Reducing the Environmental Impact of Hazardous Wastes in the Fire Protection Industry of Australia

An Interactive Qualifying Project submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE in conjunction with Fire Protection Association Australia in partial fulfilment of the requirements for the Degree of Bachelor of Science.

Date: May 1, 2013

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Abstract

This project provides the information and documents needed to help the Fire Protection Association Australia take a leadership role in reducing the environmental impact of hazardous waste generated from routine maintenance of fire protection systems. Our team observed, surveyed, and interviewed representatives from fire protection maintenance companies. We also interviewed suppliers and recyclers of fire protection equipment. An economic analysis was performed to compare current industry practices with recommended best practices. Many companies were not aware of proper disposal methods for batteries and fluorescent tubes. We created two good practice guides and a position statement for FPA Australia to distribute and promote environmental practices within the fire protection industry.

Acknowledgments

We would like to thank the organisations and individuals who helped make this project possible. There were many dedicated efforts on the parts of those involved that we wish to recognise.

First, we would like to thank Scott Williams, CEO of the Fire Protection Association Australia, for serving as our project liaison and sponsoring our project. We appreciate your dedication to making FPA Australia a leader in the environmental movement and are honored to have helped work towards that goal.

We would like to thank all of our co-workers at the FPA Australia building for welcoming us and providing help whenever we needed it. We would like to extend special thanks to Joseph Keller, Julie Spencer, Carlos Santin, Stephanie Viney, and Matthew Wright for your feedback, input, and help with our many questions.

We would like to recognise and thank Russell Porteous for developing the concept of this project and for his passion and dedication to it. We appreciate the groundwork that was laid out for us, and for providing us with avenues to evolve and strengthen the outcome of the project.

We thank the member companies of FPA Australia who took the time to respond to our surveys and participate in our phone interviews, as well as the suppliers and recyclers who took the time to speak with us. The information taken from these interviews and surveys were invaluable to the outcome.

Finally, we would like to extend an enormous thanks to our two project advisors – Professor Holly Ault and Professor Mike Aghajanian. Thank you to Professor Ault for always pushing us to think outside of the box and for remaining constructively critical throughout. Thank you to Professor Aghajanian for helping us appreciate the greater things we will take away from this project and making us realise its potential for powerful influence.

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Executive Summary

There has been ongoing research on the hidden environmental costs associated with the maintenance of fire protection systems in Australia. A main focus has been the waste associated with the importation, extensive use, and sustainable disposal of batteries and florescent tubes from active fire systems such as fire detection and alarm systems, emergency warning systems, fire pump-sets, emergency lights and exit signs. Each year, large quantities of hazardous waste from the regular maintenance of these systems are ending up in landfill. Among the toxins putting the health of humans and the environment at risk are lead, cadmium, corrosive electrolyte solutions, and mercury.

The functionality of fire protection systems is vital to the safety of building occupants, and thus the standards set forth on their maintenance are of equal importance. Australian Standard AS1851 was introduced in 2012 and calls for the regular replacement of batteries and fluorescent tubes from fire protection systems. While this ensures their working condition, it also generates a substantial amount of hazardous waste that must be handled and disposed of properly.

Fire Protection Association Australia (FPA Australia), which serves as the representative body for the fire protection industry, has taken the lead on an industry-wide movement towards environmental and sustainable practices. As stated in the FPA Australia Code of Practice, to which member companies subscribe, “Code Compliant Companies shall apply and promote practices that reduce environmental impacts and contribute to the sustainable use of resources and energy.” The specific goal of reducing the environmental impact of batteries and fluorescent tubes from the regular maintenance of fire protection systems is a priority of FPA Australia. To promote change within the industry and educate members on how to effectively achieve this goal, a position statement and two good practice guides were created that addressed the entire scope of the problem.

The data needed to support the position statement and good practice guide were collected through three methods. Initial information about current practices was obtained through an observation, an online survey, and phone interviews with fire protection maintenance company representatives. An economic analysis of current practices and alternative practices was conducted to examine the costs and benefits associated with each. This information helped determine the practices suggested in our good practice guides. Additionally, a second round of phone interviews was conducted to determine the willingness of the industry to engage in the suggested practices. The completion of data collection resulted in the final writing of the position statement and good practice guides.

The overlying issue is the amount of toxic heavy metals ending up in landfill in Australia. Preliminary research provided conservative estimates for the quantity of lead and mercury found in the environment from the fire protection industry alone. After surveying a representative sample of fire protection maintenance members, an extrapolation of data was done to more accurately quantify the amount of hazardous material. It was found that as much as 380,000 kg of lead, 27,000 kg of potassium hydroxide, 12,000 kg of cadmium, and 3700 kg of lithium hexafluorophosphate enter landfill every year from the improper disposal of batteries from the fire protection maintenance industry. Additionally, as much as 3200g of mercury pollutes the environment yearly from the improper disposal of fluorescent tubes.

The current industry practices of the importation, use, and disposal of batteries and fluorescent tubes provided the data and rationale that exists at the root of the problem. We found that sealed lead acid batteries are the most commonly used type of battery, followed by wet cell lead acid, nickel metal hydride, nickel cadmium, and lithium polymer, respectively. Safe and responsible transportation of these batteries to and from work sites is essential to the worker and client. First and foremost, batteries should always be removed from a work site after replacement. The use of a battery box during transport will prevent spark fires and electrolyte spills. Of the companies surveyed, 90% of them take their battery waste off-site, however only 35% transport with a battery box. From our data, there is widespread awareness of the hazardous nature of batteries within the fire protection maintenance industry. At least 75% of the companies surveyed are aware of the hazards and at least half of companies currently recycle their battery waste.

The lamp choice for emergency lighting and exit signs is mixed within the industry. Fluorescent tubes and light emitting diodes (LEDs) are both used frequently in lighting applications. This shows that the industry is moving from fluorescent tubes to LED technology. There is also a small portion that uses halogen lighting; however, the use of this type of lighting is limited. Of these three types of lighting, only fluorescent tubes contain hazardous waste. Mercury is contained within the tubes and is released as vapour when the tube is broken. Therefore, careful transportation practices must be used to prevent the release of mercury. The hazards of mercury-containing lamps are not well known within the industry. About 53% of companies are not aware that fluorescent tubes contain hazardous material. This contributes to the finding that only two-thirds of companies remove fluorescent tube waste from a site after replacement, and almost none of these companies recycle the fluorescent tubes.

The rationale for not responsibly disposing of hazardous waste was consistent for both batteries and fluorescent tubes. The most common reason was that companies were unaware of proper disposal methods. Second to this was laziness. Other factors cited were cost, inconvenience, not having necessary resources, and lack of awareness. All of these were taken into account in writing the good practice guides. We dealt with these barriers by suggesting practices that would reduce the burden of these factors on a company's handling and disposal processes.

We conducted interviews to gauge the willingness of the industry to engage with environmentally friendly practices. These interviews allowed us to gain insight into day to day procedures and the reasoning behind such procedures. Our results found that maintenance companies spend less than 5% of their time replacing batteries and fluorescent tubes. This means that asking them to change practices associated with this part of their business will not drastically alter their daily routines. Approximately 10% do not take their batteries off-site, but all of these companies said they would be willing to do so. In regards to transportation, 72% of companies did not use battery boxes or packaging sleeves, and only 38% of these companies would be willing to use such safe handling equipment. There appeared to be a lack of understanding of the transportation risks. We addressed this in the good practice guides by explaining the risks and giving informational guidelines on safe transportation techniques. Additionally, approximately have of maintenance companies do not recycle their battery waste, but half would be willing to change their procedure. We found that very few companies recycle fluorescent tubes, but if given the proper resources, 75% would be willing to do so. Companies were enticed to use LED technology to give the customer savings on long term operating costs, and advertise these savings. These interviews also revealed what prompts companies to use environmentally friendly practices. The top recycling incentive that companies identified was that recycling is the best and most environmentally friendly practice. Additionally, other reasons given were convenience, profit from recycling, and advertising benefits. The Australian Battery Recycling Initiative and FluoroCycle are national, government-sponsored organisations that promote the responsible recycling of batteries and fluorescent tubes under the principle of product stewardship. We found that 22% and 8% of companies were aware of the Australian Battery Recycling Initiative and FluoroCycle, respectively. Two-thirds of companies said they would be willing to work with these initiatives to find recyclers and improve their practices.

In order to make recommendations in our good practice guides that benefit the environment, maintenance companies, and their clients, an economic analysis was conducted. The economic analysis consisted of a quantitative data analysis of equipment prices, transportation costs, recycling costs, as well as more intangible factors such as environmental costs and marketing potential. LED lamps last about four times longer than fluorescent tubes, contain no hazardous material, use less energy, and cut down electrical and maintenance costs than fluorescent tubes per year. Switching from fluorescent tubes to LED results in 106 fewer kilograms (a 64% reduction) of carbon dioxide emissions due to the decreased energy usage. Our research showed that companies choose LEDs because it has the potential to save the customer 44% over 10 years compared to fluorescent systems. Maintenance companies can advertise these costs savings to entice companies to utilise their services. Our economic analysis showed that recycling for a typical FPA company only costs $1800 more per year than regular rubbish removal. However, over three-quarters of companies said there were no additional costs associated with recycling their batteries. We found that companies can see up to a 15% increase in revenue by advertising themselves as environmentally friendly. Additionally, member companies often vie for customers in the tender process. In this process, environmental consciousness can account for up to 40% of the selection criteria.

From this assessment, we found four areas of focus which will help fire protection maintenance companies reduce the environmental impact of hazardous waste. These focus areas were transitioning to LED technologies, recycling batteries and fluorescent tubes, safe equipment handling, and using recycling initiatives. While the first logical solution to the problem would be recycling waste, preventative action can be taken by maintenance companies to eliminate the presence of mercury with the use of LED technology instead of fluorescent tubes. Conversely, there are currently no alternatives to batteries used in fire protection systems that pose less of an environmental hazard. The recommended practice for disposal of batteries is responsible recycling through reputable recyclers. This will help eliminate the quantity of heavy metals and corrosive electrolyte solutions entering landfill and reduce the amount of raw material needed to manufacture new products.

Another recommendation is the safe handling and transportation of the equipment. This is to reduce the risk of fires and exposure to corrosive material associated with batteries, and the risk of mercury exposure associated with fluorescent tubes. The final focus is for maintenance companies to utilise current recycling initiatives in Australia, the Australian Battery Recycling Initiative and FluoroCycle, to find reputable recyclers that align with their company’s needs.

The main focus of this project dealt specifically with the environmental impact of batteries and fluorescent tubes. However, it represents only one area where improvements can be made in the fire protection industry's movement towards environmental and sustainable practices. A position statement was written in conjunction with FPA Australia for its member companies to formally recognise their commitment to reducing environmental impacts and the sustainable use of resources and energy. To further incentivise subscribing to the position statement, there are current plans to grant the use of an FPA Australia "Environmentally Friendly" logo to be used in marketing. The logo acts as a way of verifying a company's environmental practices. The two good practice guides, in addition to the position statement, will provide the necessary resources to the maintenance company members of Fire Protection Association Australia to reduce the environmental impacts of their wastes. On a larger scale, these documents will help FPA Australia take a leadership role in driving member companies towards environmental and sustainable practices in all aspects of the industry.

Chapter 1: Introduction

There has been a dynamic global movement towards environmental conservation, sustainability, and remediation over the last half century. Although the environment movement began in the Western world, Australia is now one of the worldwide leaders. In a study of the global environment movement and how it has shaped Australia, Pearson Education Australia concluded that "developments in Australia have featured prominently in the environment movement from the 1960s onwards" (Pearson Education Australia, 2012). The main driving force has been the belief that people need to modify their way of life for a better environment. This includes the strong belief that "business and government should not prioritise profits and economic development at the expense of the environment" (Pearson Education Australia, 2012). In spite of this growing environmental movement, many industries still dispose of hazardous wastes using methods that harm the environment.

The actual extent to which the environment is being poisoned with these toxins is unknown. For instance, the fire protection industry creates hazardous wastes from the regular maintenance of fire protection systems. These wastes come from batteries and fluorescent lighting tubes that are changed periodically, regardless of functionality, because of an Australian Standard, AS1851. These wastes contain hazardous mercury, lead, and cadmium which can leach into the ecosystem and cause many environmental problems, including damage to local food chains and in some cases harm to human populations in and around the affected area. A conservative estimate is that roughly 1000 kg of mercury is wrongfully disposed of in Australian landfills every year from the maintenance of fire protection systems (R. Porteous, personal communication, April 4, 2013). Furthermore, thousands of tonnes of lead and plastic from the batteries and glass and aluminum from the tubes are improperly disposed of in landfill (R. Porteous, personal communication, April 4, 2013). These materials could be recycled into other products rather than placing an added strain on the environment in manufacturing new materials.

There has been a movement in different industries to utilise more environmentally friendly technologies and to recycle the hazardous wastes. Australian companies can join government-sponsored programs such as the Australian Battery Recycling (Australian Battery Recycling Initiative, 2013) or FluoroCycle (FluoroCycle, 2010) to collaborate in their efforts to recycle batteries and fluorescent tubes, respectively. At the present time, the Australian fire protection industry has no coordinated approach to disposal or recycling of hazardous waste, and has not yet established guidelines on environmentally sound procedures for the disposal of hazardous wastes.

This project is intended to help Fire Protection Association (FPA) Australia take a leadership role in reducing the environmental impact of hazardous waste from the fire protection industry. As the educational and representative body for the fire protection industry, FPA Australia promotes proactively working towards a sustainable future. Member companies must abide by the FPA Australia Code of Practice, which states that "Code Compliant Companies shall apply and promote practices that reduce environmental impacts and contribute to the sustainable use of resources and energy". The industry looks to FPA Australia for such directorship and thus their role as the main architect of the movement within the industry is clearly defined. We aim to accomplish this by establishing the current recycling or disposal practices used by the Australian fire protection industry, performing an economic analysis examining environmentally friendly technologies and disposal and recycling methods, identifying reasons for improper disposal of environmentally hazardous waste, determining willingness of fire protection industry personnel/organisations to engage with alternative, more environmentally friendly technologies or strategies, and ultimately establishing good industry practices and an environmental position statement for the proper handling and disposal of hazardous waste.

Chapter 2: Background

The full scope of this project involved many layers, which needed to be uncovered before the overall goal could be fulfilled. The issue at the surface is the amount of hazardous material entering landfill from the fire protection industry alone. This leads to a deeper issue of its harmful effect on the environment. Delving even further into the project are the reasons that hazardous waste is not being disposed of properly and how to combat these. The peeling back of layers began with the organisation capable of initiating change in the fire protection industry, Fire Protection Association Australia.

2.1 Fire Protection Association Australia

Fire Protection Association (FPA) Australia is a non-profit, public organisation which acts as an educational and representative body for the fire protection industry in Australia. FPA Australia provides a central source of information and services to promote the protection of life, property and the environment in Australia. The organisation aims to achieve continual improvement in fire safety through active membership and a range of activities, such as educational workshops, national seminars, conferences, and exhibitions. The organisation provides a large database of technical documents including position statements, information bulletins, technical advisory notes, good practice guides, and reference documents. These documents provide an excellent resource that member companies depend upon to provide up-to-date information regarding the fire protection industry, including information on how to become more environmentally friendly. FPA Australia has a broad membership base which accurately represents the fire safety community. This includes 421 fire protection maintenance companies. These companies specialise in installations and repairs of fire detection & alarm systems, emergency warning systems, fire pump-sets, emergency lights and exit signs (Fire Protection Association Australia, 2013). FPA Australia has recognised that there is no consistent or coordinated approach within the fire protection industry for the responsible and sustained environmental disposal of batteries and fluorescent tubes, and that it is important to take a leadership role to help reduce the environmental impact of these wastes.

2.2 Environmental Impact: Problem and Need for Better Practices

Waste is defined by the *Environmental Protection Act 1970 (Vic)* as "any matter, whether solid, liquid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment in such volume, constituency, or manner as to cause an alteration in the environment" (EPA Victoria, 1970). The fire protection maintenance industry generates a substantial amount of hazardous waste in the form of batteries and fluorescent tubes. Australian Standard AS 1851, imposed on the industry in 2012, is a voluntary standard which states that batteries in fire protection systems should be replaced every two years, and fluorescent tubes be replaced every 2.3 years, both irrespective of working condition (Fire and Rescue Service, 2012).

The batteries that are most commonly used in the fire protection industry which contain hazardous materials are wet cell and sealed lead acid. Lead acid batteries are composed of lead, a plastic casing, and an electrolyte composed of sulfuric acid in water (Jones & Bartlett Learning, 2011). Lead is harmful to both the environment and humans. If lead is leached into the soil it can be taken up into the plant and animal populations in the area. This lead can be passed to humans by eating these lead-carrying plants or animals, and over time can lead to severe brain damage and kidney damage. Long exposure to lead at lower amounts can also be detrimental to a child's development, and in some cases can cause pregnant women to miscarry (Habeck, 2012). Sulfuric acid also poses a serious health risk; thus, lead acid batteries contain approximately 90% hazardous material by weight (Chemtrec, 2012). Sulfuric acid is a corrosive substance that is harmful when contacted, ingested, or inhaled. Skin and eye contact may produce burns, irritation, redness, and blistering. Inhalation may cause shortness of death, difficulty breathing, and in severe cases can cause death. Immediate medical attention is required for all exposure. Chronic exposure to sulfuric acid puts humans at risk for cancer development, and harmful health effects to kidneys, lungs, cardiovascular system, upper respiratory tract, eyes and teeth.

Nickel-cadmium batteries contain hazardous material in the form of the heavy metal cadmium. Nickel-cadmium cells are composed of free cadmium metal (zero oxidation) and an electrolyte solution (May, 2012). The electrolyte solution is comprised of potassium, sodium and lithium hydroxides (Saft, 2007). It is important to note the environmental impacts that may result from the improper disposal of cadmium and potassium hydroxide. Much like lead, cadmium is a toxic metal when taken up from the environment. Cadmium waste enters water streams and mainly ends up in soils. It can infiltrate the food chain and have very negative health effects on humans, including severe kidney damage, bone fracture, infertility, nervous and immune system damage, and cancer development (Lenntech Water Treatment Solutions, 2012). Potassium hydroxide, making up approximately 20% of both nickel cadmium and nickel metal hydride batteries, is extremely harmful if contacted, inhaled, or ingested. Eye contact can result in corneal damage or blindness and skin contact can produce inflammation and blistering. Inhalation can make breathing difficult and in severe cases cause death. Immediate medical attention is required for all types of exposure. Chronic exposure to potassium hydroxide can cause mutations in mammals and organ damage. Nickel cadmium batteries are not as common in the industry and are being gradually phased out by more environmentally safe option that exists in nickel metal hydride batteries. Nickel metal hydride batteries contain nickel and potassium hydroxide and should be carefully recycled as well.

Lithium polymer batteries do not contain any toxic heavy metals but do contain a hazardous electrolyte substance. Lithium polymer batteries contain about 16% lithium hexafluorophosphate by weight (Chemtrec, 2012). It is a corrosive substance when contacted, inhaled, or ingested. Skin and eye contact may cause burns and lithium hexafluorophosphate is very destructive to mucous membranes. Contact, inhalation and ingestion will cause death in extreme cases. Additionally, contact of lithium hexafluorophosphate with metals may generate hydrogen gas, which is extremely flammable.

