attitudes, lighting configuration and lamp technology all having a large impact on the potential to reduce lighting energy consumption. Lighting in the home is used for many reasons and purposes, and the requirements and lighting desires vary from user to user. Anecdotally, the general knowledge and understanding concerning lighting technologies and choices also varies greatly at a householder level, and this adds another layer of complexity in attempts to increase the efficiency of installed lighting stock.

Although some forms of incandescent lamps have been phased out, the installed stock of this technology is still quite high (22% of lamps in the average house), although these tend to be in lower usage areas. It is encouraging to see that the ownership of compact fluorescent lamps is reasonably high (especially in higher usage areas). However, it is concerning to see that halogen lamps also have a high ownership and many of these have high usage levels. Low voltage halogen lighting installed as flush mounted downlights appear to have become a very popular technology for installation, especially within newer homes. This form of lighting has numerous downsides with poor efficacy, potential fire risks and its impact on the effectiveness of ceiling insulation.

This survey gives a comprehensive picture of lighting in households by room type, as well as the power and technology of lamps. Retrofitting of lighting to increase overall efficiency levels is not a straight forward task, in part due to householder attitudes, knowledge levels and the lack of inter-changeability of some lamp types. The question of retrofitting lighting to increase general efficiency is a difficult one, and not as straight forward as a swap of an incandescent with a compact fluorescent lamp. There is no doubt that some houses have the potential to lower their electricity bills through the installation of a greater number of compact fluorescent lamps, but on the whole, incandescent lamps are found in areas of the house with lower use characteristics.

There may be significant opportunities for energy savings by retrofitting lower wattage extra low voltage halogen lamps, as technological developments mean 35 Watt Infra-Red Coated (IRC) lamps are available to replace standard 50 Watt lamps without reducing light levels. Retrofitting extra low voltage halogen lighting with fluorescent alternatives is a difficult task, as currently there are limited options available to householders without requiring a renovation of the room’s ceiling (due to holes in the plaster). LED lighting has the potential to fill this void, although it hasn’t been installed in numbers high enough to indicate widespread acceptance of the technology. There is still a rapid evolution of LED technology in progress in terms of efficacy and quality.

In overall terms, it would appear that there is the potential to increase total lighting efficiency by at least three fold in many houses that currently have lower efficiency systems. Less efficient homes have an overall average efficacy of around 15 Lumens/Watt (especially larger homes) while many of the most efficient homes have already achieved a practical overall average efficacy of nearly 60 Lumens/Watt.

In summary, the intrusive residential survey has provided valuable insight into the various complexities of residential lighting. The information enclosed will support policy makers as they carefully introduce lighting policy to support energy efficient practices in lighting.

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APPENDIX ONE

Assumptions and Standards Used

There are a number of assumptions and standards that were used during the field research and analysis of this survey. These were employed to help with data validation and enable the analysis procedures to be relatively simple and easily implemented. The key assumptions and standards used are outlined below:

- Technology and shape field identification: generally, identification of lamp technology was a straight forward task. When a lamp had a fitting that completely enclosed the globe, this was more difficult. Turning the switch on and off at times helped to show the overall shape of the lamp (especially in the case of stick or spiral compact fluorescent lamps), or helped to indicate the burner type (very apparent in the case of incandescent lamps).
- Trends in lamp technology findings: it was common to find houses that had been gifted compact fluorescent lamps by either energy retailers or government departments. Householders were normally keen to vocalise this at the start of the survey visit. This enabled power, lamp shape and technology assumptions to be made, as gifted lamps (installed in similar fittings) were normally the same power. Spot checks were periodically undertaken in each house during field research (once the lamp technology was confirmed).
- Unknown technology: fixed lamps with a technology that wasn't able to be identified in the field were assumed to be 60 W incandescent lamps. Plug lamps with a technology that wasn't able to be identified in the field were assumed to be 40 W incandescent lamps. Note that this assumption was only used when there was absolutely no indication of what lamp technology it might be – generally this occurred when there were a mix of lamp technologies found in a house.
- Cap identification: cap identification was sometimes difficult due to ceiling heights, fitting types and time constraints. General assumptions concerning cap types followed the fitting type that the lamp was found in. Oyster fittings normally used an E27 cap, whereas batten holder fittings normally used a B22 cap. Spot checks were periodically undertaken in each house during field research (once the cap type by fitting was confirmed).
- Transformer identification: identifying the transformer type of extra low voltage halogen lamps was a difficult task. Transformers are installed in the ceiling cavity for downlights and found inside the base in the case of desk lamps. As time and safety constraints disallowed visual identification, general assumptions were based on the estimated age of the lamp. Older lamps were assumed to have a magnetic transformer, while newer lamps were assumed to have an electronic transformer. It is noted that there is a high level of uncertainty in these assumptions, and therefore the transformer types recorded in the data.
- Halogen type assumption: clearly differentiating mains voltage from extra low voltage halogen lamps during field research was a difficult task. Generally low voltage lamps are found installed as a flush mounted downlight, while mains voltage lamps were commonly found as wall lights or indoor spotlights. If space for a transformer wasn't identified in the fitting, then the lamp was assumed to be mains voltage.
- Power assumptions: some lamp types are found in fittings that make removal difficult or time consuming. It was known that low voltage halogen lamps could come in two standard power levels - 35 Watt and 50 Watt, with the latter being by far the most common power found in homes. It was only through questioning the householder that 35 Watt low voltage halogens were identified, as assessing this difference in the field was virtually impossible (without removal of the lamp, which has many issues). A similar situation was found for LED lamps – the householder was questioned on whether they knew the power of any/all fixed lamps found in a house. Power assumptions were also made for halogen desk lamps (normally indicated by a power marked on the fitting), rangehoods (if incandescent, normally 40 Watts, if halogen, normally 20 Watts) and a range of other lamp types. These assumptions were confirmed through liaison with other lighting experts during data validation.
- Usage questions: usage questions were asked of every lamp found in a house. Although prompting of the householder was kept as low as possible, householders were given some leeway on occasion. Time was normally short when questions were asked, which was an issue if a house had a lot of lamps (ie above 60). In these cases, lamps were normally grouped by room and householder gave a usage indication for all lamps found in that space. Lamps that were unplugged were assumed to be rarely used, as were lamps with a missing or blown globe.

The assumed efficacy values by technology used in the analysis of different lighting technologies has been outlined in Section 2.4.

Problems Encountered

Generally any problems encountered in the field research or data validation and analysis were countered by the standards and assumption rules that were implemented. Every so often during field research, time constraints would mean that the audit was required to be split into two components – the physical audit and questioning (although lamp data recording was prioritised). This meant that usage questions were not undertaken in the house, but rather at a later date via email correspondence.

It should be noted that it is probable that not every lamp was found/recorded for a house during field research. It is expected that this situation would be true only for a very low number of lamps in a very low number of houses.

APPENDIX TWO

Sampling Approach

The sample was selected from houses in Queensland (Brisbane), New South Wales (Sydney and Newcastle), and Victoria (Melbourne and Gippsland). Each of the four cities were chosen due to their high and representative proportions of Australia's total population and also because they were among the focus cities for the 2000 and 2005 surveys. Gippsland, Victoria was chosen as being representative of a regional rural area. The five study areas were also chosen in an attempt to capture any climatic or other differences in lighting ownership and use behaviour.

Every attempt was made to select the demographic makeup of the sample to be as close to representative of the general Australian population as possible. Attempting to fully balance six individual (although somewhat related) demographic parameters was found to be a very difficult task. Beyond the study resource restrictions (money, time, sample size, etc), the largest confounding factor in this respect was the age of the Census data used for demographic comparison. In spite of these challenges, and even with the resource constraints, the final demographic spreads of the sample were considered satisfactory. Possible skews in individual demographics have been noted in the following demographic breakdown section, along with discussion concerning them.

Recruitment and Selection of Volunteer Households

The recruitment of households involved word of mouth, the circulation of emails and use of social media. Invitations of interest were sent to industry organisations, friends and family, and were subsequently further spread by the addressees. A number of participants were sourced directly from the study information page on EnergyRating.gov.au. Several specific organisations were asked to promote interest in the survey and request their employees to participate, these included:

- EnergyAustralia;
- Origin Energy;
- Port of Brisbane; and
- CSIRO.

Parties were asked to indicate their interest by completing an online demographic questionnaire. This was comprised of questions pertaining to the age, family makeup, occupant numbers, dwelling type and income bracket of the participants as well as the household type, prevalence of appliances and contact details.

In total, 228 individual online responses were received. This response rate was not ideal for selecting a sample that closely represented the Australian demographic. Of these respondents 19% were from New South Wales, 31% were from Queensland, 42% were from the Melbourne area, and 8% were from Gippsland, Victoria. A breakdown of the 2006 Census was used to define an ideal sample, with target breakdowns for the main demographic features.

The final chosen sample provides a good representation of the Australian demographic, with the following exceptions[5] (when compared to the 2006 Census breakdown):

- a high proportion (major skew) of incomes above $88,000 pa, when considering the Census predominance of incomes below $62,000 pa;
- greatly increased proportion of the age group making up the years 25 to 34;
- single member and one parent households are under-represented, with a skew towards group member households;
- major skew towards households containing couples, both with and without children; and
- given the recruitment method, there is a chance of a higher than typical ownership of computers in the sample.

[5] Please note that the age of the Census data will impact on the perceived skews in the data. There was no means to correct for this.