Fluorescent tubes are composed of phosphor-coated glass tubes which contain argon gas and mercury (Harnden, 2013). Mercury is a potent toxin, causing damage to the brain, kidneys, and gastrointestinal tract. When mercury is improperly disposed, such as being put in a landfill or incinerated with municipal garbage, it is released into the atmosphere in a gaseous form. It eventually settles either on land or in water ways. In either case, mercury is absorbed at the base of food chains, usually by filter feeding organisms. As higher level organisms consume these mercury containing organisms, the mercury content accumulates, such that in each higher level of a food chain, there is a higher concentration of mercury per organism. This amplification of mercury up the food chain has severe impact on higher level organisms such as humans and top level predators. The concentrations of these toxins can become so high that they can be lethal (Okoronkwo, Igwe, &

Okoronkwo, 2007). There are extreme risks associated with the release of these toxins and FPA Australia seeks to educate the fire protection maintenance industry with the creation of good practice guides and environmental position statement to reduce waste and prevent further damage to the environment.

2.3 Equipment Used in the Fire Protection Industry

To begin determining good practices, it is necessary to establish the equipment and practices currently used by the Australian fire protection industry. This information is vital to the project in understanding the severity of the problem and in finding solutions. The fire protection industry is highly regulated and there are specific characteristics required by code for batteries and fluorescent tubes. Control panel batteries require lead acid, nickel metal hydride, nickel-cadmium, or lithium polymer batteries. Water pumps used in these systems also require emergency batteries which are either wet cell or sealed lead acid. The batteries that are used in these systems are within the range of 7 amp hours to 120 amp hours. All of these batteries contain materials that can be recycled and reused but unfortunately lead acid batteries contain very hazardous material (R. Porteous, personal communication, April 4, 2013).

Specific characteristics of the batteries will be used to determine which alternatives are the most environmentally friendly. The practices recommended in the manuals will recognise battery selection, risks associated with batteries used in the industry, and how to properly handle them during their lifecycle. Lead acid, nickel metal hydride, nickel-cadmium, and lithium polymer batteries are all secondary batteries, which are designed to be recharged. Recharged batteries are permitted by code to be used in a variety of applications and many systems have built-in recharging capabilities. Both types of lead acid batteries are used in a variety of applications in the fire protection systems. These include back up power for control panels and alarm systems, fire pumps, and emergency light fixtures. Nickel-cadmium, nickel metal hydride, and lithium polymer batteries are all only used as backup power supplies for emergency lighting. Companies often choose to purchase lower quality batteries because the batteries must be replaced every two years irrespective of working condition (Fire Protection Association Australia, 2013). However, it is important that companies understand the differences in batteries, especially when recharging with the potential risk of overcharging or explosion. Specifics comparing these batteries are displayed in Table 1 below.

Table 1: Comparison of Nickel Metal Hydride, Lead Acid, Lithium Polymer, and Nickel-Cadmium Batteries

	Nickel Metal Hydride	*Lead Acid*	*Lithium Polymer*	*Nickel-Cadmium*
Rechargeable?	Yes	Yes	Yes	Yes
Charge Cycles	400-600	200-1000	400	Up to 3000
Average Self-Discharge (per month)	2%-3%	2%	<1%	7%
Overcharge Protected	No	Yes	No	No
Contains Toxic Material?	Semi-Toxic	Yes	No	Yes

Data provided by (Battery University, 2013; Buchmann, 2001; Isco, 1994; May, 2012; Redline Batteries, 2007; The Exit Light Company, 2013)

Additionally, wet cell and sealed lead acid batteries are very similar, yet there are advantages associated with sealed batteries. Sealed lead acid batteries are much less maintenance-intensive as opposed to wet cell lead acid batteries. There are fewer risks associated with sealed batteries. Wet cell batteries have open vents which emit corrosive gasses during use or charging, these gasses significantly increase the risk of explosion. Unlike sealed lead acid batteries, wet cell lead acid batteries require a cool down period after charging. Sealed batteries are also much easier to transport because there is no risk of spilled acid if tipped.

In regards to exit signs and emergency lighting, fire protection maintenance companies mainly use fluorescent tubes. Fluorescent bulbs have many advantages including low-intensity gas-discharge, high efficiency, low cost, and extensive range of applications (Bulbs.com, 2013). The fire protection industry chooses fluorescent tubes because they are more cost effective and last 10 to 20 times longer in comparison to incandescent bulbs (Diffen, 2013). Fluorescent tubes used in exit signs require regular maintenance and proper disposal to avoid the hazardous contents ending up in landfill (Exit Sign Facts, 2013). With an understanding of the equipment and practices currently used by maintenance companies, FPA Australia can better suggest alternative practices and technologies.

2.4 Alternative Practices: Options and Benefits

There are many options that FPA Australia could use to help reduce the environmental impact of batteries and fluorescent tubes. One option is to utilise proper disposal and recycling methods of these hazardous wastes. Another option is to look into the use of alternative, more environmentally friendly, technologies. If companies took advantage of higher quality batteries, perhaps the Australian Standard could be modified to lengthen the time until replacement is necessary. In regards to fluorescent tubes, alternative technologies, such as LED, tritium, and photoluminescence, may be the most cost effective, practical, and environmentally friendly options.

There are five types of batteries used in the fire protection maintenance industry: wet cell lead acid, sealed lead acid, nickel metal hydride, nickel-cadmium, and lithium polymer. These batteries must be transported to a recycling facility where they are subject to specific disposal procedures. On average, nickel metal hydride batteries are composed of 20% electrolytes by weight, and therefore should be recycled. The recycling process for nickel metal hydride batteries begins by removing the combustible material, such as plastics and insulation using a gas fired thermal oxidiser. The plant's scrubber then eliminates the polluting particles created by a burning process. This leaves the clean cells with their valuable metal content. At this point, the cells are chopped into small pieces and heated until the metal liquefies. Non-metallic substances are burned off. The different alloys settle according to their weights and are skimmed off while in liquid (Battery University, 2013). Many times, the extracted nickel is used for stainless-steel products (Loveday, 2010). Nickel-Cadmium (Ni-Cd) batteries are treated in a similar manner, but in a higher temperature process, which allows for the salvage and reuse of the metal. On average, nickel cadmium batteries are 18% cadmium and 20% potassium hydroxide by weight, and most of the reusable materials from recycled batteries go into making new batteries or stainless steel products (Chemtrec, 2012).

The recycling process for both sealed and wet cell lead acid batteries begins with crushing the batteries, neutralising the acid, and separating the plastic components from the lead. By weight, roughly 70 percent of a typical lead acid battery is reusable lead (Battery University, 2013). The lead is purified and delivered to battery manufacturers and other industries. The plastic is sent to a reprocessor for the manufacturing of new plastic products. Most lead acid batteries contain 60 to 80 percent of recycled lead and plastic (Benivia, 2013).

Similar to nickel metal hydride batteries, lithium polymer batteries contain 16% electrolytes by weight and should be recycled. Also, there is the possibility of a fire if the metallic lithium is exposed to moisture while the cells are corroding. If thrown in a landfill in a charged state, heavy equipment operating on top could crush the cases and expose lithium which would result in a fire. Landfill fires are very difficult to extinguish and can burn for years underground. For proper disposal and to decrease the possibility of these risks, these batteries must be fully discharged in order to consume all lithium content (Buchmann, 2001). Fire protection maintenance companies should follow these, or similar battery recycling and disposal procedures to help reduce the amount of hazardous waste ending up in landfill.

Similar to batteries, fluorescent tubes are processed using specific environmentally friendly recycling procedures. Fluorescent tubes should never be disposed of as regular garbage because they contain mercury. Mercury is within the tube of fluorescent lamps, and resides in liquid form when the tubes are not turned on. When the fluorescent tube is turned on, the mercury is heated into its gaseous state whereby it aids in emitting light. If a fluorescent tube is broken open, the mercury is released into the environment and can cause harm to those in the vicinity (Aucott, 2004). Fluorescent tubes should be recycled and salvaged for materials. SITA, a leading company in sustainable resource recovery management, begins their recycling process with crushing fluorescent tubes and sorting the material. The aluminum from the tube ends is separated and reused in the manufacture of new products. The glass can be recycled into glass wool used for home insulation. The mercury should be distilled from the phosphor powder and can be recycled and used in dental amalgam. Finally, the phosphor powder can be used in fertiliser (SITA, 2013). Fire maintenance companies should engage with recycling services that follow these or similar procedures with their fluorescent tubes to avoid mercury being released into the environment.

The recycling of these products also has profound impact on other areas of the economy and environment. The reuse of the materials from the batteries and fluorescent tubes means that there will be less hazardous material improperly disposed of into the environment, as well as less of a need to mine for raw ore that is used to make these products, therefore limiting the environmental impact of practices that are involved in the gathering of raw materials for the products. It is estimated that recycled lead requires 35% - 40% less energy to repurpose than it does to produce primary lead from ore (GravitaTechnomech, 2012). This can potentially reduce greenhouse gas emissions significantly (Environment Canada, 2009). The recycled glass, plastics, and aluminum from these products also provide materials for new products, and this limits the amount of energy usage and raw material that is needed to produce these new products from raw rather than repurposed material. The recycling of these materials also keeps them out of landfill where they are not able to be naturally broken down.

Fire protection maintenance companies service both exit lighting and emergency lighting systems. The generation of mercury-waste containing lamps is due to these systems, and in the case of emergency lighting systems, harmful battery waste is generated as well. Emergency lighting systems can be made more energy efficient and environmentally friendly by replacing fluorescent tubes with alternative light sources. Much like emergency lighting systems, fluorescent tubes illuminate many of the current exit signs installed and maintained by fire protection maintenance companies. The current market for exit signs has been trending away from fluorescent tubes and various other options are offered in their place. This includes light emitting diode (LED), photoluminescence, and tritium as alternative options.

LED emergency lighting systems are cost and energy efficient and meet the safety requirements set forth by Australian fire code standards. LEDs use approximately one-third the energy and last approximately 4 times longer than fluorescent tubes (Ballad, 2013). This can significantly decrease energy use, as well as eliminate the use of the mercury-containing fluorescent tubes. Depending on the type of LED used, there is a small potential for creating hazardous waste. Low intensity red LEDs exceed the limit for what is considered a toxic amount of lead when left in landfill. However, white LEDs which are used in most lighting applications, do not contain enough toxic heavy metal to be considered hazardous (Scheer & Moss, 2012). Also when considering the lengthy service life of LEDs, the risk of hazardous material ending up in landfill is further minimised. LED exit lights are more efficient and pose less of an environmental risk than the fluorescent lights that exist, providing an easy option for replacement.

Perhaps the most innovative exit lighting alternative on the market is photoluminescence. Photoluminescent exit signs are a new, non-electrical technology that is opening up many new possibilities for the industry. They are most effective in buildings that are lit during business hours, such as in offices, hotels, schools, and retail stores, as they “illuminate by absorbing light emitted from regular light sources, such as incandescent, halogen, and fluorescent [lighting]” (Exit Store, 2013). They usually glow for about 90 minutes in darkness, if the power inside a building were to go out. Photoluminescent signs are officially certified for the UL 924 Standard in the United States and Canada, which certifies them to the same standard as electrical exit signs.

Another non-electrical alternative to fluorescent exit lighting uses a type of hydrogen gas called tritium. Tritium lighting relies on radioluminescence to illuminate, making them self-sufficient and not reliant on any power source. This means that there is no power consumption and no maintenance required over the lifespan of a tritium exit light, which can be up to 20 years (Exit Store, 2013). Tritium lighting works similarly to fluorescent lighting, in the fact that the lamp is composed of a phosphor coated glass tube. The main difference is that instead of requiring electricity to excite argon gas and mercury vapor, which in turn stimulates the phosphor causing the emission of light, the energy emitted by the radioactive decay of the tritium is enough to stimulate the phosphor (Exit Store, 2013). Tritium “meets the requirements of the NFPA Life Safety Code 101”, making it a viable option for alternative exit lighting (The Exit Light Company, 2013). Tritium is a low energy emitting radioactive substance, and when compared to normally occurring potassium found in the body, radiation from the potassium is roughly a thousand times more damaging to the body than tritium at comparable doses (Dingwall, Mills, Phan, & Taylor, 2011). Tritium is normally found at low doses in drinking water, however the health effects of higher doses remains unclear (Dingwall et al., 2011). Like any other radioactive material, tritium lighting signs should be properly disposed of, to prevent the leaching of tritium from landfills into the water supply. “To dispose of a sign properly, a general licensee must transfer the sign to a specific licensee—such as a manufacturer, distributor, licensed radioactive waste broker, or licensed low-level radioactive waste disposal facility” (Nuclear Regulatory Commission, 2012). It is also a possibility that the sign may become severely damaged to the point where the tritium gas escapes. This could potentially cause harm to humans in the direct area, however it would be quickly dispersed by the wind or ventilation and would only pose a threat for a very short period of time, with less than 1% being retained for more than a minute, however the damaged sign should be handle as a radioactive material (Idaho State University, 2013).

LED, photoluminescence, and tritium all have the potential to replace fluorescent bulbs as the lighting source for the fire protection maintenance industry. Along with their feasibility, they come with various advantages and disadvantages. It would be beneficial to replace existing fluorescent systems with LED ones. Purchasing all new exit lighting could prove costly, however, there is the option to retrofit fluorescent lighting which will lead to significant energy and bulb replacement savings (The Exit Light Company, 2013). The non-electrical alternatives would prove even easier for implementing in any location. Photoluminescent and tritium signs could be easily installed, without the need for electrical work. A comparison of the exit sign alternative technologies is represented below in Table 2.

Table 2: Economic Analysis of Various Exit Sign Systems

	Fluorescence	*Photoluminescence*	*Tritium*	*LED*
Maintenance Requirements	Moderate	None	Low	Low
Lifespan	20-25 years	25+ years	20 years	20-25 years
Disposal Hazards	Mercury	None	Radioactive Tritium, requires special disposal	None
Available for Retrofit	No	No	No	Yes
Meet Code Requirements	Yes	No	Yes	Yes

Data provided by (Exit Sign Facts, 2013) and (O'Connell, 2006).

FPA Australia member companies can also collaborate on their recycling efforts through existing national initiatives that facilitate proper disposal and recycling practices in accordance with product stewardship. Product stewardship is defined by the United States Environmental Protection Agency as “a product-centered approach to environmental protection [calling] on those in the product lifecycle—manufacturers, retailers, users, and disposers—to share responsibility for reducing the environmental impacts of products” (United States Environmental Protection Agency, 1997). The Lighting Council of Australia and the Council of Australian Government (COAG) have teamed together to create “a voluntary scheme that aims to reduce the amount of mercury entering the environment from the disposal of waste mercury-containing lighting,” known as FluoroCycle (FluoroCycle, 2010). This scheme is specifically aimed at commercial industries, which are partially to blame for the 95% of mercury-containing lamps that end up in Australian landfill (FluoroCycle, 2010). FluoroCycle has recognised that Australia has sufficient capacity to recycle all of its waste lamps that contain mercury. The FluoroCycle Outreach Strategy is a program that builds networks in the supply and disposal chains (FluoroCycle, 2010). This gives companies the opportunity to work together to dispose of fluorescent tubes. Fire protection maintenance companies may choose to use FluoroCycle, at no cost, to gain access to service providers who can make appropriate arrangements for collection and recycling of used fluorescent tubes.

Similar to the FluoroCycle Outreach Strategy, the Australian Battery Recycling Initiative (ABRI) provides an opportunity for members to collaborate on collectively achieving effective battery stewardship. ABRI is an organisation "formed by a group of battery manufacturers, recyclers, retailers, government bodies and environment groups to promote the collection, recycling and safe disposal of all batteries" (Australian Battery Recycling Initiative, 2013). Fire protection maintenance companies can utilise ABRI to find reputable recyclers to handle their battery waste. These collaborations provide a great opportunity for the fire protection industry to work together with other industries and the Australian government in achieving product stewardship. The idea of product stewardship opens up many possible avenues for reform in reducing the number of batteries and fluorescent tubes that end up in landfill.

While the batteries and fluorescent tubes are being replaced irrespective of working condition, the possibility of a resale market for this equipment is unlikely. The service life left in batteries cannot be determined and thus the uncertainty makes resale too risky. Current testing equipment for batteries can measure the voltage drop and give a rough indication of battery health. "Capacity estimation, however, is not possible" due to the complicated chemistry that makes up a battery (Battery University, 2013). Additionally, the life left in fluorescent tubes is uncertain when they are replaced and they are usually towards the end of their service life when replaced at the 2.3 year mark, as set forth by the AS1851 standard.

The environmental benefits of better practices within the fire protection industry are evident. What is not so evident is the strong marketing potential in the environment movement. While there is thought to be a risk of financial burden in becoming an environmentally friendly business, there is the stronger potential for a lucrative return on investment. The Australian Competition and Consumer Commission has developed guidelines on green marketing because of its growing impact on industry. "Environmental claims can be a powerful marketing tool. Companies are increasingly using environmental claims in an attempt to differentiate themselves and their products from the competition" (Australian Competition and Consumer Commission, 2011). If marketed correctly, fire protection maintenance companies can help both the environment and their business.

Researcher Nicole Darnall conducted a study on how corporations can profit from being environmentally friendly. Research has found that "15 percent of consumers routinely pay more for green products" (Laskowski & Darnall, 2012). This extends to corporate buyers as well. For the fire protection industry, this research suggests that fire maintenance companies can benefit from environmentally friendly practices. They can then market their promise to responsibly dispose of materials to the businesses they serve. What was once thought of as a "win-lose proposition", now has research to claim it as a win-win. "Companies that develop greener production practices benefit society, and can also green their bottom line" (Laskowski & Darnall, 2012).

An economic analysis needed to be performed to accurately weigh the options and benefits of the alternative practices suggested. The options within an economic analysis are analysed for two main features: the costs and benefits compared in monetary terms, and how the costs and benefits are of value to the community in question (Commonwealth of Australia, 2006). Therefore, it takes into account every aspect of the options that can be quantified, as well as the supporting information that cannot. The environment is an example of an area where the economic analysis method has been usefully applied (Commonwealth of Australia, 2006). An economic analysis provided vital data in comparing the current practices and potential alternative practices.

2.5 Summary

Member companies rely on FPA Australia to be a leader in the fire protection industry. FPA Australia wants to continue being a dependable resource to provide up-to-date information, including how to become more environmentally friendly. Currently, Australia is working towards reducing the amount of hazardous waste in landfill and reusing many of the resources being dumped in landfill. At this time, there are no coordinated or consistent approaches within the fire protection industry for the responsible and sustained environmental disposal or recycling of batteries and fluorescent tubes. This presents an opportunity for FPA Australia to recommend good practices to their member companies.

This project determined what practices are currently used for disposal of hazardous wastes in the fire protection industry and identified environmentally friendly substitute strategies. The environmental position statement created the framework for good disposal practices of hazardous waste from the fire protection maintenance industry. Additionally, the good practice guides served as a reference document for the fire protection maintenance community to understand and carry out proper handling and disposal procedures of batteries and fluorescent tubes. There are numerous ways to recycle batteries and fluorescent tubes, yet many companies do not follow these recycling procedures. It was necessary to determine some of the reasons companies are not properly handling hazardous waste. In addition, the economic analysis examined environmentally friendly technologies and disposal and recycling methods. FPA Australia has a wide variety of member companies across the fire protection industry. Using these companies as a resource, this project assessed whether fire protection industry companies would be willing to engage in alternative, more environmentally friendly, technologies or strategies. This research concluded with the creation of the deliverables: an environmental position statement on the safe handling and disposal of hazardous waste, and good practice guides to reduce the environmental impact of batteries and fluorescent tubes.

Chapter 3: Methodology

This project was intended to reduce the environmental impact of fire protection maintenance companies by providing a general environmental position statement for hazardous waste from the fire protection industry and good practice guides, specifically for the reduction of hazardous waste from batteries and fluorescent tubes. We accomplished this goal by achieving a number of pertinent objectives. First, we established the current industry practices in an effort to determine what Australian fire protection maintenance companies were currently doing with their hazardous waste products. Second, and in congruence with the first objective, we identified the reasons for improper practices to determine if there was a trend as to why companies were not disposing of the hazardous wastes in an environmentally friendly way. Third, we performed an economic analysis on new, environmentally friendly technologies and disposal techniques to determine the feasibility of the changes we recommended. Fourth, we examined the willingness of industry personnel/organisations to engage with alternative, more environmentally friendly technologies, or disposal and recycling practices. Finally, we established the good industry practices, and provided an environmental position statement and good practice guides for those companies who wished to take a leadership role in reducing the environmental impact of their hazardous wastes. The methods we used to achieve our project objectives are illustrated in Figure 1.

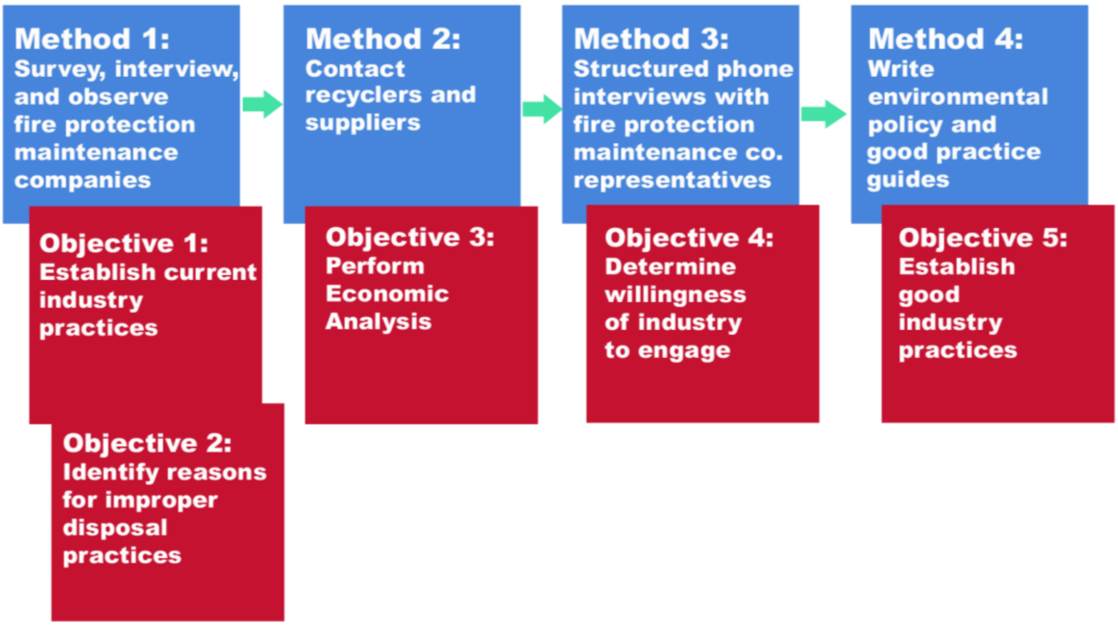

Figure 1: Overview of Methodology

3.1 Establish Current Industry Practices

Our first method was to observe, conduct interviews, and send online surveys to fire protection maintenance companies. The observation, interviews and surveys were designed to:

- Establish the current recycling or disposal practices used by the Australian fire protection industry
- Identify reasons for improper disposal of environmentally hazardous waste.

First we piloted our survey by sending it to 20 companies and conducting 10 phone interviews. After the surveys were sent out, we conducted 10 interviews in addition to the interviews we had conducted before the survey. The interviews allowed us to have a discussion with member company representatives to discover more specific and detailed information about their current practices. Our sampling frame was all of the FPA Australia member companies. In order to choose a realistic number of company representatives to interview, we randomly selected 20 representative individuals. We decided that 20 companies was a reasonable sample size because after conducting that many interviews we found that the responses were becoming very repetitive and that we were not learning any additional, new information. FPA Australia provided us with contact information and suggestions of member company representatives to interview. At the beginning of the interviews, we read a consent statement to grant confidentiality and to explain that the purpose of these interviews was to help us create an environmental position statement and good practice guides, which FPA Australia plans to distribute. We explained that the participant could stop the interview at any time, and could choose not to answer any questions. At the end of each interview we asked if the company representative would like to remove any of their given answers or if they would like to submit their answers in full. See Appendix A for interview questions.

Many of the fire protection industry’s current practices were not readily available without speaking with a company representative. Interviews allowed us to uncover many company specifics; such as if they used nickel metal hydride, nickel cadmium, wet cell lead acid, sealed lead acid, or lithium polymer batteries, or some combination of the five for their fire protection products. We asked, on average, how often batteries and fluorescent tubes were replaced, and used that information to estimate number of batteries and tubes that were being replaced and disposed of. We also asked what the company did with the replaced products and what their recycling or disposal procedures were for this waste. Even though we granted the companies confidentiality, some companies preferred not to disclose the information.

After completing the first 10 interviews and minor modifications, we sent an online Google survey to 359 of the FPA Australia’s fire protection maintenance companies. Although there are total of 421 maintenance companies, we did not send the survey to 62 companies who did not fit our profile or had already participated in a phone interview. We were given access to these company representatives’ email addresses through FPA Australia. The initial interviews and pretest survey allowed us to refine our questions and answer choices. These surveys were conducted anonymously. Anonymity was very important because company representatives were able to answer more honestly, knowing their identity remained unknown, and that any information disclosed would not be used against them. Similar to the interviews, we included a consent statement at the beginning of the survey explaining our investigation, that the survey was completely voluntary, that the participants did not need to answer every question and that their identity would remain anonymous. We explained that the participant could exit the survey at any time, and their results would not be recorded. At the end of the survey, we asked for their final consent to submit the survey and record their answers. The questions focused on quantifying the hazardous waste problem and addressed how many batteries and fluorescent tubes companies replaced weekly and how they were handled upon replacement. The survey also included a question about who the company utilised when recycling and disposing, and who supplied the company with products. The contacts we acquired from those questions were used in our second method. At the end of the survey we included our team’s email address and a link to another Google form regarding follow up phone interviews. If company representatives were willing to participate in a phone interview, they filled out a Google form with their contact information and we contacted them. This separate Google form maintained the anonymity of the participant, because their contact information was not linked to their survey answers. See Appendix B for survey questions.

Additionally, we observed a service technician from one of the FPA member companies. Our observations allowed us to gain deeper insight into the fire protection maintenance industry, and understand the current equipment and practices used. We observed a monthly fire alarm test at a hospital in Victoria. During our visit, the maintenance technician tested 10 fire panels, and we observed the process and safety procedures that he must follow. See Figure 2. We were able to see the paperwork that is filled out for each safety check, the type of batteries in the system and their date of installation. Although there were no system problems during our visit, we asked what procedures would be used if a battery failed or a detector was faulty. We took note of the exit signs and emergency lighting used throughout the hospital, and if the systems were LED or fluorescent. We were able to use the service technician's work experience to collect his opinion on which batteries were the highest quality and lasted longer, as well as other environmental issues he notices in his job. He noted potential areas for improvement including sprinkler system problems, alarm and buzzers test, aerosol smoke used to test detectors, and water wasted during flow tests. Overall, this observation provided valuable information to supplement the data from our interviews and surveys and give a more complete understanding of the fire protection maintenance industry.

Figure 2: Fire Panel Battery Testing

3.2 Identify Reasons for Improper Disposal Practices

Our second objective in these interviews was to identify reasons for improper disposal of environmentally hazardous waste. Rather than directing our questions at their company specifically, we asked general questions about the practices within the industry. This approach reduced the tendency to become defensive and removed the motivation to mislead us if they were not following environmentally friendly practices within their company. See Appendix B for questions. All of the companies were treated the same way regardless of their responses. We discussed whether they believed that improper behaviour was driven by financial reasons or other factors. We analysed the data by looking at the most common reasons for the improper disposal. These interviews provided vital data about the rationale behind current practices and the reasoning behind various companies' disposal and recycling practices.

3.3 Perform Economic Analysis

The third objective of this project was to perform an economic analysis on the current and alternative technologies or disposal and recycling techniques. We utilised all of the relevant information previously collected in this study. We also conducted phone interviews with recycling facility representatives. These interviews gathered relevant costs of implementing new strategies and technologies. We also contacted Australian suppliers of batteries, exit signs, and replacement lamps as well as browsed these supplier's web catalogs to gather pricing information on the currently used technologies, as well as the alternative technologies we suggested. See Appendix C through F for questions.

When interviewing recycling companies, we interviewed five battery recycling companies, four fluorescent tube recyclers, and one company that recycles both batteries and fluorescent tubes. See Appendix G for a complete list of companies. We found these recyclers both from our survey responses and our own online research. In these interviews we acquired a variety of information that we could use in the economic analysis. We asked if there were costs associated with dropping of hazardous waste at their facility and the costs associated with a transportation service, if they had one. We asked about the processes the companies uses to recycle their batteries, and on average, what percent of their batteries are recycled (by weight). We also asked about the process of recycling fluorescent tubes. We asked if the recycler had heard of ABRI and/or FluoroCycle, and if they were members. The information collected from the recyclers was useful for costs in the economic analysis, and to help us learn more about reputable recycling companies' procedures, which we would ultimately use in our good practice guides.

Additionally, we specifically contacted representatives from ABRI and FluoroCycle, as these were two recycling initiatives already in place, and we identified the possibility of cooperation between these organisations and FPA Australia or its member companies. There is no cost associated with utilising these organisations. These phone calls were in an effort to determine if partnering with programs that were already established would make recycling more accessible or supply companies with greater information on reputable companies to utilise in the recycling processes.

We also collected prices of fire protection equipment from a total of 26 suppliers. These suppliers were a mixture of contacts we received from our interviews and surveys as well as companies we found from our own research. We emailed these suppliers, as well as searched their website to find pricing information for a variety of fire protection equipment, including emergency exit signs, emergency lighting, replacement bulbs, and replacement battery packs. See Appendix H for a detailed list of suppliers.

Once we gathered all of the necessary information from the interviews, we conducted the economic analysis, taking into consideration all of the costs and benefits from each current and alternative strategy.

- Costs of new and current technologies in regards to initial costs as well as the total cost of ownership, which covers all of the long term costs and the savings that could be obtained from the possibility of using better products with longer service lives
- Environmental costs of current disposal practices, including both environmental and health costs, which were laid out in a more qualitative manner as we were unable to quantify these intangible values
- Costs of current disposal practices versus the costs of new recommended recycling practices
- Benefits of new strategies over the current practices. These benefits were more intangible than monetary and therefore were laid out in a purely qualitative manner. However, marketability was able to be quantified.

Throughout the economic analysis, we identified who the costs and benefits impacted. We identified when the service or equipment cost would be passed from the maintenance company onto the customer. We identified who the costs affected by talking to representatives from fire protection maintenance companies. We utilised the economic analysis in an effort to clearly establish good practice guides based on the greatest ratio of benefits to costs for the maintenance companies. Below in Table 3 were the variables we used to create the economic analysis, with a comparison between current and alternative practices.

Table 3: Economic Analysis of Current and Alternative Practices

Input Category	
Current practices costs	*Benefits*
Lamps	Environmental/Health
Fluorescent Replacement Tubes	Convenience
Fluorescent Exit Signs	Marketability
Fluorescent Emergency Lights	Membership
Batteries	FluoroCycle
Nickel-Cadmium	ABRI
Disposal	
Pick Up	
Alternative practices costs	
Lamps	
LED Replacement Lamps	
LED Exit Signs	
LED Emergency Lights	
Tritium Exit Signs	
Photoluminescent Exit Signs	
Batteries	
Nickel Metal Hydride	
Recycling	
Pick Up	
Self-Drop Off	

Table 3: Variables included in economic analysis of current and alternative practices.

3.4 Determine Willingness of Industry to Engage with Alternative Technologies and Strategies

After the economic analysis was completed, we determined the willingness of fire protection industry personnel and organisations to engage with alternative, more environmentally friendly, technologies or strategies. We conducted phone interviews with fire maintenance company representatives from across Australia. We contacted 19 randomly selected companies and found that many of the responses fell into a pattern. Therefore, we felt as though we had collected a sufficient sample. In these interviews, we asked a variety of questions about the maintenance companies' day to day practices, along with the cost associated with these practices, and whether or not they would be willing to alter their practices. We asked what percentage of a typical service personnel's day is spent replacing batteries and fluorescent tubes. This allowed us to gauge how much of the business is based on maintenance of related fire protection systems. If the companies did not recycle or use safe transportation procedures, we asked if they would be willing to do so. In order to better understand the reasoning behind companies' procedures, we asked what prompts companies to recycle or use LED technology. Identifying the reasoning behind companies' environmentally friendly practices will help us to entice other companies to also be environmentally friendly. We asked if companies would be incentivised to follow good practices if FPA Australia endorsed an environmentally friendly logo for companies to use. We also noted how many companies from our sample said they would be willing to work with recycling initiatives such as ABRI and FluoroCycle. See Appendix J for a complete list of interview questions.

These interviews were considered in the writing of our good practice manuals. We believed that guides incorporating the willingness and input of maintenance companies would be more effective than ones based solely on good practices. The good practices must be financially sustainable within the industry and positively impact both the environment and, if possible, the company.

3.5 Create Environmental Position Statement & Good Practice Guides

In an effort to complement and strengthen the effectiveness of our good practice manuals, we created an environmental position statement regarding environmental and sustainable practices within the fire protection industry. The current Code of Practice for FPA Australia does not provide detailed expectations for member companies in regards to using environmentally friendly practices. Therefore, this environmental position statement was created to provide the framework for good practices in all aspects of the industry. We worked with FPA Australia to provide an endorsement for companies subscribing to the position statement. The idea was to use the position statement to educate companies, hold them accountable to the Code of Practice, and provide incentive for following it. As incentive for complying with the position statement, we provided a logo, endorsed by FPA Australia, which allowed companies to promote their environmental credentials. Environmentally friendly practices are becoming increasingly more marketable and the FPA Australia sponsored logo was created to benefit both the environment and fire protection maintenance companies.

For a detailed reference to be used by the fire protection industry, and to professionally display our results to FPA Australia, two good practice manuals were written. These manuals outlined what we deemed to be the most appropriate solutions to help reduce the environmental impact of hazardous waste from the fire protection industry. Good practices must be financially sustainable within the industry, positively impact the environment and positively impact the company that chooses to commit to them. Therefore, we used our previous research to outline our recommendations. We interpreted the data collected from various disposal and recycling facilities, and alternative technology suppliers in order to determine the criteria for practices that fit within companies' financial limitations. We also factored in the qualitative information from interviews to determine the willingness of companies to implement our recommendations. We reviewed current industry practices to see if any aligned with what we considered a good practice. When determining good practices, we looked to overcome barriers within the industry that had previously prevented companies from reducing the environmental impact of their wastes.

The writing of the good practice manuals was done to professional standards, in collaboration with FPA Australia. The manuals were written with the intention of providing an informative and easily understood document. It was also intended to provide enough information for a company to understand the implication of their workplace decisions from purchase, to installation, to removal, and finally disposal of a product. The creation of these deliverables provided all the necessary educational materials, as well as incentives to influence companies' practices and reduce the environmental impact of their wastes.

Chapter 4: Results and Analysis

Data collection became an integral part of not only determining the full scope of the project, but also in developing the recommended practices. Much of the information was gathered through our phone interviews, online survey and economic analysis. A large portion of the data collected was numerical and could be analysed graphically or through calculations. There was, however, much intangible data that required a more in depth analysis to extract rationale and relevant conclusions. From the numerical data, we were able to determine a more accurate scope of the problem, as well as environmental and financial costs related to different practices. Alternately, the intangible data allowed us to generate a clearer picture of current industry practices and possible solutions. All results were taken into consideration for the development of our deliverables and helped us reach the ultimate end goal of the project.

4.1 Battery Information

The interviews and surveys provided a great deal of valuable information in determining the current equipment and practices used in the fire protection industry, as well as the reasons for improper disposal. We conducted 20 interviews, received 45 responses from our survey, and observed one service technician from a fire protection maintenance company. Our research showed that sealed lead acid batteries are the most commonly used in the industry, followed by wet cell lead acid batteries. Both wet cell and sealed lead acid batteries contain about 70% lead. The prevalent use of lead-based batteries provides evidence for how much lead is disposed of by the fire protection industry and the subsequent associated risk. Figure 3 shows the percentage of companies from the survey that uses each specific type of battery.

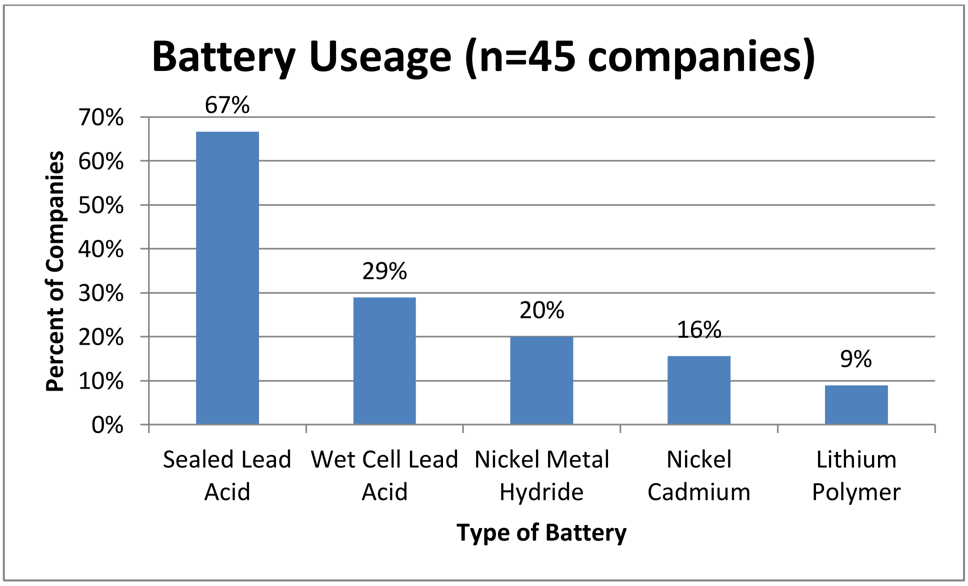

Figure 3: Battery Usage by type for FPA member companies

In the survey, along with determining the types of batteries used, we also inquired about the quantity of batteries (in kilograms) replaced per week and the companies' methods for disposal. We found that disposal method differed slightly depending on size of company and type of battery, so our extrapolation was broken down accordingly in order to most accurately estimate the extent of the problem. The distribution of size of companies in our survey sample was similar to the distribution of the population of FPA Australia's 421 maintenance member companies. See Appendix

K for full explanation of extrapolation. We deduced the amount of hazardous material which ends up in landfill every year based on the weight percent of hazardous material for each type of battery and the percentage of companies that dispose of their waste at the tip. The toxins include both electrolyte solutions as well as any heavy metals present. It is unknown whether the hazardous waste is disposed of in landfill if the waste is collected by a third party or left with the customer to dispose. See Figure 4. The data from this and graph further support that large quantities of lead and other heavy metals are ending up in landfill from the fire protection maintenance industry alone.