Survey Demographic Breakdown

The following is an outline of the key sample demographics for the survey. It is intended to give a clear illustration of the different components that make up the sample, including the influence of past survey participants (2000 and 2005). 'Past survey participants' refer to householders that participated in either of the previous intrusive standby surveys. The latest intrusive standby survey was conducted concurrently with the lighting survey for practicality reasons. The demographic elements of most interest that have been included are:

- State breakdown – securing a reasonable spread of houses by state (given available resources) was an important survey goal;
- Dwelling type – similar to household ownership status, dwelling type probably has the most impact on lighting, and could be regarded as the key demographic for lighting;
- Household size (number of occupants) – number of occupants probably has a minimal impact on the lighting characteristics found in a house. It will have an impact on lighting use;
- Household income – household income by its very nature will impact on lighting, although this impact tends to be indirect (probably through house size/location). This is the most difficult demographic to balance, as it has a large number of bins, and there are clear skews in different aspects of the sample pool of houses. There is also no way directly verify statements regarding income;
- Family type – this demographic has ties to both household size and household income;
- Occupants age – the age of occupants isn't expected to have an impact on the lighting makeup of a house, although this is difficult to predict;
- Household ownership status – this is probably one of the least important demographics (although it may be partly correlated with household income), and by itself is not likely to have much impact on lighting.

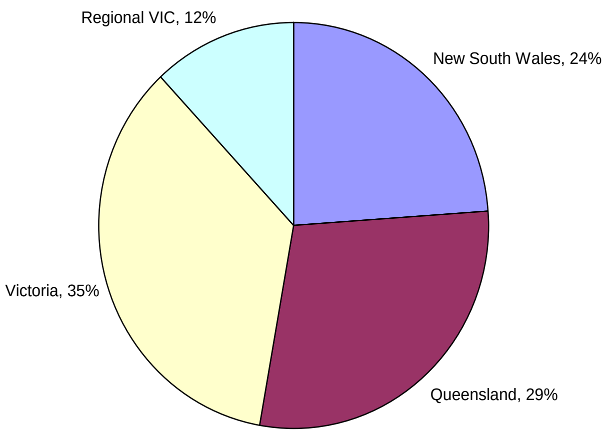
The above list of demographic elements is ordered from most to least important in terms of survey balance. Balancing the sample against the ABS Census is a difficult task, as each demographic element tends to independent – thus, balancing one demographic element may cause an imbalance in another.

A key survey goal was to measure 150 houses. These houses were to include past participants from the 2000 and 2005 surveys. This was to capture trend data for the standby component of the survey, and because past participants were 'friendly' – they knew the basic process.

State

Originally, NSW and QLD house numbers were 40 each (or 27%). This was revised to include less NSW and more VIC and QLD houses (Figure 27), as the possible participant numbers for NSW were low.

Figure 27: Breakdown of Houses Measured in Each State



Household Dwelling Type

On the whole, the dwelling type demographic splits were very reasonable (Figures 28 to 30). This is especially pleasing given this demographic will probably have the largest impact on lighting characteristics. Figures 28 to 30 respectively show the sample data versus ABS Census data for the total sample household dwelling type, the 2000 survey household dwelling type that were included as part of the total sample, and the 2005 household dwelling type that were included as part of the total sample. The latter two figures have been included to help show the influence on the sample of past household dwelling types (this has been repeated for all demographic breakdowns).

Figure 28: Total Sample Household Dwelling Type vs ABS Census Breakdown

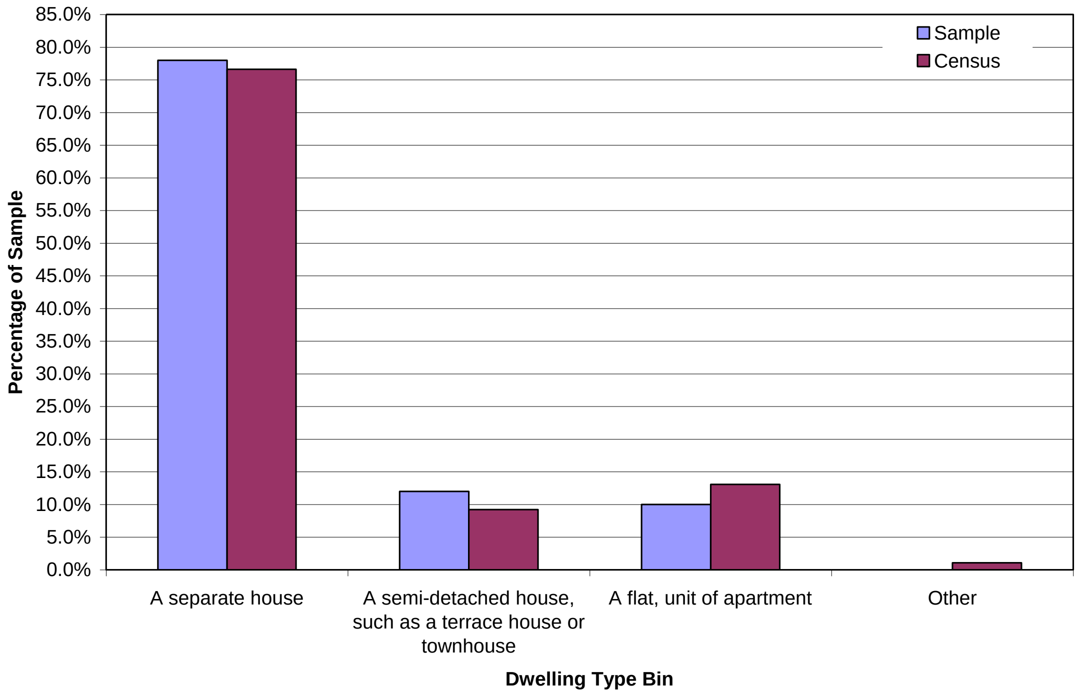
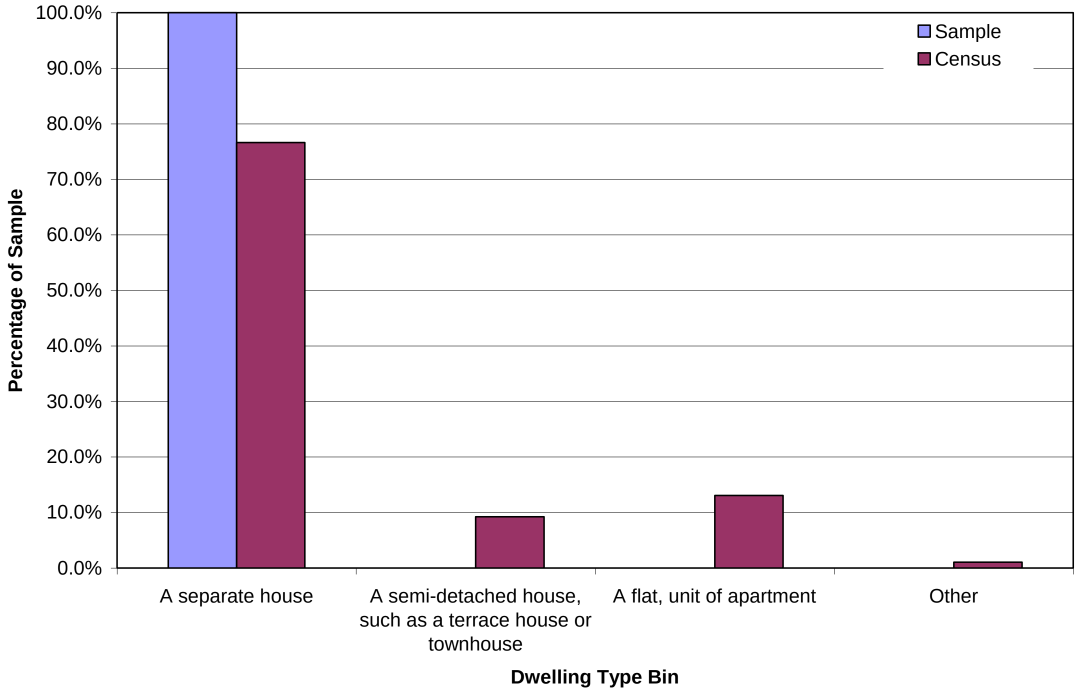
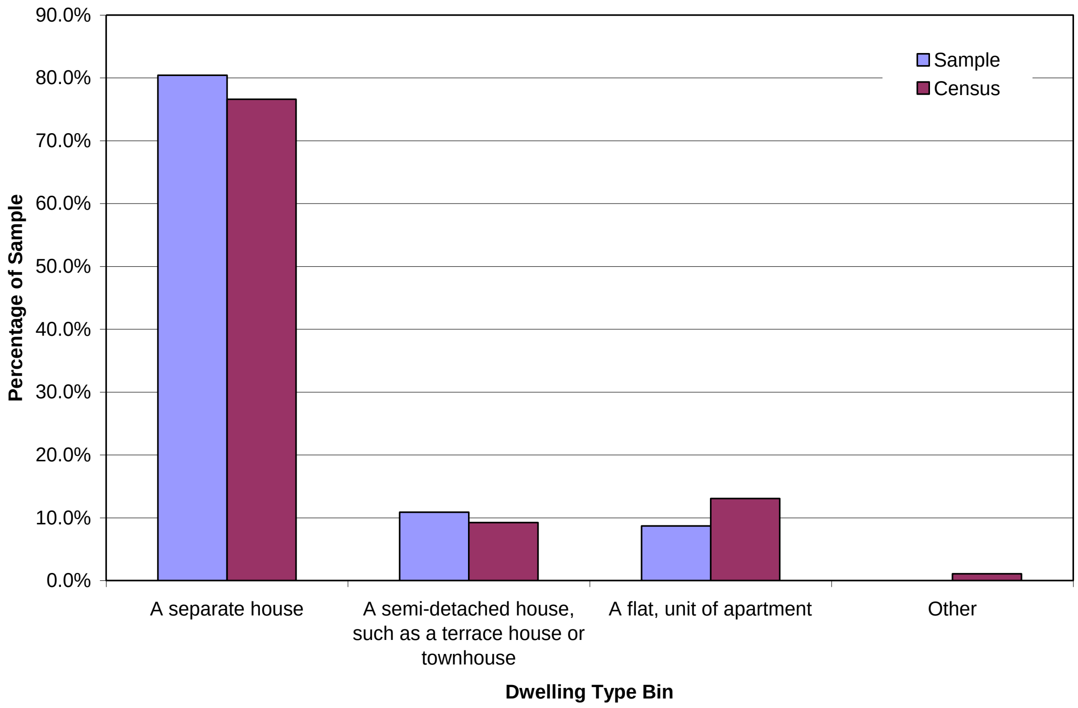


Figure 29: 2000 Survey* Household Dwelling Type vs ABS Census Breakdown



**2000 Participants x 9*

Figure 30: 2005 Survey* Household Dwelling Type vs ABS Census Breakdown



** 2005 Participants x 46*

Household Size (Occupant Number)

On the whole, the household size demographic splits were quite reasonable (Figures 31 to 33). There were some slight skews in house sizes, but not to a large degree.