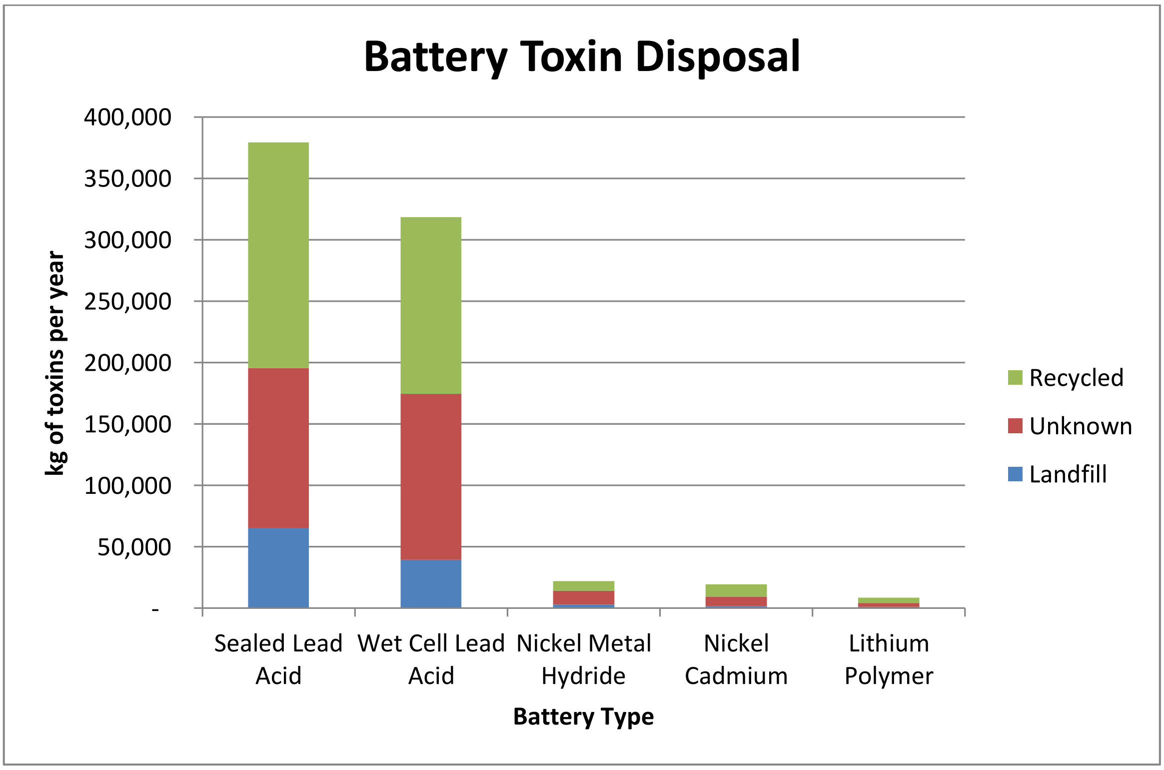

Figure 4: Battery Toxin Disposal

Using the same extrapolation technique, we were able to estimate the number of fluorescent tubes and the amount of mercury disposed in landfill per year by the 421 fire protection maintenance companies. On average, there is 9mg of mercury in each fluorescent tube, however the amount of mercury in each tube can range from 3.5mg to 15mg, so we included a range of the amount of mercury disposed of in landfill per year. We estimate that roughly 230,000 tubes are replaced by fire protection maintenance companies per year, and that at least 140,000 of these tubes are disposed of in landfill. Approximately 70,000 additional tubes are left with the customer or collected by a third party and thus the disposal methods for these tubes are unknown. We estimate that between 500 and 3200 grams of mercury are released to the environment each year. The low end of this range assumes customers and third party collectors properly dispose of fluorescent tubes, and that there is only 3.5 mg of mercury per tube. The high end of the range assumes there is 15mg of mercury per tube and that the customer and third party collector improperly dispose of fluorescent tubes.

The Australian Standard AS 1851 states that batteries in fire protection systems should be replaced every two years, and fluorescent tubes be replaced every 2.3 years. During our interviews, we asked companies their frequency of replacement for batteries and their estimated service life of the batteries. The results of these questions are shown in Figure 5 below. We found that for the 20 companies we interviewed, on average, they replace batteries every 2.35 years, and they believe that batteries last about 2.6 years. The survey also asked how often companies replaced their batteries, and the 45 responses averaged every 2.08 years. During our observation, we saw many batteries with a large range of installation dates. The batteries we saw were installed between 2005 to September 2011. The maintenance technician we observed was not aware of the standard, and said there was no purpose in replacing the batteries that frequently because the batteries are still passing the maintenance tests, and last much longer than two years. Our survey, interview, and observation showed that, on average, companies are replacing their batteries less frequently than the standard states. This could be due to the fact that AS 1851 was recently modified in 2012, so many companies are not fully aware of the standard. Also, the standard is only mandatory in the Australian Capital Territory, New South Wales, and Western Australia. The other states either have restrictions on the standard depending on the age of the building or the standard is not recognised at all. See Appendix M for a more detailed description of the use of AS 1851-2012.

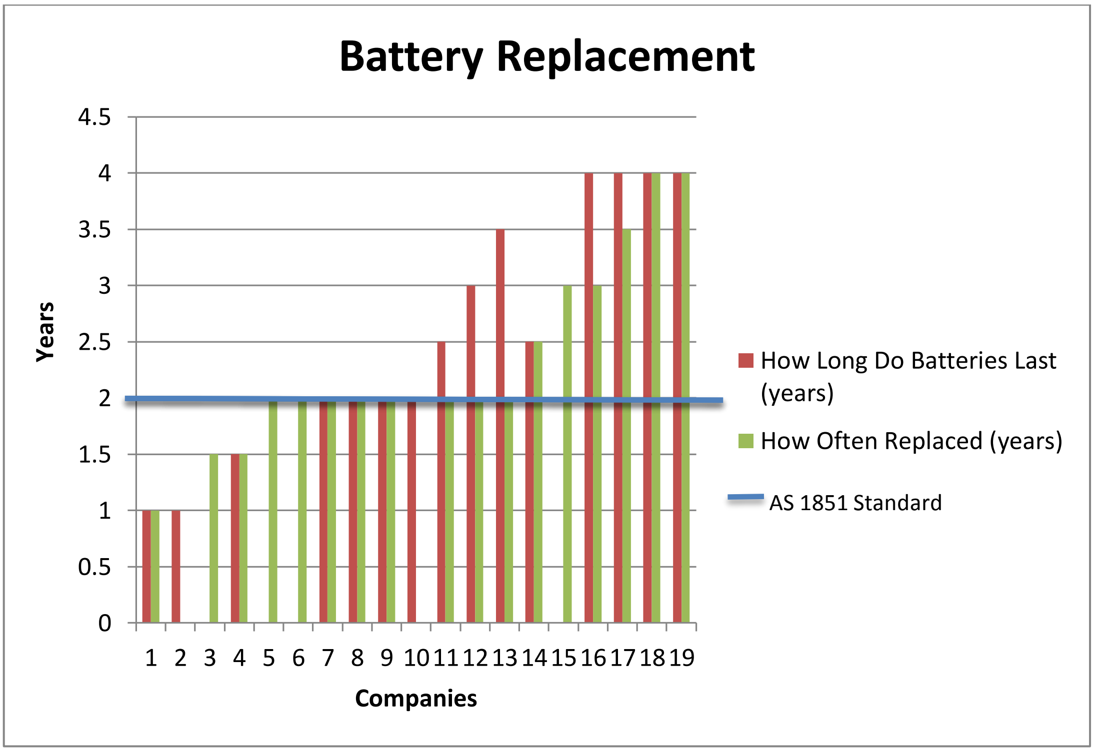

Figure 5: Battery Replacement Frequency

The best way to accomplish a reduction in the hazardous waste ending up in landfill is through recycling. A main area of focus in our good practice guides is the responsible recycling of these wastes through an accredited recycler. There are currently no alternatives to the batteries used in fire protection systems that pose less of a hazard. Therefore recycling is the best practice for handling battery waste. While fluorescent tubes can be replaced by more environmentally friendly technology, if they are to be used and replaced then the best way to manage the waste is also through recycling. During our observation, we saw a recycling bin that was not properly managed. The recycling bin was filled with water which increases the risk of fire and hazardous material leaching into the environment. See Figure 6.

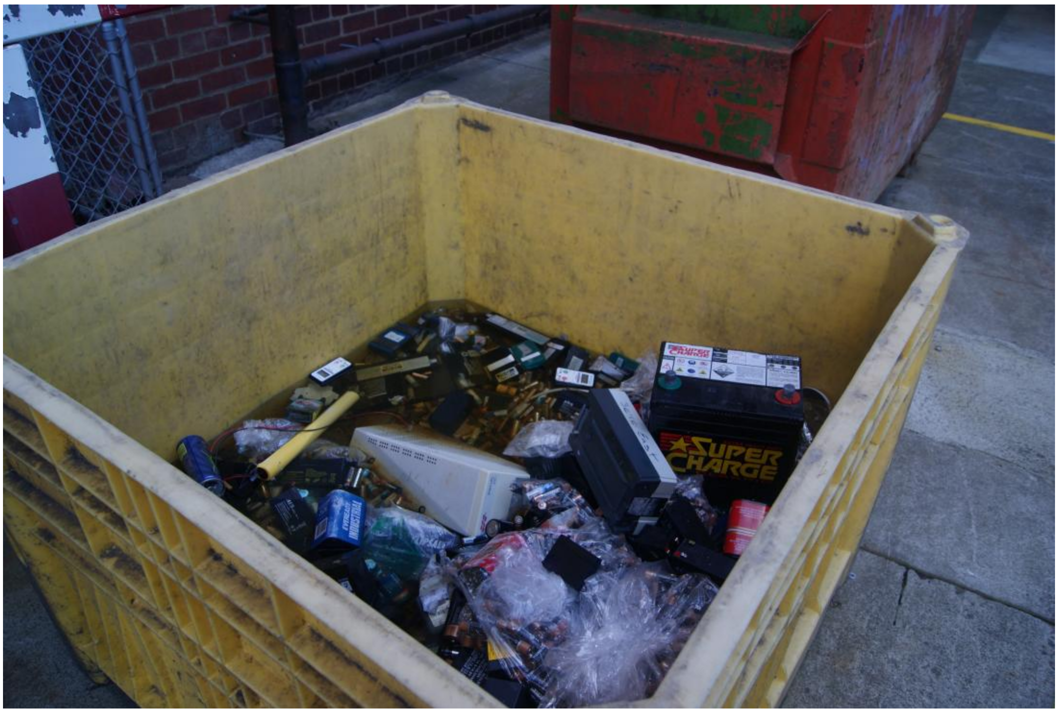

Figure 6: Observed Improper Battery Handling

An important part of the industry's current practices is the transportation of waste off-site. Only 10% of the companies we interviewed did not transport their batteries off site. However, only 35% of companies that do transport batteries off site use a specialised battery box. Although no batteries were replaced during our observation, we asked the service technician about his company's practices for doing so. They always take their battery waste off site and transport it using a battery box. Safe handling procedures must be used for batteries during transportation because improper battery packaging can potentially start a fire, cause environmental damage through spills, or cause health problems for people in the vicinity. Therefore our good practice guide is written to educate member companies on the safety risks associated with transportation of batteries. Specifically, it details how to avoid fires and explosions during the recharging of batteries, and fire and electrolyte spills during transportation.

Safe battery transportation, from installation to disposal, is very important due to the hazardous material within the batteries. In our interviews, we asked companies if they think most other companies are aware that batteries contain hazardous material such as lead, cadmium, and other heavy metals. From their responses, we estimate that 75% of the industry is aware of the hazardous nature of batteries.

4.2 Lighting Information

In the interviews, we asked company representatives the types of exit and emergency lighting that they used. Our interview sample found the overall industry trend for LED lamps to replace fluorescents. See Figure 7. Also, there were only 2 companies who used halogen lamps, and these were used in conjunction with fluorescent tubes and LED lighting. At the hospital, we saw a mixture of LED and fluorescent tube exit and emergency lighting. However, we found that companies did not switch to LEDs because they are more environmentally friendly, instead because they are more cost effective and require less frequent replacement. On average, from our 20 interviews, fluorescent tubes are replaced every 1.49 years, which is more frequently than AS 1851 states. AS 1851 prescribes that fluorescent tubes should be replaced every 2.3 years. However, during our interviews, companies informed us that companies are replacing fluorescent tubes when they no longer function, and that the tubes tend not to last as long as 2.3 years. See Figure 8 for a breakdown of fluorescent tube replacement time. Company representatives were not sure how often LEDs would be replaced, on average, because LED technology is new for the industry. However, LEDs are proven to have a longer service life than fluorescent tubes. For these reasons, we have suggested an industry-wide transition from fluorescent tubes to LED lighting in all emergency lighting and exit light applications.

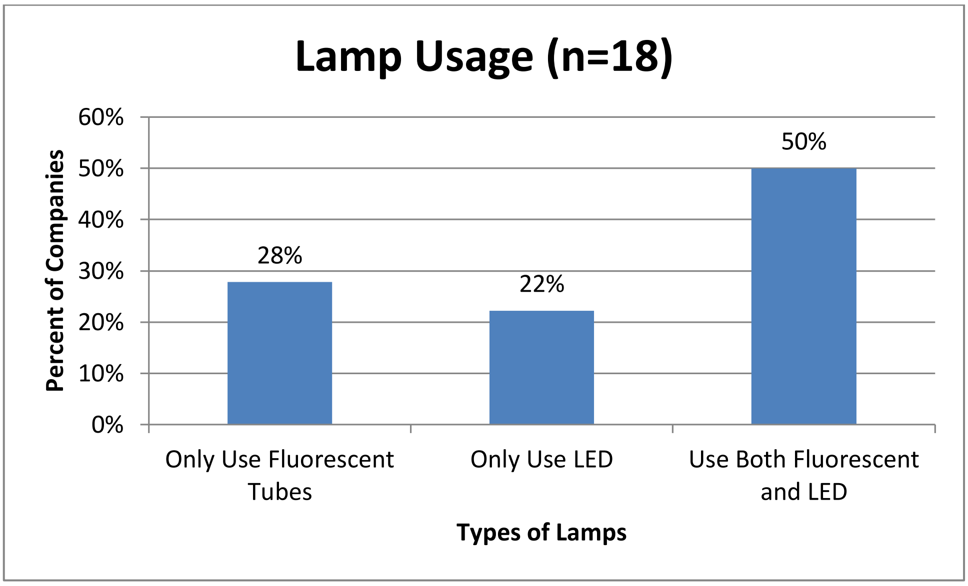

Figure 7: Lamp Usage

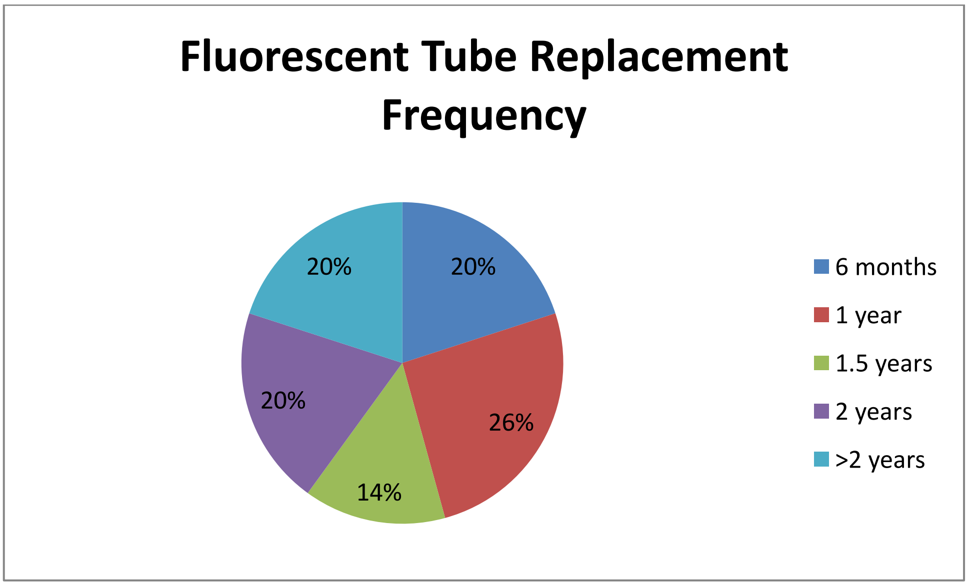

Figure 8: Fluorescent Tube Replacement Frequency

Safe transportation methods are also very important for fluorescent tubes. If the fluorescent tube breaks, it releases mercury into the air and can cause harm to those exposed to it. The good practice guide is written to educate member companies on these hazards and how to safely transport them using packaging sleeves. In our interviews, we found that 67% of companies transport their fluorescent tubes off-site. Despite two-thirds of companies taking the initiative to take fluorescent tubes off-site, not nearly as many companies are aware of the hazardous waste they contain. Less than half (47%) of the company representatives believed that the fire protection industry was aware of the hazards of fluorescent tubes.

4.3 Reasons for Improper Disposal

The second objective from the surveys and interviews was to determine reasons and rationale for improper disposal. After combining the data from the interviews and surveys, the most common reason for improper disposal of both batteries and fluorescent tubes were that companies are unaware of proper disposal methods. The second most common response was laziness. See Figure 9. There are two different rationales that can be extracted from the top responses. For many companies, a lack of information and education about the hazards associated with the waste and their proper disposal methods prevents them from responsibly disposing. However, as perceived by others in the industry, some companies, although aware of hazards and responsible disposal procedures, are too lazy to implement such practices.

Our interviews provided important data for the rationale behind improper disposal. Cost is usually assumed to be an overriding factor for practices within a business. However, only 26% and 14% of companies used this as a reason for improperly disposing of battery and fluorescent tube waste, respectively. From these results, it might suggest that companies don't consider the costs associated with recycling large enough to pose a significant financial burden on them. However, cost is a much more significant reason for batteries as opposed to fluorescent tubes. Another response that accounted for 24% and 21% of the responses for batteries and fluorescent tubes, respectively, was the inconvenience associated with proper disposal. This rationale might suggest a lack of knowledge on the recycling services available, many of which require little effort on the part of the maintenance company. Closely associated with this rationale may be the response that claimed companies do not have the necessary resources for proper disposal. Again, this is most likely a lack of information on the resources available for recycling batteries and fluorescent tubes. Recycling initiatives ABRI and FluoroCycle are valuable resources for companies to find reputable recycling companies. However, from our interviews and survey, we found that only 22% and 8% of companies are aware of ABRI and FluoroCycle, respectively, and none of the interviewed company representatives stated that their companies were members of these organisations.

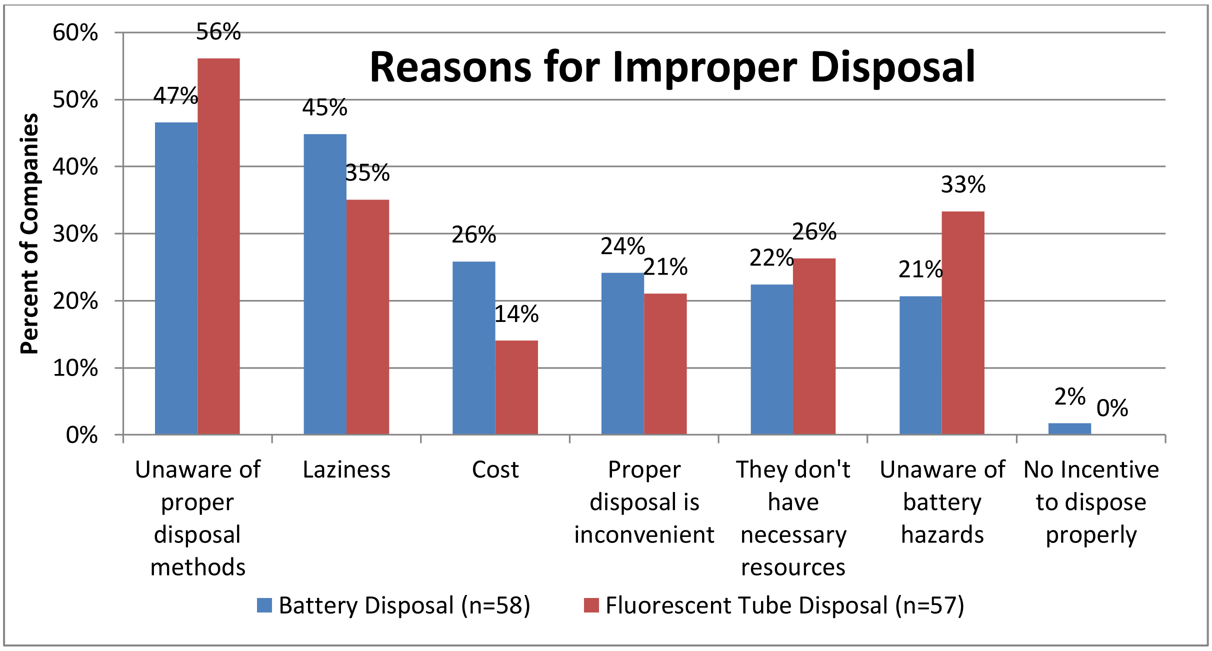

Figure 9: Reasons for Improper Disposal

4.4 Economic Analysis

This economic analysis was performed to lay out the costs and benefits associated with changing from currently employed practices in the fire protection maintenance industry to the alternative practices that were suggested in the good practice guides.

4.4.1 Costs and Benefits of Switching From Fluorescent Technologies

We researched the costs of the equipment used in exit signs and emergency lighting. The respective costs for fluorescent, LED, tritium, and photoluminescent systems are compared in Table 4. Various assumptions, based on our research, were taken into account for these calculations. The annual operating costs listed are the average yearly maintenance costs of the unit, excluding electricity costs. A 10-year period was chosen as the timeline for calculations in order to display long-term savings. As stated by AS 1851-2012, the total cost over 10 years reflects the regular replacement of batteries and fluorescent every 2 and 2.3 years, respectively. For LED lighting, the total cost over 10 years is based on the average lifetime, 8.4 years. The prices of tritium and photoluminescent lighting systems were converted from USD to AUD (based on a 0.95 conversion rate) because these technologies are most widely used in U.S. markets. The comparisons are used to highlight the potential savings if these technologies are eventually implemented into the Australian fire protection industry. For the replacement costs of batteries, the pricing was based on NiMH batteries, which are most prevalent in these lighting systems. Finally, The annual electricity cost were calculated from average kWh and price of kWh, from the year 2012, as indicated by the Australian Energy Market Commission (Mountain, 2012).

Table 4: Lighting Costs

	Fluorescent	LED	Tritium	Photoluminescent
Average Exit Signs Costs (per unit)*	$252	$310	$295	$128
Range of Exit Sign Costs (per unit)	$108 - $517	$120 - $415	$75 - $445	$17 - $324
Replacement Lamps (per tube)*	$8	$19	$0	$0
Replacement Batteries (per pack)	$41	$41	$0	$0
Kilo-watt hours (kWh) Used per year	236	78	0	0
Annual Electricity Cost	$59	$20	$0	$0
Annual Operating Cost	$30	$5	$0	$0
Lifetime Hours of Operation	17,306	73,953	N/A	N/A
Annual CO2 Emission (kg)	165	59	0	0
Total Costs Over 10 Years	$1,378	$779	$295	$128
Percent Savings Over 10 Years Compared to Fluorescent	N/A	44%	79%	91%

*These prices are averages from data gathered from RS Infinity, Rexel, and Pierlite.

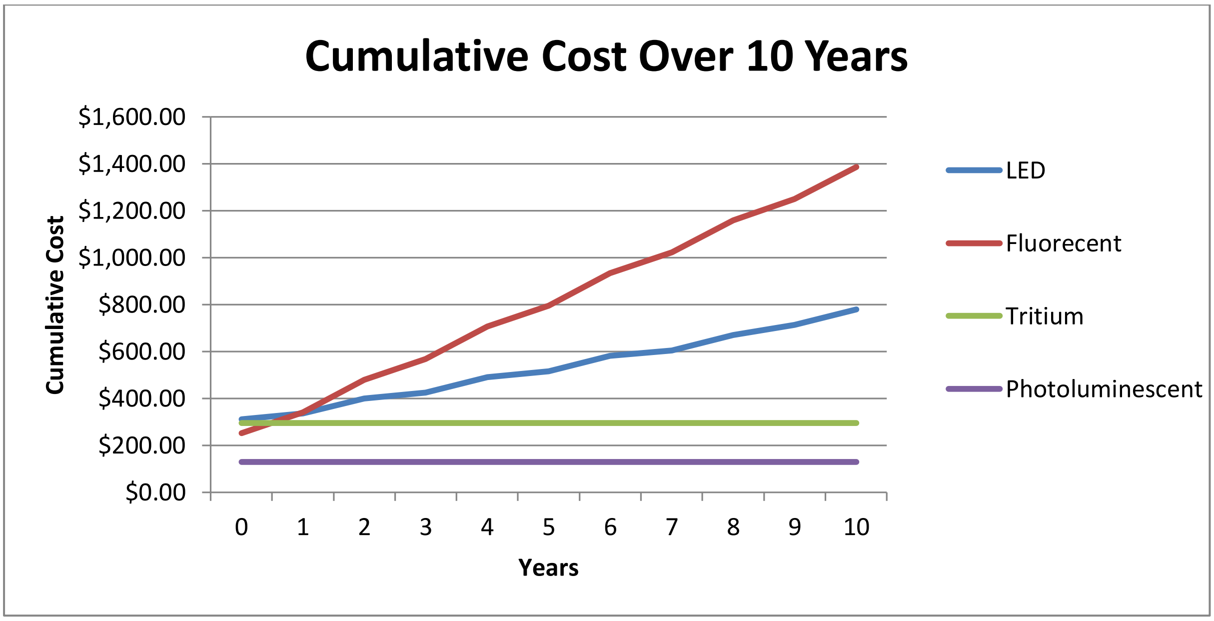

Figure 10: Cumulative Comparison of the Annual Costs of Different Emergency Exit Sign Technologies

Our comparison of the different types of systems shows that LED and tritium fixtures have a higher initial cost than fluorescent tube exit sign fixtures, whereas photoluminescent fixtures cost less than all of the other three technologies. Unlike LED and tritium fixtures, photoluminescent technology has limited applications because the photoluminescence only illuminates for 90 minutes in the absence of another light source such as ordinary office lights.

The cost for emergency lighting fixtures is roughly equal for both LED and fluorescent technologies. LED replacement lamps are more than twice as expensive as fluorescent tube replacement lamps. However, LED lamps last over four times longer than fluorescent tubes and use one-third of the electricity that fluorescent tubes use. We calculated the operation and maintenance costs for each type of exit sign technology (Figure 10). We found that an LED exit sign is roughly $61 cheaper for the customer than a fluorescent sign per year. This equates to approximately 70% savings per year. Both tritium and photoluminescent technologies are non-electric and do not require replacement tubes which leads them to be more cost effective than LED and fluorescent systems. Tritium and photoluminescent technologies have only the cost of purchase and installation, and therefore are a onetime cost incurred by the customers. Tritium has the potential to replace electric exit signs in all applications, while photoluminescent can only replace electric exit signs in well-lit locations because they require exterior light sources to "charge" them. Also, it should be noted that because tritium exit signs contain radioactive material there are much higher disposal costs than the other technologies. Disposal costs can be up to $75 dollars per sign, however, some United States companies have trade back programs which eliminate this cost if the customer purchases another sign at the time of disposal (Product Stewardship Institute, 2006). In well-lit locations where photoluminescent signs would be exposed to sufficient light, this technology is the cheapest option over a 10 year period.

In comparison to a fluorescent exit signs, customers can save 44%, 79%, and 91% over 10 years by switching to a LED, tritium, and photoluminescent exit signs (Table 4). Not only do these technologies decrease costs for customer, but also reduce the maintenance-related interruptions of the work place. These costs and maintenance reductions can benefit the fire protection maintenance companies as a selling point in the tender process.

4.4.2 Environmental Benefits of Switching from Fluorescent Technologies

Switching to LED technology has environmental advantages in addition to financial ones. LEDs contain no hazardous material, whereas, on average fluorescent tubes contain about 9 mg of mercury, a hazardous heavy metal. LEDs require less energy which results in a reduction of carbon dioxide emissions. We calculated the decrease in carbon dioxide emissions as an average from a variety of sources (see Appendix I for a list of sources). We found that switching from fluorescent to LED technologies would equate to a 64% decrease in carbon dioxide emissions.

Switching to tritium or photoluminescent technologies could result in even more environmental benefits. These non-electric technologies result in no CO_2 emissions. They do not need replacement lamps, so they eliminate a large portion of the lamp waste stream. The entire photoluminescent or tritium fixture usually needs to be replaced roughly once every 10 to 20 years (The Exit Store, 2011). These fixtures also require no battery backup system, therefore eliminating a portion of the battery waste stream.

4.4.3 Costs and Benefits of Switching from Nickel-Cadmium Batteries to Nickel Metal Hydride

Our research shows that nickel metal hydride batteries are slightly more costly than nickel-cadmium (Table 5 below). These costs were based on a range of batteries of each type of chemistry, in terms of both voltage and amp hour (Ah) rating. It should be noted that with increases in Ah ratings, there was higher costs associated, and that the average difference in cost stayed roughly the same between comparable batteries of each type. Both types of batteries are allowed under the current standards and regulations in Australia and there are many advantages to choosing nickel metal hydride batteries over nickel cadmium batteries. Nickel metal hydride batteries are capable of carrying higher charge capacities than nickel-cadmium. They are also less prone to memory formation, which is the damaging formation of crystals at the diodes which shorten the battery's life and disrupt its output (Buchmann, 2001). However, there are a few drawbacks to the increased charge capacity. Nickel metal hydride batteries have 200-300 charge cycles, while nickel-cadmium batteries have the capacity for almost 1000 charge cycles. As a result, nickel metal hydride batteries may require more frequent replacement than nickel cadmium batteries (Buchmann, 2001). However, switching to nickel metal hydride batteries has environmental benefits. Nickel metal hydride batteries do not contain any significant environmental hazards. Conversely, nickel cadmium batteries contain cadmium, which is an environmental and health hazard.

Table 5: Replacement Battery Costs

	NiMH	NiCad
Average Price per Battery Pack*	$41	$30
Range of Prices per Battery Pack*	$13 - $90	$15 - $46

*These prices are from data gathered from Australian Suppliers (Appendix H)

4.4.5 Costs and Benefits Associated with Recycling Batteries and Fluorescent Tubes

After calling four recycling companies, two of which are national recycling chains, to determine recycling costs, we found that lead acid batteries tend to have lower recycling costs than other types of batteries including nickel metal hydride, nickel cadmium, and lithium polymer batteries (See Table 6). There is also the potential for companies to receive monetary compensation for recycling lead acid batteries, depending on the market price of lead at the time, and the quantity of lead dropped off. Therefore this would be an associated benefit to recycling lead acid batteries, as it can be financially beneficial. We calculated our average recycling costs based on the recycling companies we contacted. See Appendix G for a complete list.

Based on the information from the survey, we made assumptions about waste generation of an average maintenance company to determine the annual recycling costs. The amount of lead acid battery waste generated by a maintenance company was assumed to be 50kg per week. As for nickel cadmium, nickel metal hydride, and lithium polymer batteries, we assumed that maintenance companies produce an average of 10kg per week. The recycling costs of fluorescent tubes were based on the assumption that 5 lamp tubes are replaced every week.

Table 6: Battery Recycling Costs

Recycling Costs for Dropping Off Batteries and Fluorescent Tubes		
Battery Type	**Average Cost per Kilogram**	**Range of Costs per Kilogram**
Lead Acid	$0.19	$0 - $0.77
Nickel Cadmium	$3.71	$0 – $6.00
Lithium Polymer	$3.28	$0 - $6.00
Nickel Metal Hydride	$3.00	$0 - $6.00
	Average Cost per Tube	**Range of Costs per Tube**
Fluorescent Tube	$1.95	$1.10 - $2.50
Recycling Costs Per Year		
Lead Acid	$494	
Nickel Cadmium	$1929	
Lithium Polymer	$1706	
Nickel Metal Hydride	$1560	
Fluorescent Tubes	$507	

Maintenance companies may see recycling as an inconvenience to their business, as seen by the results of our survey. One of the potential reasons for this is that it may be difficult to find a reputable recycling company in the area that fits their needs. Both the Australian Battery Recycling Initiative and FluoroCycle have no cost to refer maintenance companies to reputable recycling companies. There are many recycling locations that are close to the maintenance companies, which can also play a role in the convenience factor or recycling, making it easier for companies to be able to drop off their wastes in order to reduce costs of recycling. See Figure 11.

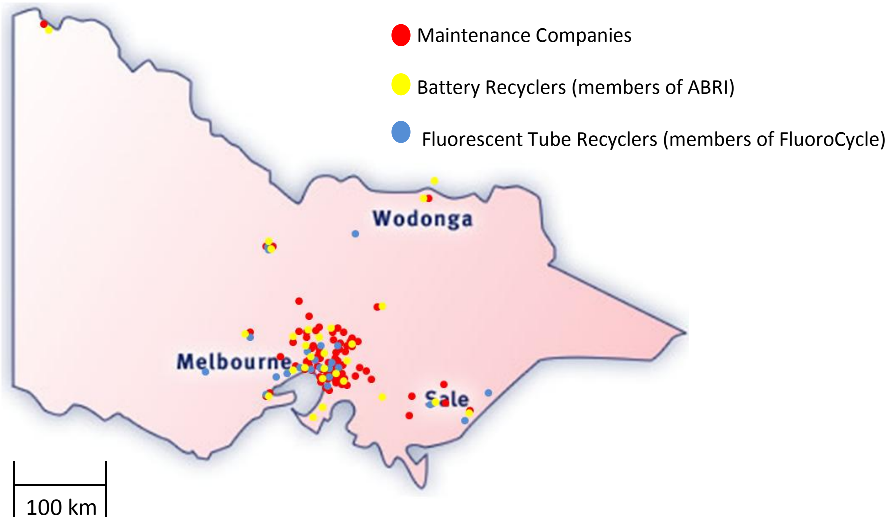

Figure 11: Distribution of Fire Protection Maintenance Companies and Recyclers in Victoria*

***See Appendix L for the distribution for all states**

We calculated the distances from FPA member maintenance companies to reputable battery and fluorescent tube recyclers. We found that 95% of companies are within 5 km of an ABRI recycler and 87% of companies are within 20 km of a FluoroCycle recycler. See Figure 12 and 13 for a breakdown of the distances. Although the majority of maintenance companies are close to a recycler, it can still be an inconvenience to drop off their batteries and fluorescent tubes. Many recycling companies have transportation services to combat this inconvenience. These services usually provide a storage bin for smaller batteries like nickel-cadmium and nickel metal hydride; whereas the larger lead acid batteries are transported on pallets. These battery storage bins would also add convenience to the recycling process by providing a convenient place to store batteries before they are picked up. These services would likely contest laziness, but will incur higher costs than dropping the batteries off.

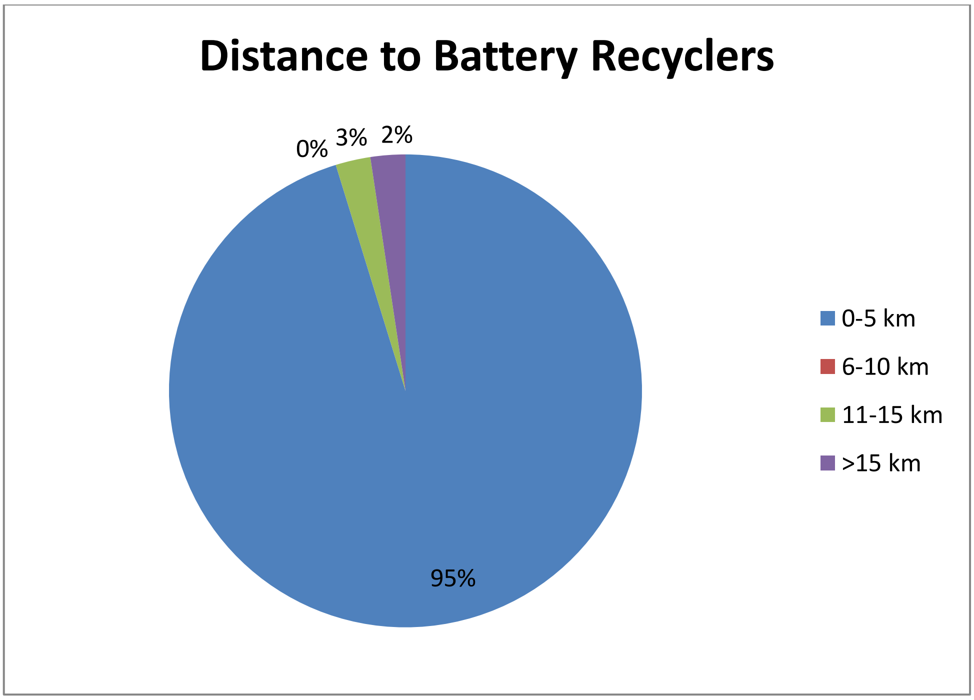

Figure 12: Distance from Maintenance Companies to ABRI Recyclers

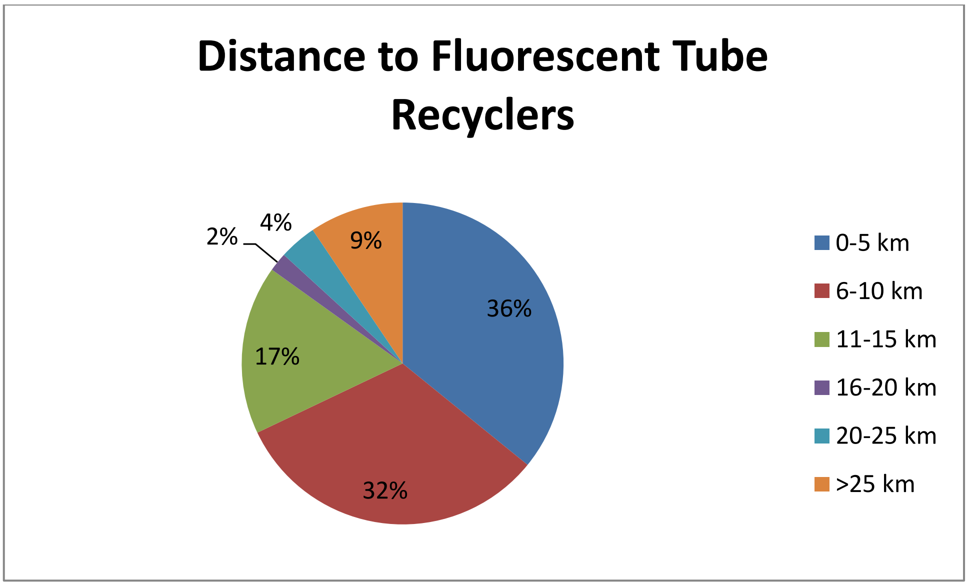

Figure 13: Distance from Maintenance Companies to FluoroCycle Recyclers

Compared to dropping batteries off, which costs roughly $3 dollars per kilo for batteries other than lead acid, and as much as $0.77 per kilo for lead acid batteries (Table 6), transportation costs are much higher. We found, from interviews with maintenance companies, that roughly 75% assume no cost to recycle their batteries. Having batteries transported by a collection service or recycler, however does incur a cost, which were quoted at a minimum of $8.75 per kilo plus a transport fee of $65 to $24 dollars for larger batteries, depending on quantity to be transported. These numbers are based on transportation in metropolitan areas such as Melbourne. Dropping of fluorescent tubes costs about $2 per tube, compared to roughly $150 for a box that holds 350 0.3m lamps as well as approximately $107 per hour for the transportation for collection service. The transportation costs consider multiple factors including how far the material needs to be transported, how much material is to be transported, and what types of material are to be transported. This means that transportation costs will be specialised to tailor the specific needs of a company. It is clear that using collection services to transport hazardous wastes is more costly than dropping them off.