Figure 31: Total Sample Household Size (Occupants) vs ABS Census Breakdown

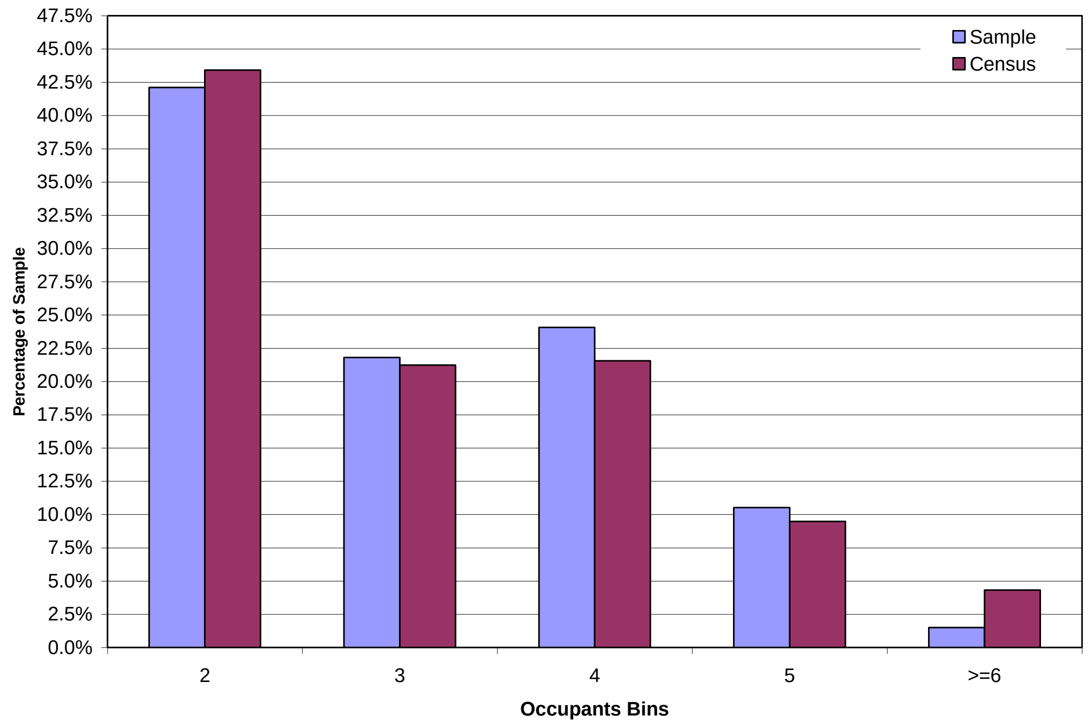
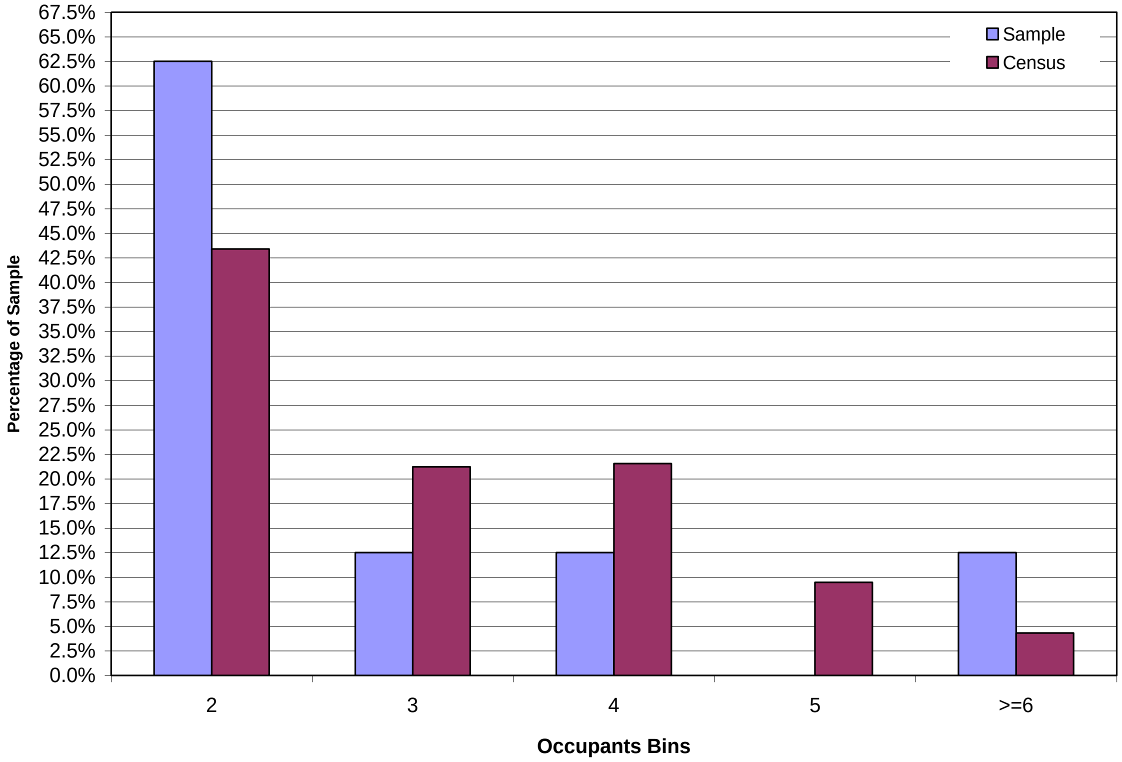
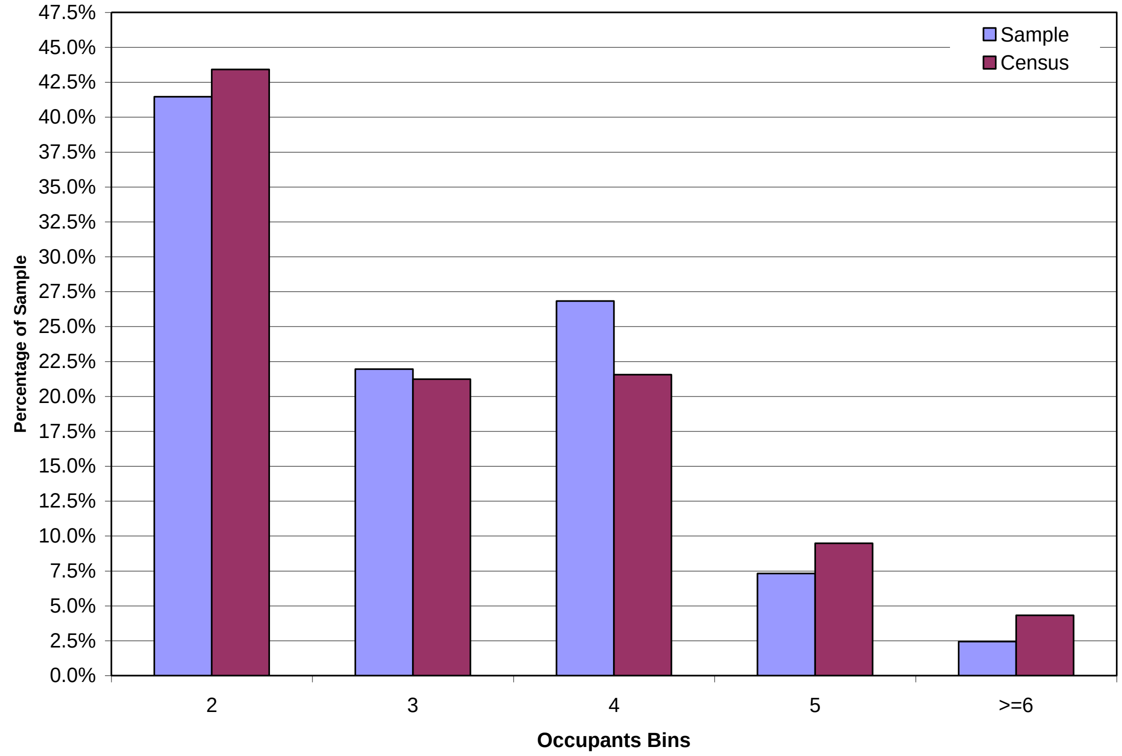


Figure 32: 2000 Survey* Household Size (Occupants) vs ABS Census Breakdown



** 2000 Participants x 9*

Figure 33: 2005 Survey* Household Size (Occupants) vs ABS Census Breakdown



** 2005 Participants x 46*

Household Income

The household income demographic split is by far the largest concern for the sample. There is a heavy weighting towards the higher income bins (Figures 34 to 36), and there are a number of possible reasons for this.