4.4.6 Analysis of Disposal Methods

There are a number of ways to dispose of the waste batteries and fluorescent tubes. While recycling is the best option environmentally, it is not the only one employed by maintenance companies. One way some companies deal with this waste is leaving it with the customers. While this practice incurs no cost, it is not the best practice. It is unknown how these companies will handle the waste, and there is the possibility that it will be improperly disposed of into landfill. FPA Australia recommends that all fire protection maintenance companies be responsible for the proper removal and disposal of all wastes generated through the maintenance of fire protection systems. Another disposal means is to throw the waste away with the regular rubbish, and this waste stream also has a cost associated with it. Based on average waste removal and recycling costs cited by 9 companies in our interviews (Appendix G), recycling of lead-based batteries is about 5 times more costly than disposal with the regular waste. These costs were based on a service that charges by the kilogram. For a small company that disposes 50 kg of lead-based batteries and 10 kg of nickel metal hydride batteries per week, the incremental annual cost would only amount to about $1800.

4.4.7 Marketability of the Use of Environmentally Friendly Technologies and Practices

There are obvious financial costs associated with the responsible disposal of hazardous waste and the implementation of environmentally friendly practices. However, along with the environmental benefits, responsibly disposing of these wastes can also be financially beneficial. For a commitment to environmental and sustainable practices, FPA Australia will endorse a logo for subscribing companies. See Figure 14. This logo will be an extremely valuable marketing tool. Companies that advertise themselves as using environmentally friendly products can see up to a 15% increase in sales (Laskowski & Darnall, 2012). In the tender process, when customers are looking for a reputable maintenance company, environmental consciousness can account for up to 40% of their selection criteria (R. Porteous, personal communication, April 4, 2013).

Figure 14: FPA Australia Environmentally Friendly Logo

Maintenance companies who utilise LED technology can also market the reduced energy consumption and the fact that less frequent replacement is also more convenient and less disruptive to the customer's work place. The use of LED technology can be considered a win-win for the customer in reducing both environmental and financial costs.

4.5 Willingness of Industry to Engage

Responsible handling and disposal of batteries and fluorescent tubes comes with certain costs attached. To determine how these costs might affect the business of a maintenance company, we asked what percent of their day is spent doing maintenance of related systems. More than 60% of companies spend between 0% and 5% of their time replacing batteries and fluorescent tubes. See Figure 15. From these data, it is clear that for most companies, battery and fluorescent tube replacement represents only a small portion of their work and income. So, any changes associated with the responsible handling battery and fluorescent tube waste will not present companies with a significant burden.

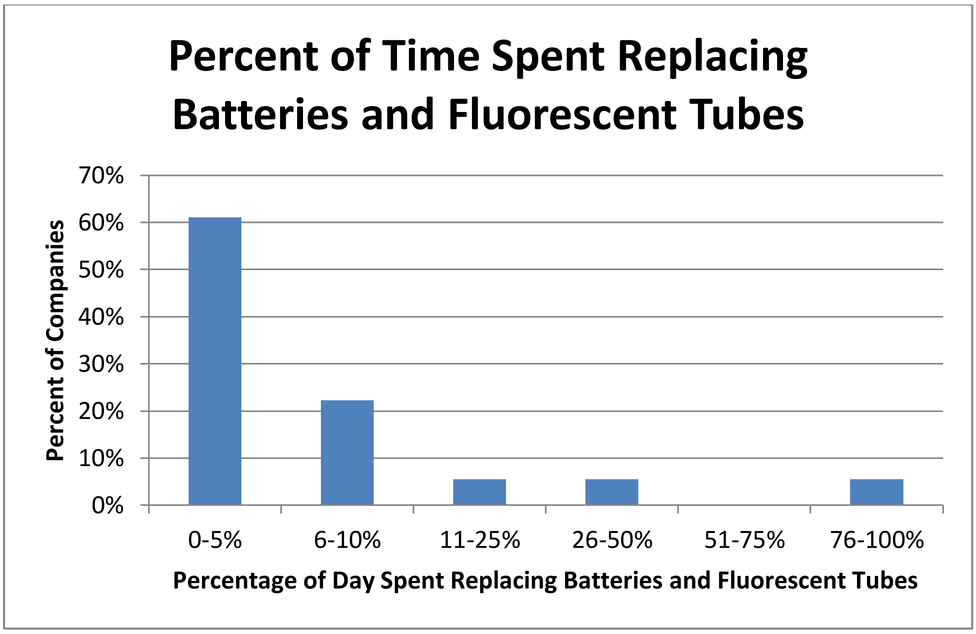

Figure 15: Percent of Time Spent Replacing Batteries and Fluorescent Tubes

Battery and fluorescent tube waste should always be taken off site after replacement. Of the companies interviewed, only 11% were not engaging in this practice. However when asked if they would be willing to do so, all of these companies said they would. When asked about their transportation practices, 72% of companies did not use battery boxes or packaging sleeves. The majority of these companies did not see the need to use such precautions during transportation and only 38% indicated their willingness to use battery boxes and sleeves.

The responsible practice for disposal of batteries is through recycling. Based on results from our survey and interviews, approximately half of companies currently recycle their battery waste. Of those who do not currently recycle their waste, half of them said they would be willing to start recycling. To paint a better picture of why companies already recycle, we asked those who recycle about their incentives to do so. One-third cited environmental benefits as their main incentive to recycle and another 27% said that they believed recycling was the best practice to use. The other reasons given were convenience, potential profit, and positive marketing. See Figure 16. As supplement to our previous interviews and economic analysis, we asked the companies who recycled if they incurred extra costs for doing so. More than three-quarters of companies said there are no additional costs associated with recycling their batteries. This leads us to believe that it is not uncommon to find a free recycling facility. Ninety-four percent of companies interviewed said they did not have a recycling company transport the waste for them and did not want to incur the additional cost. Additionally, none of the companies interviewed recycled their fluorescent tubes. However, 75% of those companies would be willing to do so if given the proper resources.

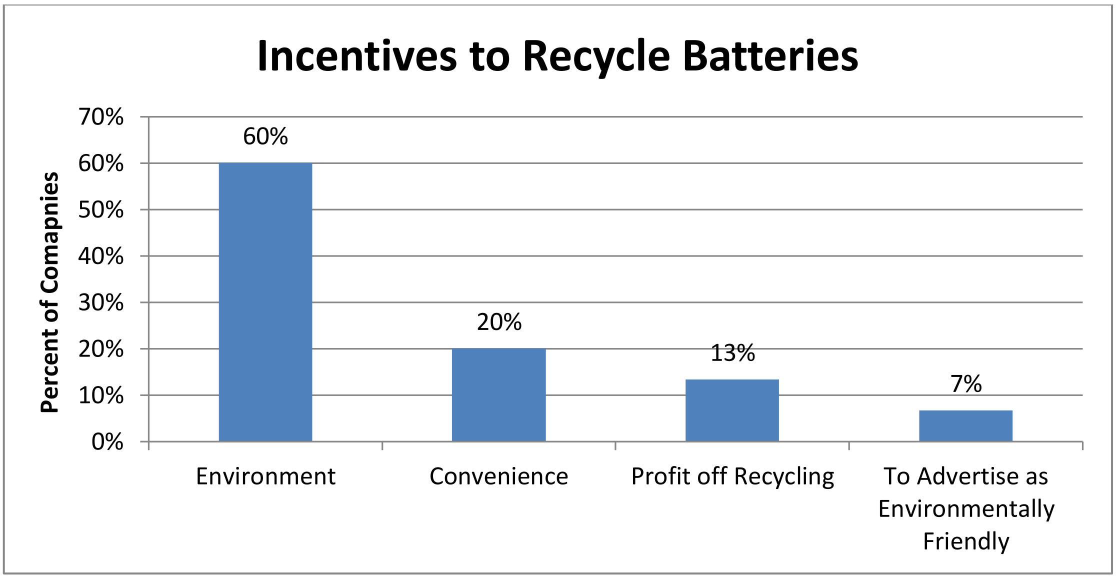

Figure 16: Incentives to Recycle Batteries

Another recommended practice is to use LED technology instead of fluorescent tubes in lighting applications. As is consistent with our previous interviews, LEDs are used by 72% of companies. Company representatives were asked what incentivised them to do so. The main reason was not environmentally based but financially. Over 50% of companies said that LED technology saves the customer money and is more marketable. Additionally, they cited the reduced power consumption and longer life of LEDs as reasons for implementation. Only 8% of companies said they used LED technology because it is less hazardous. The financial and energy benefits of LEDs are better known within the industry than the environmental advantages. See Figure 17. Education about the environmental advantages associated with LEDs will provide even more incentives for companies to use them as their main lighting equipment.

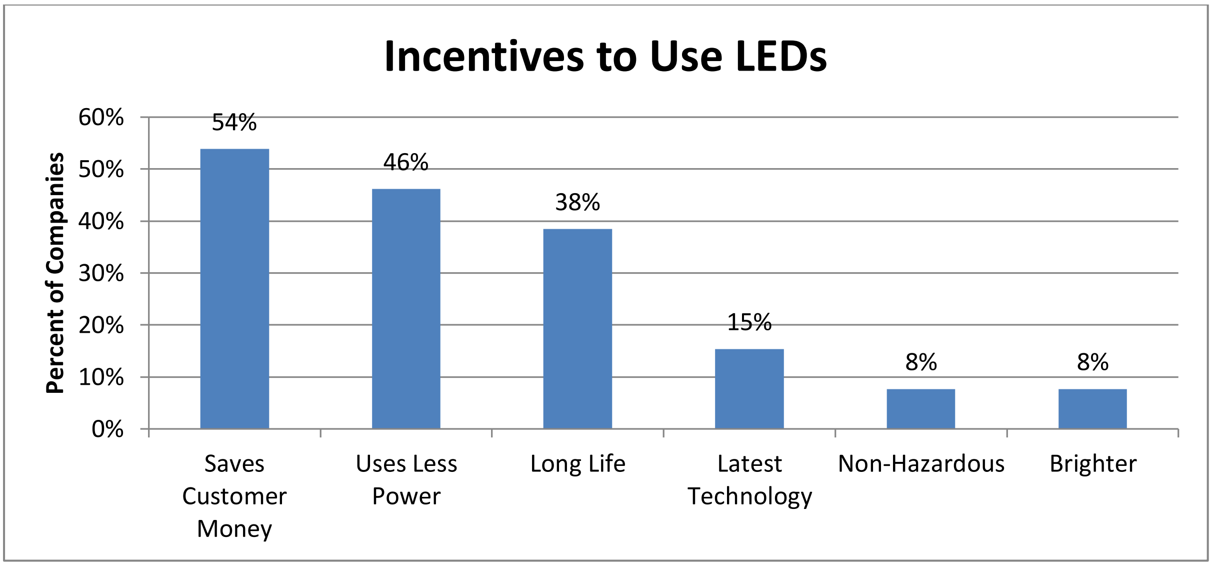

Figure 17: Incentives to Use LEDs

As growing initiatives in Australia, other questions focused on the role of ABRI and FluoroCycle on the recycling practices of maintenance companies. Both are cost-free to use and can help find reputable recyclers. When asked, 68% of companies said they would be willing to work with these initiatives to find recyclers and improve their practices. This is another area of focus in our good practice guides. We are suggesting that member companies utilise ABRI and FluoroCycle to find reputable recyclers and make their recycling practices as efficient and effective as possible. We contacted both ABRI and FluoroCycle and they said they would be pleased to highlight FPA Australia's support for recycling on their websites. FluoroCycle also recommended that FPA Australia become a Facilitator, at no cost, to the scheme in the category of Peak Body. Peak Bodies are associations that have a representative role in the private sector in which their key role is to encourage members to take appropriate action to become Signatories to the FluoroCycle scheme. Examples of current Peak Bodies are Lighting Council Australia, the Property Council of Australia, and Facility Managers Association (FluoroCycle, 2010).

The final question in our interview focused on the incentive of using an FPA Australia endorsed environmentally friendly logo. Companies were asked if they were willing to complete an assessment in exchange for use of the logo and 89% of companies found this to be an appealing incentive.

4.6 Summary

Our observation, surveys, interviews, and economic analysis provided us with valuable data to incorporate into the position statement and good practice guides. It is apparent that the industry most commonly uses lead acid batteries, and companies are switching from fluorescent tubes to LED technology. Our surveys and interviews lead us to believe that batteries and fluorescent tubes are replaced more often than the standard requires. Our economic analysis showed that it is most cost and environmentally effective for the customer to use LED technology as opposed to fluorescent tubes, and the maintenance company can advertise these savings. Overall, we found that maintenance companies were conscious of the hazard of batteries, yet not well-educated regarding the hazards of fluorescent tubes. The vast majority of companies are not aware of the recycling initiatives ABRI and FluoroCycle. These companies are extremely useful as they provide references to reputable recycling companies at no cost.

Not only did the economic analysis reveal numerous environmental benefits, but also there are several marketing benefits for maintenance companies. Following environmentally friendly procedures can allow companies to use the FPA Australia endorsed logo, which has the potential to increase sale. About 54% of companies in our sample chose to use LED technology because it saves their customers money. With the right practices, maintenance companies and their customers can enjoy convenience, financial savings, and the benefits of being environmentally friendly.

Chapter 5: Conclusion

The purpose of this project was to help Fire Protection Association Australia reduce the environmental impact and risks associated with hazardous waste generated by the fire protection maintenance industry. The number of batteries and fluorescent tubes ending up in landfill in Australia is growing and putting both humans and the environment at risk from the hazardous materials that they contain. This project resulted in two good practice guides which address the selection, use, and disposal of batteries from active fire systems such as fire detection & alarm systems, emergency warning systems, fire pump-sets, emergency lights and exit signs. Additionally, a position statement was created to define and promote the industry's commitment to practices that reduce environmental impacts and contribute to the sustainable use of resources and energy.

Research was conducted through observation, interviews, and surveys on the current practices of fire protection maintenance companies. We were able to generate a more accurate scope of the amount of hazardous waste entering landfill due to the improper disposal of batteries and fluorescent tubes. Further, we were able to determine the rationale behind improper disposal and identify ways to help companies implement good practices. An economic analysis was conducted to help understand the costs and benefits associated with the responsible disposal of batteries and fluorescent tubes. This information was considered in establishing recommended practices, along with the willingness of companies to engage in these practices.

Our research culminated in four areas of focus to help reduce the environmental impact of batteries and fluorescent tubes. The first is an industry-wide transition from fluorescent tubes to LED lighting. This will eliminate hazardous wastes and reduce energy consumptions and carbon emissions. The second is to recycle all batteries and fluorescent tubes replaced during the maintenance of fire protection systems through accredited recycling companies. Our third focus is informing companies on the safe handling and transportation of these materials. This includes using battery boxes and packaging sleeves to reduce safety risks and exposure to hazardous material. Finally, we are promoting the use of the recycling initiatives ABRI and FluoroCycle as a way to find reputable recyclers and create good recycling practices within the fire protection industry.

Fire Protection Association Australia is taking a leadership role in reducing the environmental impact of batteries and fluorescent tubes by distributing the good practice guides. They are also promoting a commitment to environmental and sustainable practices in all aspects of the fire protection industry with the environmental position statement and incentive of an FPA Australia "environmentally friendly" logo. These efforts will help to make fire protection an exemplary industry in the global movement towards environmental conservation and sustainability.

Chapter 6: Recommendations

The improper disposal of batteries and fluorescent tubes represents only one area where improvements to industry practices can be made. Through our research, we recognised the potential for environmental action to be taken in various other aspects related to the fire protection systems and equipment. We have seven additional recommendations for FPA Australia to consider as they move forward as the leader of the fire protection industry's movement towards environmental and sustainable practices.

6.1 Environmental Online Assessment

As a supplement to the position statement on environmental and sustainable practices, we recommend that FPA Australia develop an online assessment for member companies to demonstrate their understanding of proper hazardous waste handling. This will be beneficial for both the member companies and FPA Australia. It will ensure that the information given in the position statement is being interpreted correctly and make it easier for member companies to implement the suggested practices. We also recommend that in the future, that in order to use the FPA Australia environmentally friendly logo, all maintenance technicians must pass the assessment. This will help to verify that companies using the logo are subscribing to the position statement and engaging in environmental and sustainable practices.

6.2 Smoke Alarm Good Practice Guide

While batteries and fluorescent tubes have been the focus for the reduction of hazardous material in the environment, another area for concern is the replacement of ionisation smoke alarms. Ionisation smoke alarms contain a form of radiation known as americium-241 (Am-241). External exposure to Am-241 poses a cancer risk to all organs of the body. If taken up in the environment, Am-241 can do harm to plants and animals, causing damage to animals' lungs, liver and thyroid. We recommend that FPA Australia create a good practice guide for the proper handling and disposal of ionisation smoke alarms. Similar to the good practice guides created for batteries and fluorescent tubes, this guide will educate member companies on the hazards of ionisation smoke alarms and help reduce their risk of exposure as well as the environmental impact of Am-241.

6.3 Fire Pump Set Good Practice Guide

Environmental sustainability is of growing importance within the fire protection industry. Although testing of fire pump sets poses no risk of hazardous waste entering the environment, it can still be environmentally taxing. With each test of a fire pump set, thousands of liters of water are being flushed through the system and sent into drains, effectively wasted. While the testing of fire pump sets is essential to the function, maintenance and safety of these systems, there are measures that can be taken to make them more sustainable. Putting systems in place that recycle the water within these fire pump sets can greatly reduce the amount of water being wasted during regular testing. We recommend that FPA Australia create a good practice guide for the sustainable recycling of water used in fire pump sets.

6.4 Non-Electric Replacement of Exit Signs

Switching to non-electric exit signs such as tritium and photoluminescent technologies could have profound impacts on the amount of environmental waste that is generated from the maintenance of exit signs. Photoluminescence lighting only illuminates for 90 minutes after the lights go out, and therefore can only be used in specific applications. However, where appropriate, it is the more recommended technology because it is more environmentally friendly and it is less expensive than fluorescent tubes. Photoluminescence and tritium technologies would eliminate lamp waste more effectively than LED because there would be no lamp replacement required for 10 – 20 years, at which point the entire sign would need to be changed. This would also cut down on maintenance costs and provide potential savings for the customer. These non-electric alternatives are permitted by Australian code as long as the equipment meets the specifications, such as the light being visible from a certain distance. Our recommendation would be to look into the implementation of these technologies as alternatives to electric exit signs.

6.5 Legislative Incentive for Recycling

A possible avenue for increasing battery recycling within the industry is through legislation. The costs associated with responsible recycling can be substantial. We recommend that FPA Australia lobby for legislation that would give money back to companies who recycle their batteries. This would increase the cost of the battery at initial purchase, but companies would be more apt to bring their batteries to a recycler in order to receive monetary compensation.

6.6 Modify Standard AS 1851

Currently AS 1851 is a prescriptive regulation, meaning there are set requirements for the periodic maintenance of fire protection systems. By this standard, batteries must be replaced every 2 years. We are recommending that the standard is altered to be performance based, so the batteries do not need to be replaced if they are still functioning properly and passing maintenance tests. We also recommend adding a recycling requirement into the standard, to ensure that batteries are not disposed of in landfill. During our observation, the installation date of batteries was noted in each fire panel. Batteries dating back as far as 2005 were still operational and passing maintenance tests. Therefore, it is recommended that FPA Australia look into the expected capacities of batteries, and possibly modify the AS 1851 standard to reflect the quality of batteries and add a requirement to recycle replaced batteries.