- Historical issues – due to the re-measuring of 2000 and 2005 survey participants. The 2000 and 2005 surveys both had a similar issue with a skew towards high income households, resulting from the sampling and participant sourcing methods used.
- ABS household income – the Census data that is used as a comparison was captured in 2006 and it is quite possible that household incomes have increased significantly over the following four years. Note also that this measures household size, thus it is quite possible for larger households to have a high income level (even if they are traditionally low income groups like student rentals).
- East coast metropolitan areas – the survey focuses on the east coast of Australia, primarily the Brisbane, Sydney and Melbourne metropolitan areas. It is probably safe to assume that these cities have a higher average household income than most other areas of the country.
- Higher study interest from higher income groups – it is possible that there was higher interest and therefore higher participation from people (through self selection) that come from high income bins. Recruitment through the internet also tends to favour selection of households with computers, which may be correlated to income. This may also be due to a correlation with education levels, although this demographic was not captured for the survey and so is difficult to prove.
- Single member and single parent households – the sample is underweight for both these demographic types. It is expected that these demographics would naturally correlate with lower household income levels.

All efforts were made to balance the sample with the Census, with a focus on household income levels (while keeping some thought as to the other demographics). It is difficult to know how this issue could have been better addressed without greatly increasing the pool of potential participants (which would have corresponding time and resource issues).

Figure 34: Total Sample Household Income vs ABS Census Breakdown

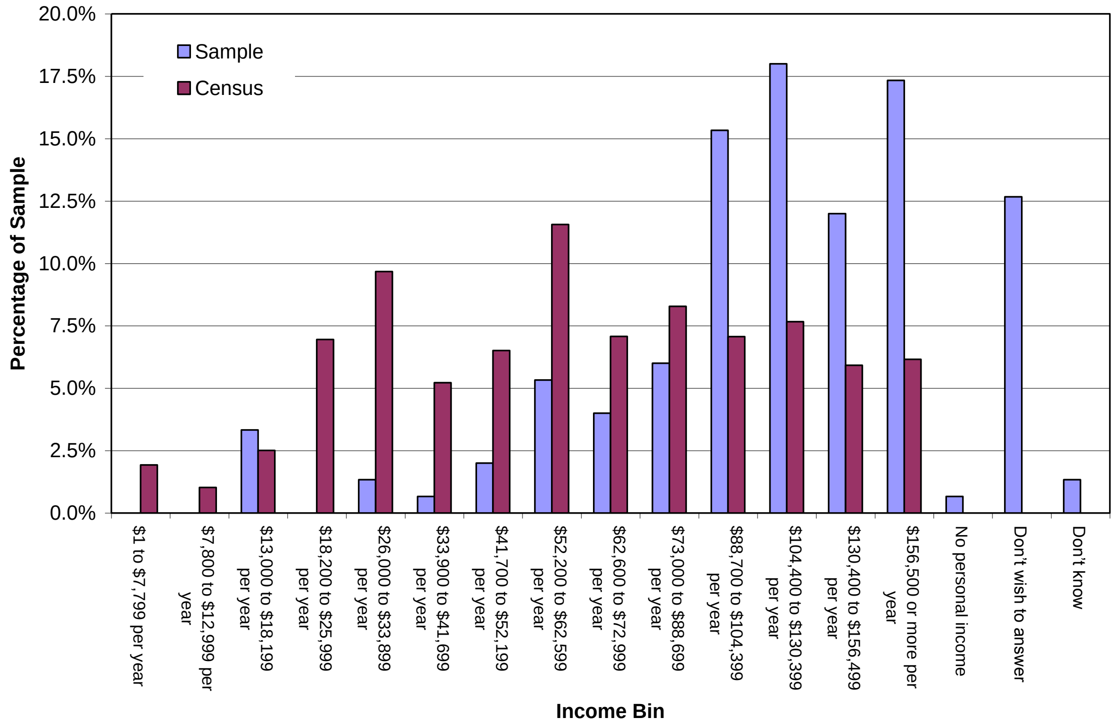
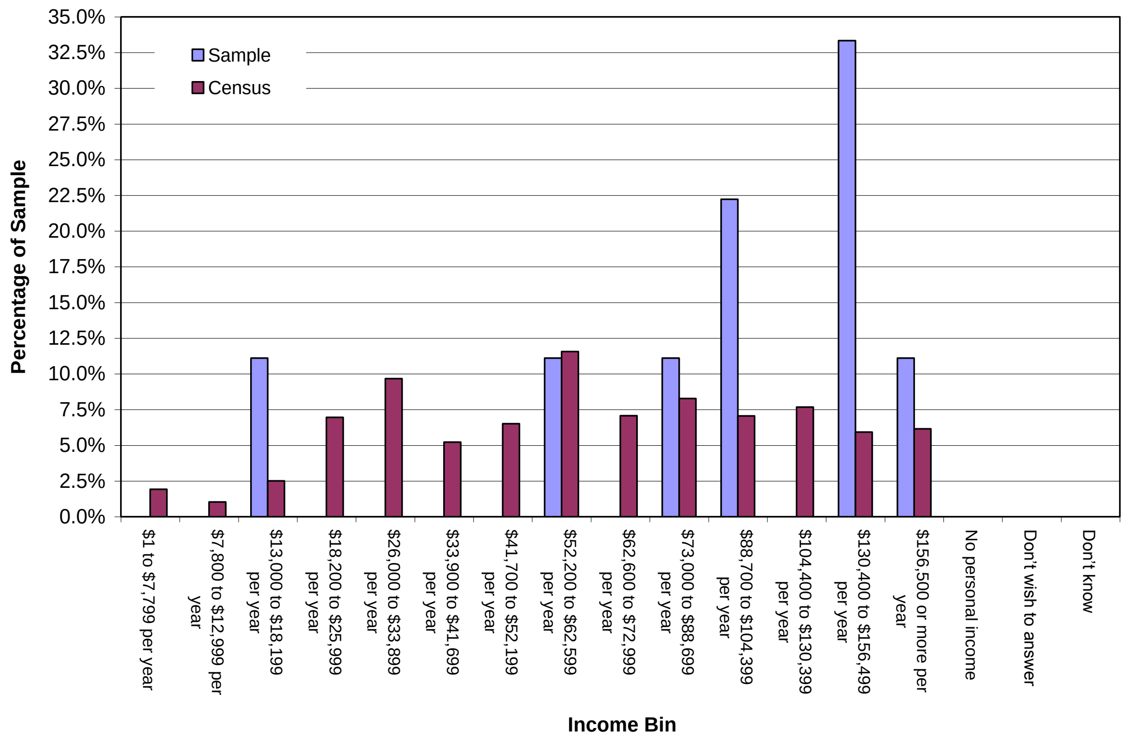
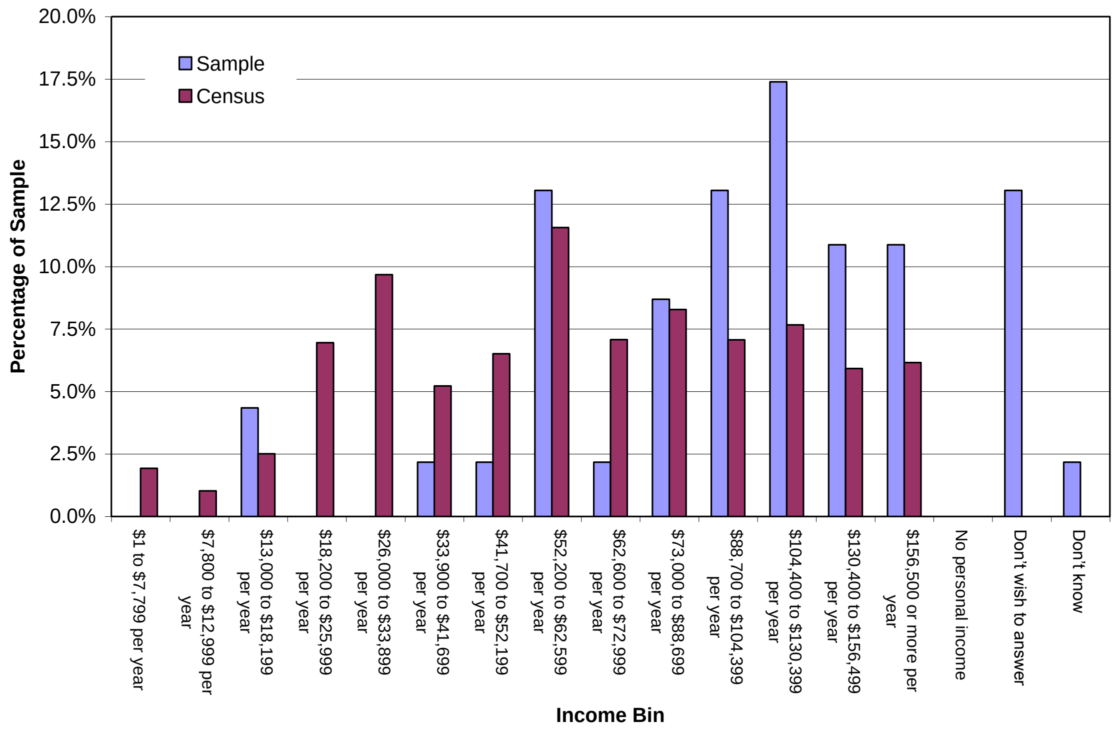


Figure 35: 2000 Survey* Household Income vs ABS Census Breakdown



** 2000 Participants x 9*

Figure 36: 2005 Survey* Household Income vs ABS Census Breakdown



** 2005 Participants x 46*

Household Family Type

Related to the skew issues found in the household income demographic, the family type demographic (Figure 37) in the sample was of concern. There is a historical bias (in the 2000 and 2005 surveys, Figures 38 and 39 respectively) towards couples with children and couples without children, resulting in one parent family and single member households being under represented. It is difficult to know whether this bias has been accentuated by the sampling techniques used. The sample also shows a skew towards group households – once again it is unknown whether the sampling techniques have accentuated this bias.

Figure 37: Total Sample Household Family Type vs ABS Census Breakdown

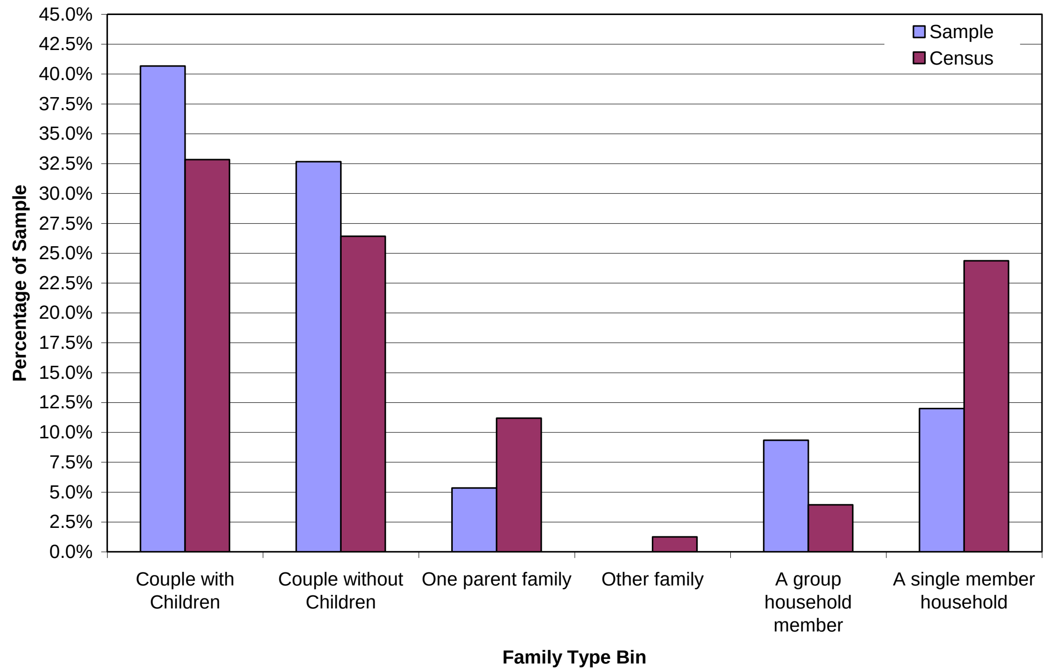
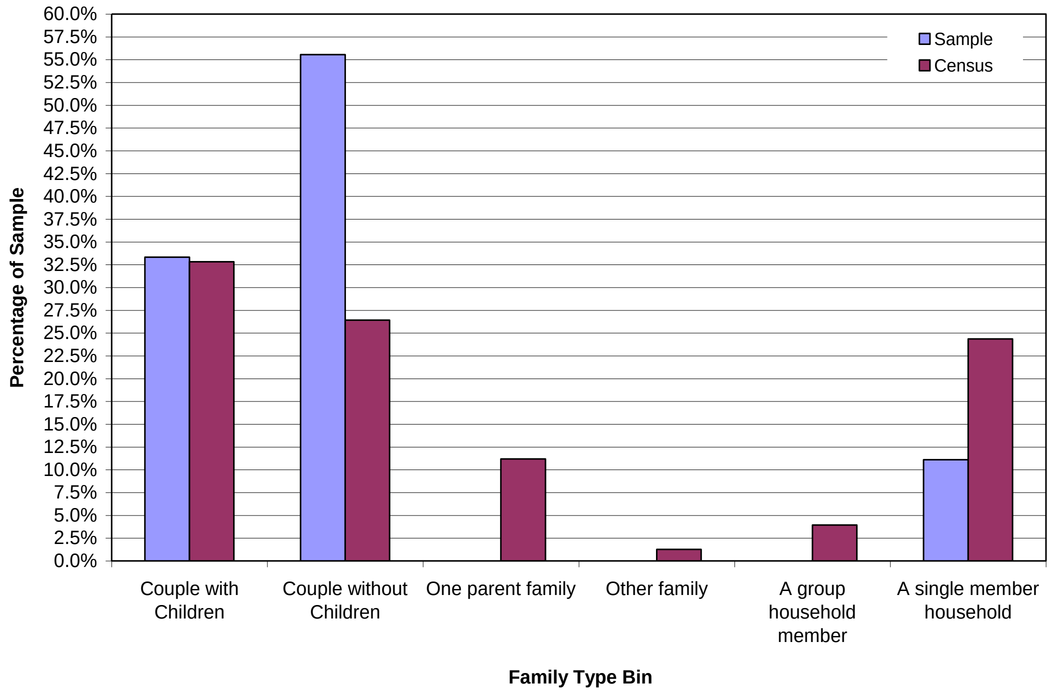
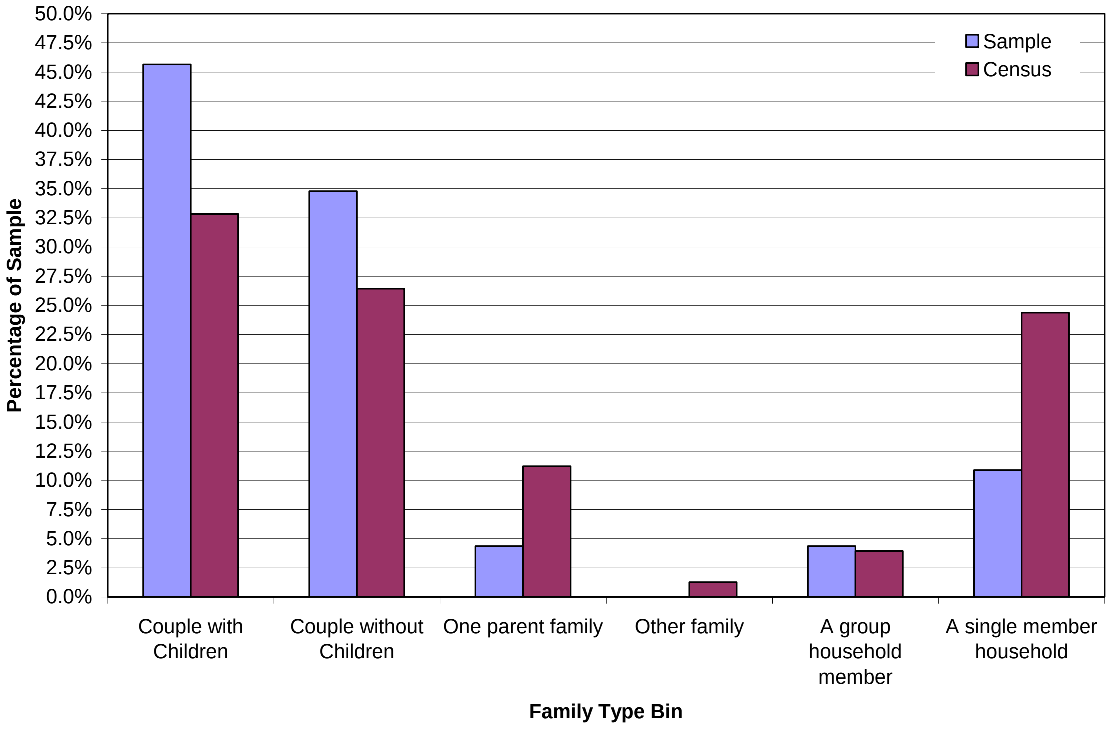


Figure 38: 2000 Survey* Household Family Type vs ABS Census Breakdown



** 2000 Participants x 9*

Figure 39: 2005 Survey* Household Family Type vs ABS Census Breakdown



** 2005 Participants x 46*

Household Occupant Age

The occupant age demographic is of interest, although attempting to balance it against the Census is a very difficult task. With the exception of the age groups 25-34, 45-54, and 65 or over, the spread of participant ages is reasonable (Figure 40). The age 25-34 was over represented and the 55-64 and 65 or over age groups are under represented. These skews did not occur in previous surveys (Figures 41 and 42), and two reasons for them could be either participant interest levels and/or the participant communication method (it is possible that the older age groups may have lower level of internet access).