6.7: Government Funded Educational Program

The fire protection industry is not well educated on the hazardous mercury contained in fluorescent tubes, nor the proper means of disposal. Fluorescent tubes are used in so many applications aside from fire protection emergency lighting and exit signs, as they are used to light most homes and buildings. The fire protection industry alone may be accounting for up to 3000g of mercury entering the environment every year. It is likely that there is an additional large quantity of mercury entering the environment from other industries and the general population and that there is a similar lack of knowledge regarding this hazardous waste. It costs $51,000,000 to remove 1000g of mercury from the environment, so this presents a very expensive way to provide for the safety of the environment (District Council of Mallala, 2013). We recommend that FPA Australia push for government funded programs to educate the industry and related stakeholders on the hazards of fluorescent lighting, as well as ways to reduce the environmental impact of this waste.

Chapter 7: Deliverables

7.1 Position Statement

Position Statement:

1.0 Purpose Statement

FPA Australia aims to promote a commitment to practices that reduce environmental impacts and contribute to the sustainable use of resources and energy.

The purpose of this position statement is to define the commitment to environmental and sustainable practices and provide information and education about ways to subscribe.

This position statement is intended for:

(i) FPA Australia members
(ii) Key stakeholders in the Fire Protection Maintenance Industry
(iii) The general public

2.0 Background

As stated in the Environmental Sustainability Policy, FPA Australia is committed to delivering services to all members to achieve continual improvement in fire safety in an environmentally friendly and sustainable manner to protect the quality of biodiversity, water, soil and air for current and future generations.

There is a wide range of environmental practices that have been extensively researched as ways to reduce the hidden environmental costs associated with various aspects of the fire protection industry. These practices include water and natural resource conservation, use of harmful substances, correct and safe disposal of all substances, and waste minimisation.

FPA Australia recognises the need for guiding principles on environmental practices and promotes their adoption. The environmental performance of member companies must continue to make strides towards excellence. A commitment to doing so will help FPA Australia further support Australia's *National Strategy for Ecological Sustainable Development*, which defines ecological sustainable development as:

"Using, conserving and enhancing the community's resources so that ecological processes on which life depends are maintained and the total quantity of life, now and in the future, can be increased."

This position statement will provide information on some environmental principles that are examples of the commitment to a sustainable future.

3.0 Environmental and Sustainability Principles

3.1 Water Conservation

Significant amounts of water are wasted each year in Australia through the routine testing of fire safety systems. Recently the waste of water has become a growing problem in Australia, due to recent climatic events, and there has been an increased emphasis on water conservation strategies. For the fire protection industry these could include retrofitting an existing system to include break tanks and return lines, pump recirculating tanks, variable speed pumps, or remote annubar test facilities. Another way to cut down on water waste would be to use recycled water in the system. Sources of this water could be storm water run-off, shower and bathroom water, or cleaned sewage water.

3.2 Use of Harmful Substances

Harmful substances are contained within some fire protection systems and equipment. The use of these substances must be controlled in order to prevent harm to humans and the environment. An area that provides a specific example of this is fire extinguishers. Many extinguishing agents used in firefighting applications contain ozone depleting substances or synthetic greenhouse gases. Ozone depleting substances are detrimental to the ozone layer and contribute to the formation of holes in the ozone layer, much like the one above Australia. Synthetic greenhouse gases act similarly to carbon dioxide in the atmosphere and therefore contribute to global warming. In order to minimise the impacts on the environment, these agents should only be discharged in order to extinguish a fire. They should also be handled, stored, transported, and disposed of in a manner that minimises the risk of accidental discharge.

3.3 Correct and Safe Disposal of All Substances

The importation, use, and maintenance of various fire protection systems and equipment inevitably results in the need to dispose of related materials. Whether these materials are hazardous or not, all substances need to be disposed of correctly and safely. Practices should be adjusted according to the correct disposal procedure for a particular substance.

Hazardous material is contained in many components of fire protection systems, of which member companies should be aware. Some examples are batteries, fluorescent tubes and smoke alarms. Batteries such as lead acid, nickel cadmium, nickel metal hydride, and lithium polymer contain toxic heavy metals and corrosive electrolyte solutions. Ionisation smoke alarms contain radioactive material, and fluorescent tubes contain mercury. Improper disposal can put the health of humans and the general welfare of the environment at risk.

Material such as plastics, metals, and glass, though not hazardous, can be harmful if not disposed of safely. These materials are not easily degradable in the environment and put ecosystems at risk.

3.4 Waste Minimisation

3.4.1 Reduce, Reuse, Recycle

An effective method of reducing the amount of waste generated from the fire protection industry is the circular practice of “reduce, reuse, and recycle”. Reduction of waste can begin with the careful selection of equipment. Products made from recycled materials are an integral part of “reduce, reuse, recycle”. Another consideration should be made for products that are the most environmentally friendly of their kind. For example, using light-emitting diodes (LEDs) instead of fluorescent lamps greatly reduces the amount of waste and hazardous material generated and energy used during its lifecycle. Reusing materials, such as water in fire systems, will reduce waste and environmental impact. Most material waste can be recycled and this is considered the best practice for all hazardous and non-hazardous waste. It prevents the build-up of waste in landfill and provides material to be reused in the production of new products, which cuts down on energy usage during production and reduces the need for raw material.

3.5 Summary

i. Conservation of water resources and minimisation of wastewater disposal can be achieved through practices such as retrofitting and designing systems to cut down water usage and to use recycled water.

ii. Harmful substances must be used with controlled and safe practices to reduce the risk of ozone depletion and other harmful environmental effects.

iii. All substances, whether hazardous or non-hazardous, must be responsibly disposed of in the correct way as to reduce waste and environmental impact.

iv. The principle of "reduce, reuse, recycle" creates opportunities for environmental sustainability in all stages of industry practices.

4.0 FPA Australia Position Statement

FPA Australia encourages members to support ecological sustainable development. In conjunction with the Code of Practice and Environmental Sustainability Policy, FPA Australia looks for member companies to take a committed approach to practices that reduce environmental impacts and contribute to the sustainable use of resources and energy.

5.0 Associated Actions

FPA Australia would like to recognise excellent environmental performance for member companies subscribing to this position statement with a branded "Environmentally Friendly" logo.

Figure 1: FPA Australia Environmentally Friendly Logo

6.0 Disclaimer

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1. Code of Practice – Version FPAA001-2008 – published by the Fire Protection Association Australia, 2008.

2. Environmental Sustainability Policy – published by the Fire Protection Association Australia, 2012.

3. *National Strategy for Ecological Sustainable Development* – prepared by the Ecologically Sustainable Development Steering Committee, endorsed by the Council of Australian Governments, December 1992.

4. *Water saving options available when testing fire safety systems* – published by the Victoria Building Commission, November 2007.

5. Code of Practice for the Reduction of Emissions of Ozone Depleting & Synthetic Greenhouse Gas Fire Extinguishing Agents – published by the Fire Protection Industry (ODS & SGG) Board, September 2007.

7.2 Battery Good Practice Guide

Recommendations for Reducing the Environmental Impact of Batteries from the Fire Protection Industry

FPA Australia aims to promote the protection of life, property and the environment from fire related emergencies.

1.0 Scope

This document has been prepared by FPA Australia to provide guidance to the fire protection industry in relation to the safe handling and disposal of batteries, in order to reduce the environmental impact and risks associated with their hazardous waste.

The number of batteries ending up in landfill in Australia is growing and putting both humans and the environment at risk from the hazardous materials that they contain. This guideline presents features of good practice in relation to the selection, use, and disposal of batteries from active fire systems such as fire detection & alarm systems, emergency warning systems, fire pump-sets, emergency lights and exit signs.

2.0 Definitions

2.1 Waste

Waste is defined by the *Environmental Protection Act 1970 (Vic)* as "any matter, whether solid, liquid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment in such volume, constituency, or manner as to cause an alteration of the environment".

2.2 Hazardous Waste

Hazardous waste is defined by the Australian National Waste Policy as "a substance or object that exhibits hazardous characteristics, is no longer fit for its intended use and requires disposal. Some of these hazardous characteristics include being toxic, flammable, explosive, and poisonous.

Hazardous wastes include:

- Chemical by-products from industrial processes
- Metals or metallic compounds such as lead, mercury and cadmium
- Waste mineral oils
- Household chemicals and pesticides, and
- Biological wastes."

3.0 Implications of Hazardous Material to Health and the Environment

3.1 Lead

Both sealed lead acid and wet cell lead acid batteries contain about 70% lead by weight. Lead is a toxic heavy metal that is very harmful to humans, other living organisms, and the environment. When lead ends up in landfill, it can leach into the soil through rainwater. When this occurs, lead can be taken up into local plant and animal populations. Humans can consume these lead-carrying plants and animals and be exposed to serious health risks. These risks include severe brain and kidney damage, developmental problems in children, and infertility.

3.2 Cadmium

Nickel-Cadmium batteries contain about 18% cadmium by weight in the form of cadmium hydroxide. Cadmium is a toxic heavy metal that can enter the environment through water streams, ultimately being taken up by soil, and infiltrate food chains. Cadmium can have severe negative health effects on humans. These risks include severe kidney damage, bone fracture, infertility, nervous and immune system damage, and cancer development.

3.3 Electrolyte Solutions

Electrolyte solutions found in batteries are hazardous and precautions must be taken in the handling of such substances. Contact should be avoided and the solutions must be disposed of properly to reduce the risk of personal and environmental harm.

3.3.1 Sulfuric Acid (H_2SO_4)

Lead acid batteries contain, on average, 20% sulfuric acid (H_2SO_4) by weight. Sulfuric Acid is a corrosive substance that is harmful when contacted, ingested, or inhaled. Skin and eye contact may produce burns, irritation, redness, and blistering. Inhalation may cause shortness of death, difficulty breathing, and in severe cases can cause death. Immediate medical attention is required for all exposure. Chronic exposure to sulfuric acid puts humans at risk for cancer development, and harmful health effects to kidneys, lungs, cardiovascular system, upper respiratory tract, eyes and teeth.

3.3.2 Potassium Hydroxide (KOH)

Both nickel metal hydride and nickel cadmium batteries contain approximately 20% potassium hydroxide solution by weight. Potassium hydroxide is extremely harmful if contacted with, inhaled, or ingested. Eye contact can result in corneal damage or blindness and skin contact can produce inflammation and blistering. Inhalation can make breathing difficult and in severe cases cause death. Immediate medical attention is required for all types of exposure. Chronic exposure to potassium hydroxide can cause mutations in mammals and organ damage.

3.3.3 Lithium Hexafluorophosphate ($LiPF_6$)

Lithium polymer batteries contain about 16% lithium hexafluorophosphate by weight. It is a corrosive substance when contacted, inhaled, or ingested. Skin and eye contact may cause burns and lithium hexafluorophosphate is very destructive to mucous membranes. Contact, inhalation and ingestion will cause death in extreme cases. Additionally, contact of lithium hexafluorophosphate with metals may evolve hydrogen gas, which is extremely flammable.

4.0 Selecting a Battery

4.1 Transition from nickel cadmium to nickel metal hydride

There are many advantages to choosing nickel metal hydride batteries over nickel cadmium batteries. Nickel metal hydride batteries are capable of carrying higher charge capacities than nickel cadmium. They are also less prone to memory formation, which is the damaging formation of crystals at the diodes which shorten the batteries life and disrupts its output. However, there are a few drawbacks to the increased charge capacity. Nickel metal hydride batteries have 200-300 charge cycles, while nickel-cadmium batteries have the capacity for almost 1000 charge cycles. As a result, nickel metal hydride batteries may require more frequent replacement than nickel cadmium batteries. However, switching to nickel metal hydride batteries has environmental benefits. Nickel metal hydride batteries do not contain any significant environmental hazards. Conversely, nickel cadmium batteries contain cadmium, which is an environmental and health hazard.

4.2 Transition from wet cell lead acid to sealed lead acid

Wet cell and sealed lead acid batteries are very similar, yet there are advantages associated with sealed batteries. Sealed lead acid batteries require less maintenance than wet cell lead acid batteries. There are fewer risks associated with sealed batteries. Wet cell batteries have open vents which emit corrosive gasses during use or charging, these gasses significantly increase the risk of explosion. Unlike sealed lead acid batteries, wet cell lead acid batteries require a cool down period after charging. Sealed batteries are also much easier to transport because there is no risk of spilled acid.

5.0 Safe Handling Procedures

After servicing fire systems, any waste generated should be taken off site after the work is complete. It is an especially good industry practice to remove used batteries from the site after replacement. This will allow for control over where the battery waste ends up instead of relying on the customer to practice responsible disposal practices.

5.1 Transporting Wet Cell Batteries

Wet Cell Lead Acid

Wet cell batteries must be transported in sealed containers with acid/alkali leak-proof liner to prevent leakage. The batteries should be fastened securely with terminals sealed and fill opening and vents facing up to prevent short-circuiting or overheating. Batteries should be placed side by side and separated by nonconductive dividers.

5.2 Transporting Other Batteries

Sealed Lead Acid, Nickel Cadmium, Nickel Metal Hydride, Lithium Polymer

Dry batteries should be transported in a nonconductive battery box with the batteries separated by nonconductive dividers side by side and fastened securely in place. The terminals should be sealed to prevent short-circuiting or overheating.

5.3 Landfill Fire Risk

Lithium Polymer

Lithium polymer batteries contain metallic lithium which reacts violently when in contact with moisture. If thrown into landfill in a charged state, heavy equipment operating on top could crush the cases and expose lithium which causes a fire. Landfill fires are very difficult to extinguish and can burn for years underground. For proper disposal and to decrease the possibility of these risks, these batteries must be fully discharged in order to consume all lithium content.

5.4 Safe Recharging Procedures

Nickel Metal Hydride, Nickel Cadmium

Nickel metal hydride and nickel cadmium batteries must only be charged used specialised chargers. Incorrectly charging either type of battery can result in damage to the battery, the charger, and /or fire. While most nickel metal hydride chargers will charge nickel cadmium batteries, it is important to check the instructions on the charger before use. Always check the battery label to ensure it is rechargeable before putting it into a recharger.

6.0 Recycling Practices

The best way to dispose of a used battery is through the process of recycling. As much as 99% of a battery, by volume, can be recycled. It is important that recycling is performed by an accredited recycler.

6.1 Lead Acid Batteries

The recycling process for both sealed and wet cell lead acid batteries begins with crushing the batteries, neutralising the acid, and separating the plastic components from the lead. By weight, approximately 70% of a typical lead acid battery is reusable lead. The lead is purified and delivered to battery manufacturers and other industries. The plastic is sent to a reprocessor for the manufacturing of new plastic products. Most lead acid batteries contain 60 to 80 percent of recycled lead and plastic.

6.2 Nickel Cadmium Batteries

Nickel-Cadmium (Ni-Cd) batteries are treated in a higher temperature metal reclamation process, which allows for the salvage and reuse of the metal. Prior to the smelting process, the plastic materials must be separated from all metal components. Cadmium is a metal that vapourises at high temperature. While the cadmium is heated, a fan blows the cadmium vapour into a large tube cooled with water mist. The vapours condense to produce cadmium that is 99.95% pure. The metals and plastics are used in the making of new batteries or stainless steel products.

6.3 Nickel Metal Hydride Batteries

The recycling process for nickel metal hydride batteries begins by removing the combustible material, such as plastics and insulation using a gas fired thermal oxidiser. The plant's scrubber, which is a device that removes pollutants from smokestacks and exhaust systems, then eliminates the polluting particles created by a burning process. This leaves the clean cells with their valuable metal content. At this point, the cells are chopped into small pieces and heated until the metal liquefies. Non-metallic substances are burned off. The different alloys settle according to their weights and are skimmed off while in liquid. Many times, the extracted nickel is used for stainless-steel production.

6.4 Lithium Polymer Batteries

The contents of lithium polymer batteries are exposed using a shredder or a high-speed hammer depending of the battery size. The contents are then submerged in corrosive, alkaline water. This corrosive solution neutralises the electrolytes, and non-ferrous and ferrous metals are recovered. The scrap metal can then be sold to metal recyclers. The solution is then filtered to extract the carbon. The carbon is pressed and occasionally recycled with cobalt. The lithium in the solution (lithium hydroxide) is converted to a fine white powder, lithium carbonate. The lithium carbonate is technical grade and can be used to make lithium ingot metal, foil for batteries, or lithium metal for the manufacture of sulfur dioxide batteries.

7.0 Australian Battery Recycling Initiative (ABRI)

The Australian Battery Recycling Initiative (ABRI) provides an opportunity for members to collaborate on collectively achieving effective battery stewardship. Battery stewardship is an approach to environmental protection calling on those in the battery lifecycle – manufacturers, retailers, users, and disposers – to share responsibility for reducing the environmental impact of batteries. ABRI is a government sponsored organisation which promotes the collection, recycling and safe disposal of all batteries. Fire protection maintenance companies can utilise ABRI, at no cost, to find reputable recyclers to handle their battery waste. These collaborations provide a great opportunity for the fire protection industry to work together with other industries and the Australian government in achieving product stewardship. The idea of product stewardship opens up many possible avenues for reform in reducing the number of batteries and fluorescent tubes that end up in landfill.

8.0 Environmental Benefits

There are numerous environmental benefits to following this good practice guide. First and foremost, following correct recycling and disposal procedures will greatly decrease the amount of hazardous waste disposed of in landfill. Along those lines, it will also decrease the risk of a landfill fire. Less hazardous waste in landfill not only benefits the environment, plants and animals, but ultimately reduces the risk for severe health problems in humans. Additionally, following the recommendations set forth in this guide when handling batteries will decrease the risk of explosions, short-circuiting, and overheating.

9.0 Company Benefits

In addition to environmental benefits associated with this guide, there are also many company benefits. Companies can advertise that they practice environmentally friendly procedures. Utilising the Australian Battery Recycling Initiative will facilitate a more convenient recycling process, as well as ensure recycling is performed by accredited recycling companies. Company personnel can also benefit from the outlined transportation techniques and improve the safety for the service technicians who handle batteries.

10.0 Conclusion

Use of the considerations and processes outlined in this good practice guide will assist industry in reducing the environmental impact of batteries. This guide addresses the key concepts that should be considered when selecting, handling, and disposing of batteries.

11.0 Disclaimer

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7.3 Fluorescent Tube Good Practice Guide

Recommendations for Reducing the Environmental Impact of Fluorescent Tubes from the Fire Protection Industry

FPA Australia aims to promote the protection of life, property and the environment from fire related emergencies.

2.0 Scope

This document has been prepared by FPA Australia to provide guidance to the fire protection industry in relation to the safe handling and disposal of fluorescent tubes, in order to reduce the environmental impact and risks associated with their hazardous waste.

The number of fluorescent tubes ending up in landfill in Australia is growing and putting both humans and the environment at risk from the hazardous materials that they contain. This guideline presents features of good practice in relation to the selection, use, and disposal of fluorescent tubes from active fire systems such as emergency lights and exit signs.

2.0 Definitions

2.1 Waste

Waste is defined by the *Environmental Protection Act 1970 (Vic)* as "any matter, whether solid, liquid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment in such volume, constituency, or manner as to cause an alteration of the environment".

2.2 Hazardous Waste

Hazardous waste is defined by the Australian National Waste Policy as "a substance or object that exhibits hazardous characteristics, is no longer fit for its intended use and requires disposal. Some of these hazardous characteristics include being toxic, flammable, explosive, and poisonous.

Hazardous wastes include:

- Chemical by-products from industrial processes
- Metals or metallic compounds such as lead, mercury and cadmium
- Waste mineral oils
- Household chemicals and pesticides, and
- Biological wastes."

3.0 Implications of Hazardous Material in Humans and the Environment

3.1 Mercury

Mercury is a toxic heavy metal found in all types of fluorescent tubes and lamps. It exists as a liquid when a lamp is turned off, and exists as a vapour when the lamp is on. The mercury is released to the environment as vapour when a tube or lamp is broken. When improperly disposed, mercury settles on land or in waterways. It is absorbed at the base of food chains, usually by filter feeding organisms. There is an amplification of mercury as it works its way up the food chain and it can have a severe impact on higher level organisms such as humans and other top level predators. The risks include damage to the brain, kidneys, and gastrointestinal tract. In cases of high concentrations, mercury is lethal.