Figure 40: Total Sample Household Occupant Age vs ABS Census Breakdown

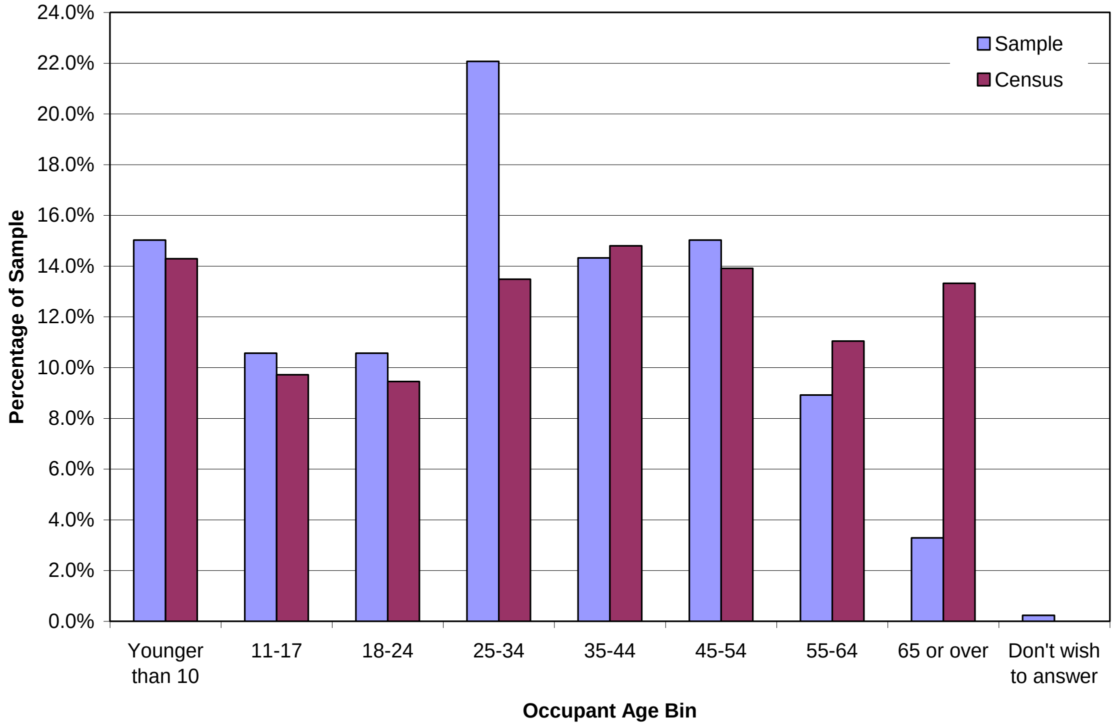
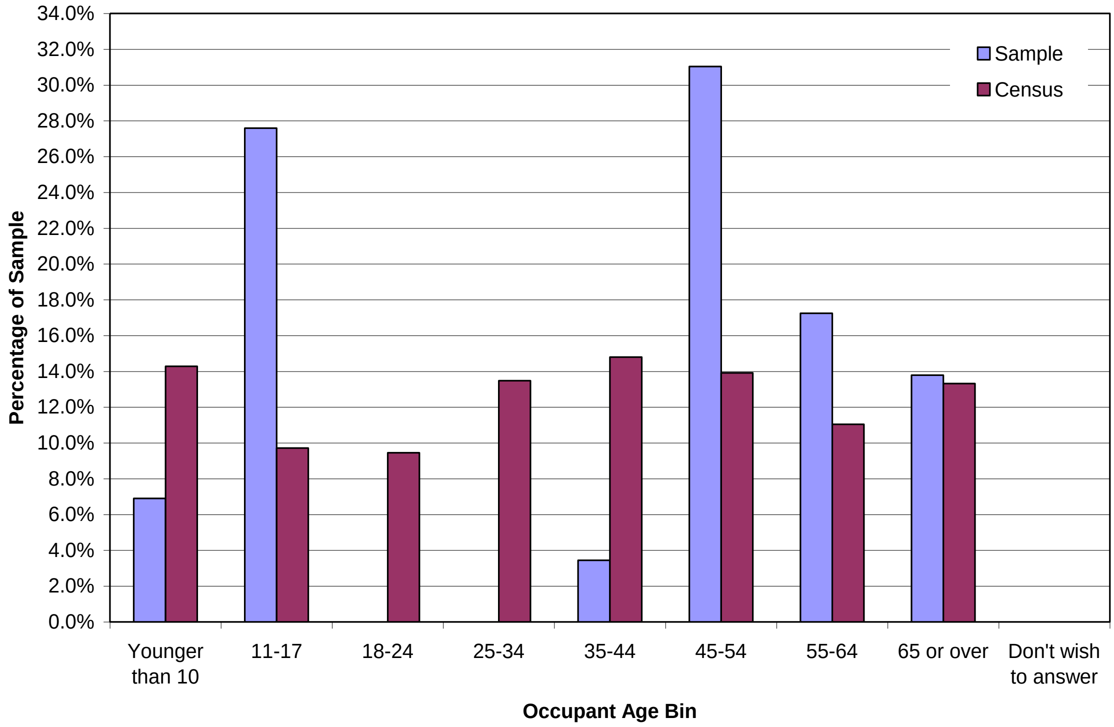
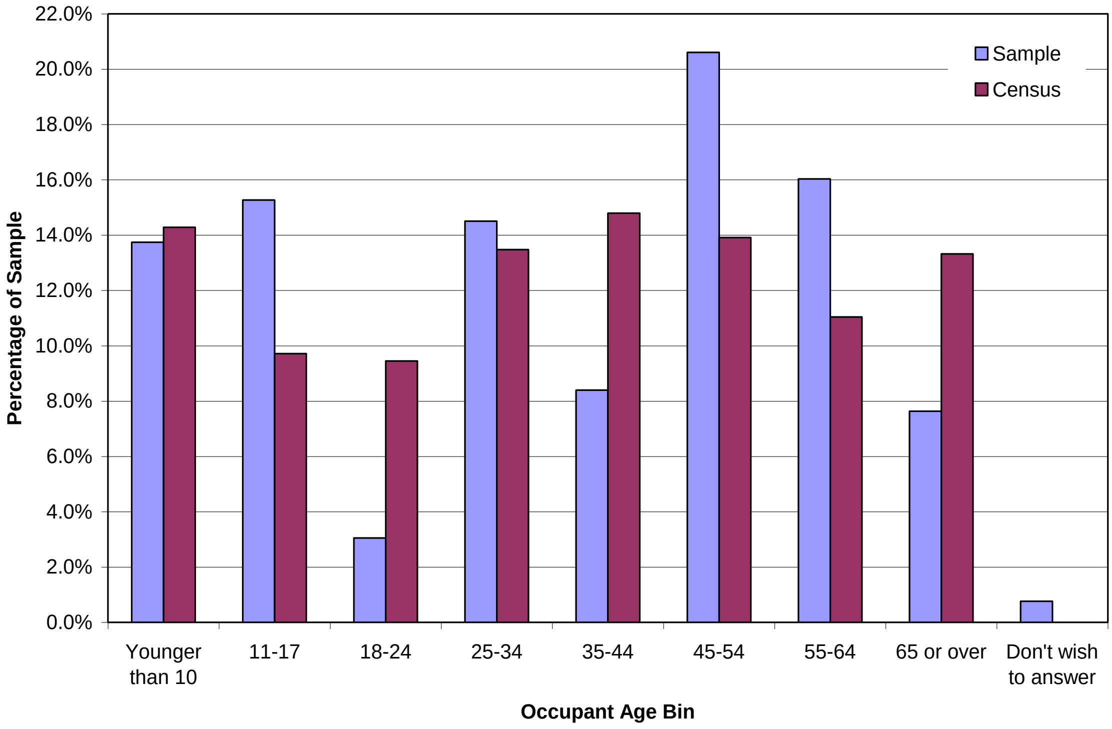


Figure 41: 2000 Survey* Household Occupant Age vs ABS Census Breakdown



** 2000 Participants x 9*

Figure 42: 2005 Survey* Household Occupant Age vs ABS Census Breakdown



** 2005 Participants x 46*

Household Ownership Status

The sample ownership status demographic was reasonably balanced against the Census (Figure 43), although fully owned are over represented and rented houses are under represented. This stems from attempting to balance 'more important' demographic bins. This situation was similar as in previous surveys (Figures 44 and 45), where there were large skews towards different bin types.

Figure 43: Total Sample Household Ownership Status vs ABS Census Breakdown

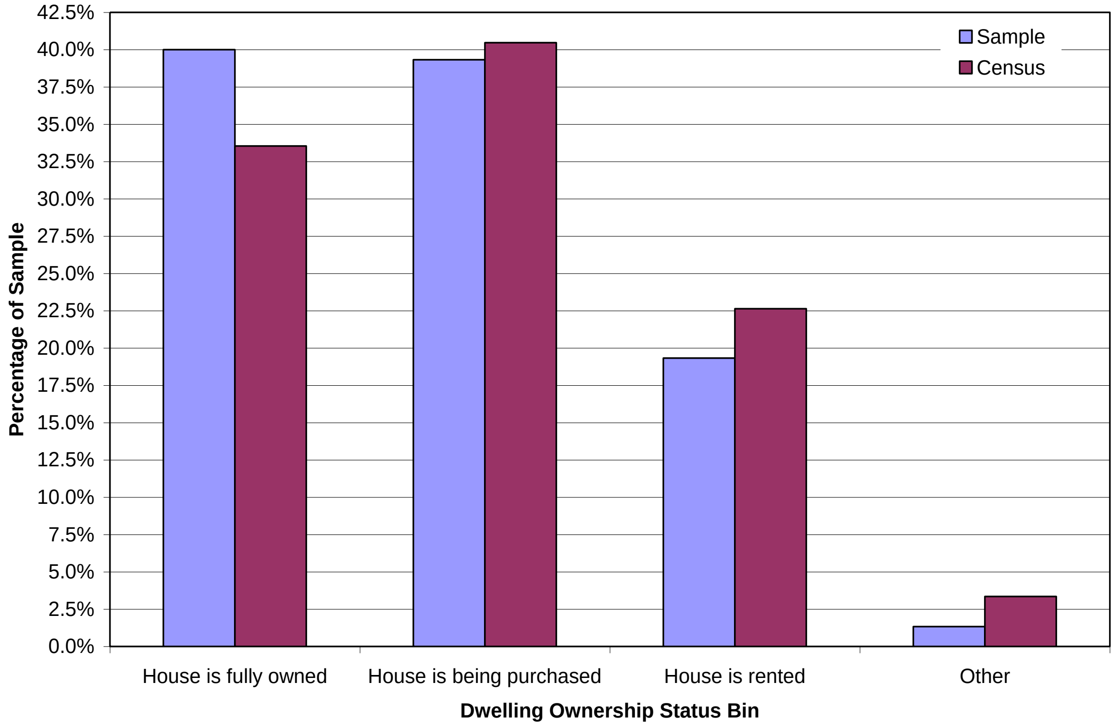
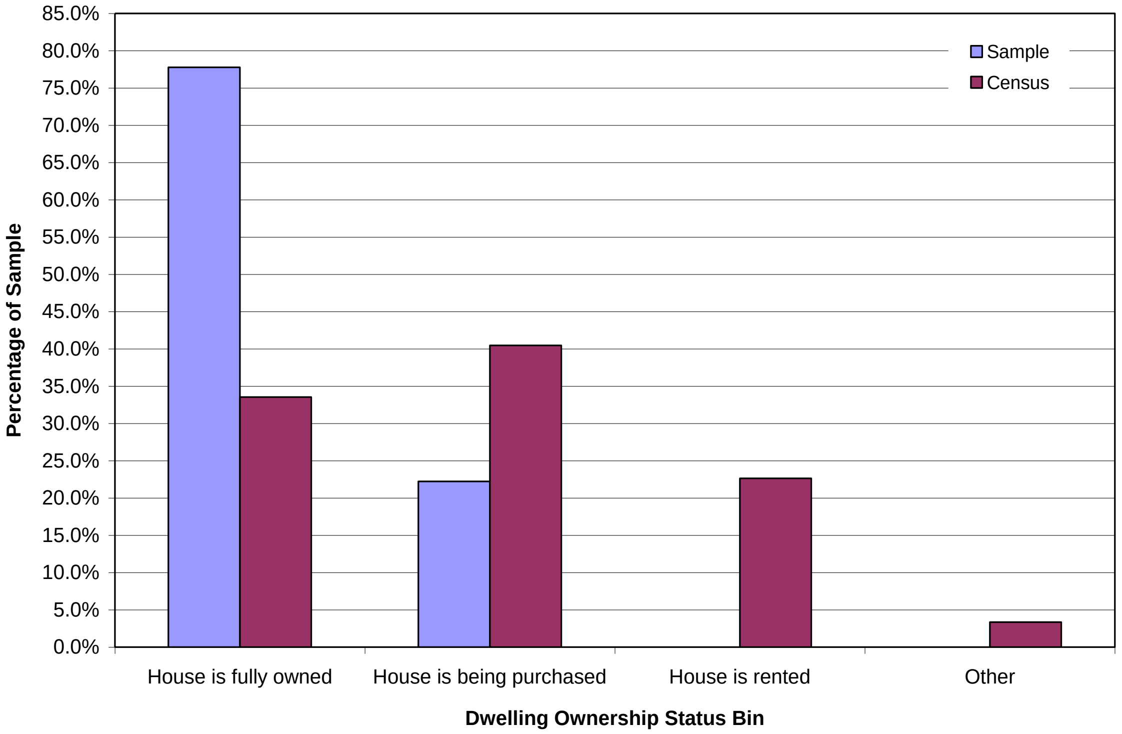
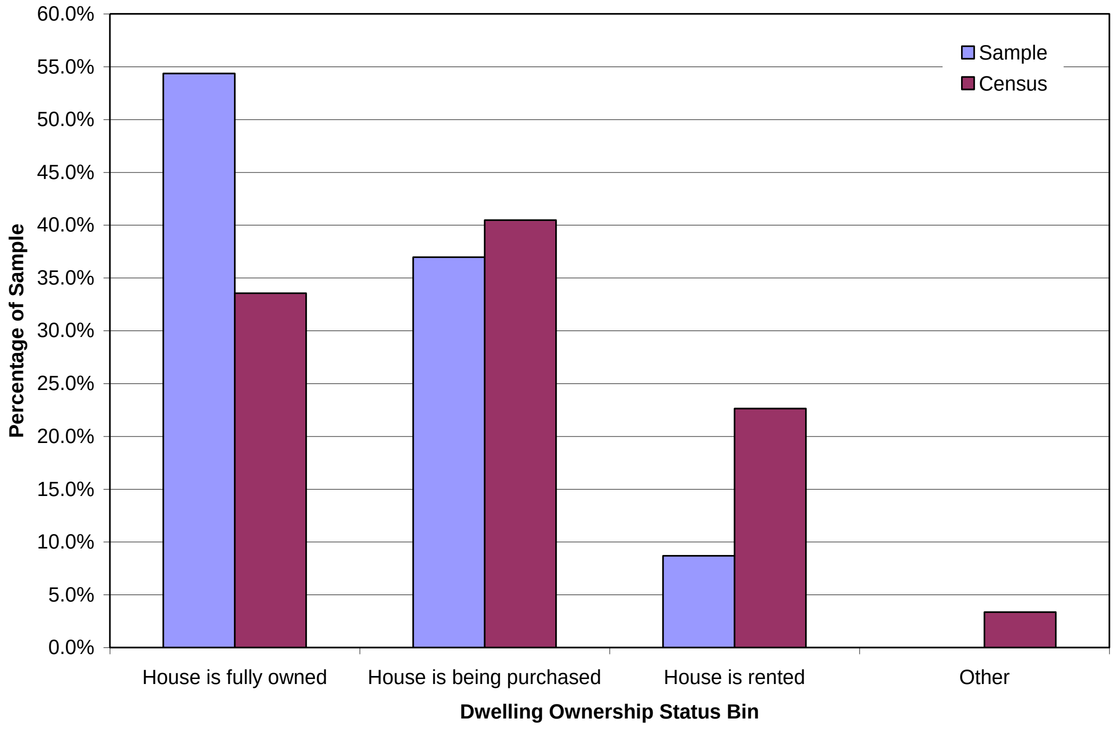


Figure 44: 2000 Survey* Household Ownership Status vs ABS Census Breakdown



** 2000 Participants x 9*

Figure 45: 2005 Survey* Household Ownership Status vs ABS Census Breakdown



** 2005 Participants x 46*

APPENDIX THREE

Living Area Split Analysis and Discussion

The following sections outline the analysis for a split of the living room type. As these are the higher use areas of the house, it was decided that an investigation into the key differences between the following room types would be warranted:

- Separate kitchens (SK);
- Kitchen living areas (K/L); and
- Separate living areas (SL) (this includes lounges, living-other and dining areas).

Separate kitchens and separate living areas are commonly found in many houses, with probably no design by age trend, whereas open space living areas (ie kitchen living areas) have probably become more common in recent times.

Lamp Numbers and Connection Type

Table 80 shows the lamp numbers and connection type by area. Separate living areas were found to have more than double (8.4) the number of lamps found in separate kitchens (3.9) and kitchen/living areas (4). For each of these spaces, the average number of switches meant that there were around two lamps per switch (ranging from 1.8 for kitchen/living areas to 4.3 for separate living areas).

The number of fixed lamps was the same for separate kitchens and kitchen/living areas (3.7 fixed lamps). Separate living areas had almost double the number of fixed lamps than these other two areas (6.9). There were 0.2 plug lamps found in separate kitchens, 0.3 for kitchen/living and 1.5 for separate living areas.

Table 80: Lamp Numbers and Connection by Living Area

Average Per House	Separate Kitchen	Kitchen/Living	Separate Living
Number of Lamps	3.9	4.0	8.4
Number of Switches	2.0	1.8	4.3
Number of Fixed Lamps	3.7	3.7	6.9
Share of Fixed Lamps	95.9%	91.9%	82.5%
Number of Plug Lamps	0.2	0.3	1.5
Share of Plug Lamps	4.1%	8.1%	17.5%

Room and Area Findings

Table 81 shows the room and area findings by space type. In terms of the number of rooms, separate living areas was found to have more than double (1.7) that of separate kitchens (0.7) and kitchen/living areas (0.3). Separate living areas had over three times the floor area (almost 37 m^2) of separate kitchen (10.2 m^2), and kitchen/living areas (13.3 m^2). The share of all rooms and floor area corresponded with these findings – separate living was much larger than both separate kitchen and kitchen/living areas.

The lamps per m^2 for separate kitchens was found to be 0.4, while for kitchen/living areas it was found to be 0.3 and for separate living it was 0.2. There were 11.8 lamps per room for kitchen/living areas, and less than half that number for separate kitchens (5.7) and separate living areas (4.8).

Table 81: Room and Area Findings by Space Type

Average Per House	Separate Kitchen	Kitchen/Living	Separate Living
Number of Rooms	0.7	0.3	1.7
Floor Area (m^2)	10.2	13.3	36.8
Share of all Rooms	4.4%	2.2%	11.2%
Share of all Floor Area	6.5%	8.4%	23.3%
Lamps per m^2	0.4	0.3	0.2
Lamps per Room	5.7	11.8	4.8

Watt Findings

Table 82 shows the Watts findings by space type. In terms of total Watts, once again separate living areas were found to have over double (319 Watts) that of separate kitchens (140 Watts) and kitchen/living areas (155 Watts). The share of Watts for fixed lamps was 97% in separate kitchens, while for kitchen/living areas it was 94% and for separate living areas it was around 84%.

The power density for separate kitchens was found to be about 13.7 Watts/m^2, in kitchen/living areas it was around 11.6 Watts/m^2 and for separate living areas it was around 8.7 Watts/m^2. The power density for fixed lamps in separate kitchens was around 13 Watts/m^2, while for kitchen/living areas it was 11 Watts/m^2, and for separate living areas it was around 7.3 Watts/m^2. The power density for plug lamps in separate living areas was 1.4 Watts/m^2, while for kitchen/living areas it was 0.6 Watts/m^2, and for separate kitchens it was 0.5 Watts/m^2.

Table 82: Watts Findings by Space Type

Average Per House	Separate Kitchen	Kitchen/Living	Separate Living
Total Watts	140.0	154.8	319.3
Share Watts – Fixed Lamps	96.5%	94.0%	83.7%
Share Watts – Plug Lamps	3.5%	6.0%	16.3%
Power density (Watts/m^2)	13.7	11.6	8.7
Power density (Watts/m^2) – Fixed Lamps	13.2	11.0	7.3
Power density (Watts/m^2) – Plug Lamps	0.5	0.6	1.4

Lumen Findings

Table 83 shows the Lumens findings by space type. In terms of total Lumens, separate living areas were found to have higher overall Lumens (6823), as well as higher Lumens for both fixed and plug lamps (although the Lumens share was the lowest of all three room types). Partly this is due to this room type having the highest share of plug lamps (16%). Conversely, Lux was higher in separate kitchens (345), and kitchen/living areas (265) compared to separate living areas (185). Fixed and plug lamp Lux were similar to the proportions for overall Lumens.

Table 83: Lumens Findings by Space Type

Average Per House	Separate Kitchen	Kitchen/Living	Separate Living
Lumens	3533	3522	6823
Lumens – Fixed Lamps	3431	3255	5755
Lumens Share – Fixed Lamps	97.1%	92.4%	84.3%
Lumens – Plug Lamps	102	267	1068
Lumens Share – Plug Lamps	2.9%	7.6%	15.7%
Lighting levels (Lux)	345	265	185
Lighting levels (Lux) – Fixed Lamps	335	245	156
Lighting levels (Lux) – Plug Lamps	10	20	29

Technology Characteristics

Table 84 shows the number of lamps by space type and lamp technology. Separate living areas were found to have the highest number of lamps for each technology (with the exception of linear fluorescent lamps), while both separate kitchens and kitchen/living areas had similar lamp numbers. Low voltage halogen lamps were the most common in all room types (34% to 40%), followed by compact fluorescent lamps (between 24% and 33%).

Incandescent lamps were the next most common, between 13% and 19% for all rooms. Mains voltage halogen were around 11% in kitchen/living areas, and around 7.5% in the other two room types. Linear fluorescent lamps were most common in separate kitchens, at almost 10%, while for kitchen living areas they were around 6.5% and in separate living areas they were only 3% of lamps. LED, unknown and missing lamp technologies were found in small numbers (less than 2.5%) in each of the three room types.

Table 84: Lamp Numbers by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown	Missing
Number of Lamps – SK	0.5	0.3	1.5	1.0	0.4	0.04	0.1	0.04
Number of Lamps – K/L	0.6	0.4	1.6	1.0	0.3	0.1	0.1	0.01
Number of Lamps – SL	1.5	0.6	2.8	2.8	0.3	0.1	0.1	0.2
Number Share – SK	13.4%	7.4%	39.5%	25.5%	9.8%	1.0%	2.2%	1.0%
Number Share – K/L	15.9%	10.9%	38.4%	24.0%	6.6%	2.3%	1.5%	0.3%
Number Share – SL	18.2%	7.6%	33.7%	33.0%	3.0%	1.3%	1.1%	2.0%

Table 85 shows the Watt findings by space type and lamp technology. Separate kitchens and kitchen/living areas had similar Watt totals for each lamp technology, whereas separate living areas had comparatively much larger totals for incandescent, low/mains voltage halogen and compact fluorescent lamps. The Watts share for each lamp technology was generally similar for each room type, even for separate living areas.

With the exception of incandescent and mains voltage halogen lamps, the Watts per lamp findings were similar for each room type. For incandescent lamps, separate living areas had a higher Watts per lamp than both separate kitchens (around 12 Watts more) and kitchen/living areas (around 8 Watts more). For mains voltage halogen lamps, separate living areas were much higher than those in both separate kitchen and kitchen/living areas (at least 20 Watts in both cases).

Table 85: Watt Findings by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown	Missing
Watts Total – SK	23	15	72	13	12	0	4	NA
Watts Total – K/L	34	21	74	14	8	1	3	NA
Watts Total – SL	87	46	135	37	8	1	5	NA
Watts Share – SK	16.6%	11.0%	51.6%	9.2%	8.6%	0.2%	2.8%	NA
Watts Share – K/L	21.7%	13.6%	47.8%	9.2%	5.4%	0.4%	2.0%	NA
Watts Share – SL	27.3%	14.5%	42.1%	11.7%	2.6%	0.2%	1.5%	NA
Watts per Lamp – SK	43.5	57.7	46.9	13.2	31.8	6.6	44.7	NA
Watts per Lamp – K/L	47.3	52.5	46.8	14.8	30.7	5.6	46.7	NA
Watts per Lamp – SL	55.6	79.2	47.5	13.5	30.4	4.5	52.3	NA

Table 86 shows the Lumen findings by space type and lamp technology. As for Watts findings, separate kitchens and kitchen/living areas had similar Lumens totals for each lamp technology, whereas separate living areas were found to have comparatively much larger totals for incandescent, halogen and compact fluorescent lamps. The Lumens share for each lamp technology was similar for each room type, even for separate living areas, with the exception of linear fluorescent lamps where separate kitchens had a 20% higher Lumens share than separate living areas.

Table 86: Lumens Findings by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown	Missing
Lumens Total – SK	279	246	1156	706	1085	14	46	NA
Lumens Total – K/L	404	336	1183	781	755	26	37	NA
Lumens Total – SL	1047	742	2153	2057	735	31	58	NA
Lumens Share – SK	7.9%	7.0%	32.7%	20.0%	30.7%	0.4%	1.3%	NA
Lumens Share – K/L	11.5%	9.5%	33.6%	22.2%	21.4%	0.7%	1.0%	NA
Lumens Share – SL	15.3%	10.9%	31.6%	30.1%	10.8%	0.5%	0.8%	NA
Assumed Lumens/Watt	12	16	17	55	90	60	12	NA

Table 87 shows the number of dimmers by space type and lamp technology. For each of the three room types, halogen lamps had the most dimmers, and for both separate kitchens and kitchen/living areas only low voltage halogen lamps were found with dimmers. For separate living areas, the highest number of dimmers (1.2 per house) were on low voltage halogen lamps, while incandescent, compact fluorescent and LED lamps had small numbers of dimmers.

Table 87: Dimmers by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown	Missing
Dimmers – SK	0.0	0.0	0.2	0.0	0.0	0.0	0.0	NA
Dimmers – K/L	0.0	0.0	0.5	0.0	0.0	0.0	0.0	NA
Dimmers – SL	0.3	0.2	1.2	0.1	0.0	0.1	0.0	NA

Usage Findings

Table 88 shows the frequent long usage findings by space type and lamp technology. For both separate kitchens and kitchen/living areas, low voltage halogen lamps had the most frequent long responses. For separate living areas, compact fluorescents had the most frequent long responses. Compact fluorescent lamps were found to have the second most number of frequent long responses for separate kitchens and kitchen living areas, while for separate living areas low voltage halogen lamps had the second most number of frequent long responses. Incandescent, mains voltage halogen, linear fluorescent and LED lamps had similar numbers of responses for each of the three room types.

Table 88: Frequent Long Usage by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Long - SK	0.11	0.20	0.90	0.66	0.16	0.06	0.01
Frequent Long – K/L	0.21	0.14	0.83	0.60	0.17	0.03	0.00
Frequent Long – SL	0.14	0.14	0.75	1.39	0.05	0.00	0.00

** For houses where usage questions were asked – N = 87*

Table 89 shows the frequent short usage findings by space type and lamp technology. For all room types, low voltage halogen lamps had the most frequent short usage responses, although at far lower levels than frequent long responses (Table 88) for that lamp technology. In fact, with the exception of incandescent lamps in separate kitchens, each lamp technology for each room type had a lower number of responses for frequent short use compared to frequent long use. This would suggest that lamps in these areas are used regularly and for long periods, with no discernible difference when considering space type.

Table 89: Frequent Short Usage by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Frequent Short - SK	0.15	0.06	0.53	0.08	0.06	0.00	0.01
Frequent Short – K/L	0.03	0.09	0.23	0.07	0.00	0.03	0.00
Frequent Short – SL	0.05	0.03	0.52	0.28	0.00	0.03	0.00

** For houses where usage questions were asked – N = 87*

Table 90 shows occasional usage by space type and lamp technology. Low voltage halogen lamps in separate living areas had higher occasional use (0.59; Table 90) than frequent short use (0.52; Table 89), and similar frequent long use (0.75; Table 88), indicating these lamps are either on most of the time or not used. Compact fluorescent lamps were found to have more occasional use in each room type, compared to frequent short use, although less than frequent long use. Once again, this indicates that these lamps are either on all the time or not used. Occasional use responses for incandescent lamps in separate living areas was higher than for both frequent long or short use. Mains voltage halogen lamps were had a higher amount of occasional use in both kitchen/living areas and separate kitchens than frequent long or short uses.

Table 90: Occasional Usage by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Occasionally - SK	0.11	0.02	0.18	0.36	0.02	0.00	0.00
Occasionally – K/L	0.08	0.23	0.05	0.17	0.05	0.00	0.00
Occasionally – SL	0.22	0.29	0.59	0.44	0.05	0.00	0.01

** For houses where usage questions were asked – N = 87*

Table 91 shows rare usage by space type and lamp technology. Interestingly each room type had a similar range of responses to frequent long usage (Table 88). The key difference was for separate living areas and low voltage halogen lamps. These had far higher rare use than any other response, indicating that this lamp technology is not used often in this space, possibly because plug fittings are used instead (high compact fluorescent frequent long use may indicate this).

Table 91: Rare Usage by Space Type and Lamp Technology

Average Per House	Incandescent	Mains Voltage Halogen	Low Voltage Halogen	Compact Fluorescent	Linear Fluorescent	LED	Unknown
Rare - SK	0.31	0.03	0.34	0.22	0.01	0.00	0.03
Rare – K/L	0.30	0.07	0.22	0.16	0.07	0.08	0.00
Rare – SL	0.76	0.25	1.05	0.68	0.00	0.09	0.00

** For houses where usage questions were asked – N = 87*

APPENDIX FOUR

Methodology - Field Survey Manuals

Lighting Field Guide – Lamp Fittings (5 pages)

Lighting Field Guide – Lamp Technology (3 pages)

Lighting Field Guide – Lamp Shape (4 pages)

Equipment Energy Efficiency

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