4.0 Recommended Environmental Procedures

4.1 Removal of Fluorescent Tube Waste from Site

After servicing fire systems, any waste generated should be taken off site after the work is complete. It is an especially good industry practice to remove used fluorescent tubes from the site after replacement. This will allow for control over where the waste ends up instead of relying on the customer to practice responsible disposal practices. Additionally, the hazardous material in fluorescent tubes, mercury, is easily exposed, and leaving the waste on-site puts the customer at risk of exposure.

4.2 Safe Handling Procedures

The hazardous material in fluorescent tubes, mercury, is released only when the tube is broken. Therefore, safety precautions must be taken when handling and transporting tubes to reduce the risk of exposure. Tubes should be stored in their original packaging sleeves during transportation and storage to avoid breakage.

4.3 Recycling

Recycling is the most responsible way to dispose of waste mercury-containing lamps. The process begins by crushing fluorescent tubes and sorting the material. The aluminum from the tube ends is separated and reused in the manufacture of new products. The glass can be recycled into glass wool used for home insulation. The mercury should be distilled from the phosphor powder and can be recycled and used in dental amalgam. Finally, the phosphor powder can be used in fertiliser. It is best to utilise a recycler that follows these, or similar, recycling procedures to prevent mercury from being released into the environment.

5.0 FluoroCycle

The Lighting Council of Australia and the Council of Australian Government (COAG) have teamed together to create a voluntary scheme, known as FluoroCycle, that aims to reduce the amount of mercury entering the environment from the disposal of waste mercury-containing lighting. The FluoroCycle Outreach Strategy is a program that builds networks in the supply and disposal chains. This gives commercial industries the opportunity to work together to dispose of fluorescent tubes. Fire protection maintenance companies may choose to use FluoroCycle, at no cost, to gain access to service providers who can make appropriate arrangements for collection and recycling of used fluorescent tubes.

6.0 Light Emitting Diode Technology

Light Emitting Diodes (LEDs) are a non-hazardous alternative to fluorescent lighting. LEDs have many environmental and economic benefits. LEDs last approximately four times longer than fluorescent tubes, so they require much less frequent replacement. This can be very convenient for both service personnel and customers. Additionally, LEDs use approximately one-third the energy compared to fluorescent tubes, and result in approximately 100 fewer kilograms (a 64% decrease) of carbon dioxide emissions. Maintenance companies can advertise these long term savings and environmental benefits to the customer.

7.0 Conclusion

Use of the considerations and processes outlined in this good practice guide will assist industry in reducing the environmental impact of fluorescent tubes. This good practice guide addresses the key concepts that should be considered when selecting, handling, and disposing of fire protection lighting systems.

8.0 Disclaimer

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Appendix A: Interviews with Fire Protection Maintenance Companies

Method: Interview fire protection maintenance companies

Informed Consent Statement

You are being asked to participate in a research study interview. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation. The purpose of this study is to evaluate and understand the waste generated from the replacement of batteries and fluorescent tubes within the fire protection industry. We are looking to measure the amount of this waste, as well as explore various disposal methods being used within the industry. The overall goal is to gather information to help reduce the environmental impact of battery and fluorescent tube waste in the environment. This interview will take approximately 15 minutes to complete. You will be asked a series of questions related to the study and your results will be recorded. All personal company information from this interview will be kept confidential. By participating in this study, you are at risk to expose any illegal practices that may be used by your company. The benefits related to participating in this study are receiving educational information for your disposal practices, validation for proper disposal practices, and the potential to help reduce the environmental impact of hazardous waste from the fire protection industry in Australia. Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or its designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (Ethics Board) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you. All data will be kept on a password-protected computer, to which only the study investigators will have access. Participation in this study will not put the participant at risk of any consequences related to exposed practices. As compensation for completing this survey, you will be provided with a copy of a good practices manual to be developed at the end of the study.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

Study Investigators: Megan Forti, Michael LeBlanc, Kelly McManus

Email: wpi@FPAA.com.au;

Professor Kent Rissmiller, Institutional Review Board (Ethics) Chair

Tel. 508-831-5019, Email: kjr@wpi.edu;

Michael J. Curley, University Compliance Officer

Tel. 508-831-6919, Email: mjcurley@wpi.edu

The interview will begin only with your verbal consent and you may choose to not answer questions. If at any point you choose to stop the interview, any questions previously answered will not be recorded. You will be asked for final consent at the end of the interview, at which point you have the right to ask for some or all answers to be stricken from our records.

1. What types of batteries do you use in fire protection systems?
2. Which supplier(s) do you get your batteries from?
3. Are these batteries brand new when received or have they had a previous shelf-life?
4. Do you know what your average cost per battery is?
5. How long do these batteries typically last?
6. How often do you replace your batteries?
7. How many batteries do you replace per week?
8. Do you take the batteries from a site after you replace them?
9. Do you have a special method for transporting these batteries?
10. How do you currently dispose of your battery waste?
    - What company/companies do you utilise to dispose of the waste?
11. Do you think that members of the fire protection maintenance industry are aware that batteries such as these contain hazardous materials such as lead and other heavy metals and that these materials are harmful to humans and the environment?
12. In the fire protection maintenance industry a lot of these batteries are often improperly disposed of into landfill. In your opinion why do you think these other companies do not dispose of these hazardous wastes properly?
13. What types of lighting do you use in fire protection systems?
14. How often do you replace these lights?
15. How many fluorescent tubes do you replace per week?
16. Do you transport these waste lamps off site to a storage facility?
    - How do you currently dispose of these lamps?
        - What company/companies do you utilise to dispose of this waste?
17. Do you think that members of the fire protection maintenance industry are aware that some of these lamps, for instance fluorescent tubes contain hazardous materials such as mercury and other heavy metals?
18. In the fire protection industry, much like the batteries, these lamps are often being improperly disposed of into landfill. In your opinion why do you think these other companies do not dispose of these hazardous wastes properly?

Appendix B: Survey Fire Protection Maintenance Companies

Method: Survey fire protection maintenance companies

Reducing the Environmental Impact of Hazardous Waste From the Fire Protection Industry in Australia

This study is being conducted by a third party group contracted by Fire Protection Association Australia

Informed Consent Agreement *

You are being asked to participate in a research study survey. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation. The purpose of this study is to evaluate and understand the waste generated from the replacement of batteries and fluorescent tubes within the fire protection industry. We are looking to measure the amount of this waste, as well as explore various disposal methods being used within the industry. The overall goal is to gather information to help reduce the environmental impact of battery and fluorescent tube waste in the environment. This survey will take approximately 15 minutes to complete. You will be asked a series of questions related to the study and your results will be recorded. All results will be kept anonymous. By participating in this study, you are at risk to expose any illegal practices that may be used by your company. The benefits related to participating in this study are receiving educational information for your disposal practices, validation for proper disposal practices, and the potential to help reduce the environmental impact of hazardous waste from the fire protection industry in Australia. Any publication or presentation of the data will not identify you. All data will be kept on a password protected computer, to which only the study investigators will have access. Participation in this study will not put the participant at risk of any consequences related to exposed practices. As compensation for completing this survey, you will be provided with a copy of a good practices manual to be developed at the end of the study. For more information about this research or about the rights of research participants, or in case of research-related injury, contact: Study Investigators: Megan Forti, Michael LeBlanc, Kelly McManus Email: wpi@FPAA.com.au; Professor Kent Rissmiller, Institutional Review Board (Ethics) Chair Tel. 508-831-5019, Email: kjr@wpi.edu; Michael J. Curley, University Compliance Officer Tel. 508-831-6919, Email: mjcurley@wpi.edu By checking the box below, you acknowledge that you have been informed about and consent to be a participant in the study described above. There will be an additional agreement check box at the end of the survey to confirm your consent before submitting the online results. Make sure that your questions are answered to your satisfaction before checking the agreement box below and at the end of the survey.

- I agree to the above conditions

What is the location of your company?

- City
- Town
- Rural

What is the category/type of your company?

- Maintenance Company
- Manufacturer
- Design
- Other:

How many service personnel does your company employ?

- 1
- 2-5
- 5-20
- 20-50
- 50-100
- >100

On average, how many kilograms of wet-cell lead acid batteries does your company replace per week?

- None
- 0-50 kg
- 50-100 kg
- 100-250 kg
- 250-500 kg
- 500-1000 kg
- >1000 kg

How do you dispose of your wet cell lead-acid batteries?
Please check all that apply

- At the tip
- Recycle
- Collected by a third party
- Used in resale
- Customer is responsible for disposal/recycle

On average, how many kilograms of sealed lead acid batteries does your company replace per week?

- None
- 0-50 kg
- 50-100 kg
- 100-250 kg
- 250-500 kg
- 500-1000 kg
- >1000 kg

How do you dispose of your sealed lead-acid batteries?
Please check all that apply

- At the tip
- Recycle
- Collected by a third party
- Used in resale
- Customer is responsible for disposal/recycle

On average, how many kilograms of nickel metal hydride batteries does your company replace per week?

- None
- 0-50 kg
- 50-100 kg
- 100-250 kg
- 250-500 kg
- 500-1000 kg
- >1000 kg

How do you dispose of your nickel metal hydride batteries?
Please check all that apply

- At the tip
- Recycle
- Collected by a third party
- Used in resale
- Customer is responsible for disposal/recycle

On average, how many kilograms of lithium polymer batteries does your company replace per week?

- None
- 0-50 kg
- 50-100 kg
- 100-250 kg
- 250-500 kg
- 500-1000 kg
- >1000 kg

How do you dispose of your lithium polymer batteries?
Please check all that apply

- At the tip
- Recycle
- Collected by a third party
- Used in resale
- Customer is responsible for disposal/recycle

On average, how often do you replace batteries from fire protection systems?

- 6 months
- 1 year
- 1.5 years
- 2 years
- >2 years

On average, how many facilities does your company service per week?

- 0-10
- 10-50
- 50-100
- >100

If you answered "Collected by a third party" to any of the previous four questions, please specify which company/companies

What companies do you use as battery suppliers?

Have you heard of the Australian Battery Recycling Initiative?

- Yes, I am currently a member
- Yes, but I am not a member
- No

What companies do you use for recycling your batteries?
If you do not use a company to recycle batteries, please write "none"

Have you considered a resale market for batteries?

- No
- Yes

Why might companies improperly dispose of batteries?
Please check all that apply

- They don't know batteries contain hazardous material
- Proper disposal is too costly
- Proper disposal is inconvenient
- They don't have necessary resources
- Other:

On average, how many fluorescent tubes does a service employee replace per week?

- 0-50
- 50-100
- 100-200
- >200

Do the fluorescent tubes still function properly upon replacement?

- Yes
- No

On average, how often do you replace a fluorescent tube?

- 6 months
- 1 year
- 1.5 years
- 2 years
- > 2 years

How do you dispose of fluorescent tubes?
Please check all that apply

- At the tip
- Recycle
- Collected by a third party
- Used in a resale market
- Customer is responsible for disposal/recycle

If you answered "Collected by a third party" to the previous question, please specify which company/companies

What companies do you use as fluorescent tube suppliers?

What companies do you use for recycling your fluorescent tubes?
If you do not use a company to recycle your fluorescent tubes, please write "none"

Have you heard of FluoroCycle?

- Yes, I am currently a member
- Yes, but I am not a member
- No

Have you considered a resale market for fluorescent tubes?

- Yes
- No

Why might companies improperly dispose of fluorescent tubes?
Please check all that apply

- Don't know fluorescent tubes contain hazardous material
- Proper disposal is too costly
- Proper disposal is inconvenient
- They don't have the necessary resources
- Other:

Please provide any additional comments you may have

Do you wish to submit these survey answers? *
By clicking yes, and submitting your answers, your anonymous results will be recorded. If you wish to discontinue this survey, please close your browser now and your results will not be recorded.

- Yes

Appendix C: Phone Interviews with Battery Recyclers

Method: Phone interviews with recyclers for economic analysis

"Hello, my name is _______, and I am calling from Fire Protection Association Australia. We are conducting a research study on the recycling of hazardous waste. Could we ask you a few questions to help us better understand your recycling processes?"

1. Does your company have a recycling service? (for companies that were mainly battery suppliers but were listed in the survey responses)
2. What is the cost to utilise your recycling service?
3. Do you have transportation services?
    a. If yes, are there extra costs associated with these services? What are the costs?
    b. Do you have any special handling process for transportation?
4. What processes do you use to recycle batteries?
    a. Which materials are recycled?
    b. What is done with the rest of the materials?
    c. On average, what percent (by volume or weight) of the battery is recycled?
5. Do companies receive money after recycling their batteries?
6. Have you heard the Australian Battery Recycling Initiative (ABRI)?
    a. If yes, are you a member of the ABRI?

Appendix D: Phone Interviews with Fluorescent Tube Recyclers

“Hello, my name is _______, and I am calling from Fire Protection Association Australia. We are conducting a research study on the recycling of hazardous waste. Could we ask you a few questions to help us better understand your recycling processes?”

1. What is the cost to utilise your recycling service?
2. Do you have transportation services?
    a. If yes, are there extra costs associated with these services? What are the costs?
    b. Do you have any special handling process for transportation?
3. What processes do you use to recycle fluorescent tubes?
    a. Which materials are recycled?
    b. What is done with the rest of the materials?
    c. What percentage of the material is recycled?
4. Have you heard of or are you a part of the FluoroCycle?
    a. If yes, are you a signatory of FluoroCycle?

Appendix E: Phone Interviews with Battery and Fluorescent Tube Recyclers

"Hello, my name is _______, and I am calling from Fire Protection Association Australia. We are conducting a research study on the recycling of hazardous waste. Could we ask you a few questions to help us better understand your recycling processes?"

1. Does your company recycle either batteries or fluorescent tubes? (for companies that do not specify what they recycle)
2. What is the cost to utilise your recycling service?
3. Do you have transportation services?
    a. If yes, are there extra costs associated with these services? What are the costs?
    b. Do you have any special handling process for transportation?
4. What processes do you use to recycle batteries?
    a. Which materials are recycled?
    b. What is done with the rest of the materials?
    c. On average, what percent (by volume or weight) of the battery is recycled?
5. Do companies receive money after recycling their batteries?
6. What processes do you use to recycle fluorescent tubes?
    a. Which materials are recycled?
    b. What is done with the rest of the materials?
7. Have you heard the Australian Battery Recycling Initiative (ABRI)?
    a. If yes, are you a member of the ABRI?
8. Have you heard of FluoroCycle?
    a. If yes, are you a signatory of FluoroCycle?

Appendix F: Email Battery, Fluorescent Tube, and LED Suppliers

Method: Email suppliers for economic analysis

Battery Suppliers:

"Hello,

We are a third party group, contracted by Fire Protection Association Australia to conduct a research study on hazardous waste handled by the fire protection maintenance industry. Would it be possible for you to send us cost information regarding your (wet cell, sealed lead acid, nickel-cadmium, nickel metal hydride, or lithium polymer depending on what the specific company supplies) batteries to help us in our research?

Please send this information to wpi@FPAA.com.au.

Thank you"

Fluorescent Tubes and LED Suppliers:

"Hello,

We are a third party group, contracted by Fire Protection Association Australia to conduct a research study on hazardous waste handled by the fire protection maintenance industry. Would it be possible for you to send us cost information regarding your Fluorescent tubes and LEDs lights to help us in our research?

Please send this information to wpi@FPAA.com.au.

Thank you"

Fluorescent and LED Exit Sign and Emergency Lighting Suppliers:

"Hello,

We are a third party group, contracted by Fire Protection Association Australia to conduct a research study on hazardous waste handled by the fire protection maintenance industry. Would it be possible for you to send us cost information regarding your Fluorescent (LEDs or both) lighting and/or Exit Signs to help us in our research?

Please send this information to wpi@FPAA.com.au.

Thank you"

Appendix G: List of Recyclers

Battery Recyclers:

1. Century Yuasa Batteries PTY LTD
   Phone: 1300 362 287
   Website: http://www.centurybatteries.com.au/
2. MRI ecycle solutions
   Phone: 1300 4 39278 Email: will@mri.com.au
   Website: http://www.mri.com.au/
3. Battery World
   Phone: 1-800-961-9193
   Website: http://www.batteryworld.com/
4. Olympic Batteries
   Phone: 61 8 8297 5157 Email: salesed@olympicbatteries.com.au
   Website: http://www.olympicbatteries.com.au/index.html

Fluorescent Tube Recyclers:

1. Chemsal
   Phone: 03 9369 4222 Email: enquiries@chemsal.com.au
   Website: http://www.chemsal.com.au/
2. Cleartech
   Phone: (08) 9248 3505 Email: ashley.dixon@clear-tech.com.au
   Website: http://clear-tech.com.au/
3. Northern Territory Recycling Service
   Phone: 8947 2721
   Website: http://www.ntrs.com.au/
4. SITA
   Phone: 13 13 35
   Website: http://www.sita.com.au/

Battery and Fluorescent Tube Recyclers

1. CMA Ecocycle
   Phone: 1300 358 676
   Website: http://www.cmaecocycle.net/

Appendix H: List of Suppliers

LED Exit Signs:

1. RS Infinity
   Phone: 02 9681 8500 Email: oztech@rs-components.com
   Website: http://australia.rs-online.com/web/generalDisplay.html?id=rsinfinity
2. Rexel
   Phone: 1300 310 152 Email: webservices@rexel.com.au
   Website: http://www.rexel.com.au/
3. Pierlite
   Phone: 61 2 9794 9300 Email: lighting@pierlite.com.au
   Website: http://www.pierlite.com/

Fluorescent Exit Signs:

1. Rexel
2. Pierlite
3. Cooper
   Phone: 44 (0) 1302 303250 Email: sales@cooper-ls.com
   Website: http://www.cooper-ls.com/

Tritium Exit Signs

1. Exit Sign Warehouse
   Phone: 888 953 3948 Email: info@exitsignwarehouse.com
   Website: http://www.exitsignwarehouse.com/CONTACT.html
2. 4eixts.com
   Phone: 1866 345 4837 Email: custsvc@4exits.com
   Website: http://4exits.com/
3. Trtiumdisposal.com
   Phone: 866-540-8588 Email: sales@tritiumdisposal.com
   Website: http://tritiumdisposal.com/contact_us.php
4. 1000bulbs.com
   Phone: 800-624-4488
   Website: http://www.1000bulbs.com/

Photoluminescent Exit Signs

1. Koffler Sales Company
   Phone: 1-847-438-1152 Email: customerservice@kofflersales.com
   Website: http://www.kofflersales.com/
2. 4exits.com
3. exitsinage.com
   Phone: 866 697 9560 Email: cs@exitsignage.com
   Website: http://exitsignage.com/

4. theexitstore.com
   Phone: 1-866-471-2849 Email: cs@theexitstore.com
   Website: http://theexitstore.com/

LED Replacements:

1. DH Gate
   Phone: 86-10-82257676
   Website: http://www.dhgate.com/wholesale/australia.html
2. LEDstrips8
   Phone: 86 755 83066884
   Website: http://www.ledstrips8.com/
3. LED Lights Hub
   Phone: 086—020- 36212120 Email: sales@ledlightshub.com
   Website: http://www.ledlightshub.com/
4. myshopping.com.au
   Website: http://www.myshopping.com.au/
5. Alibaba
   Website: http://www.alibaba.com/

Fluorescent Tube Replacements:

1. Pierlite
2. Beacon Lighting
   Phone: (03) 8561 1599
   Website: http://www.beaconlighting.com.au/
3. The Light Bulb Shop
   Website: http://www.lightbulbshop.net/
4. Buylighting.com
   Phone: 1-888-990-9933
   Website: http://www.buylighting.com/Default.asp
5. Bunnings
   Phone: (03) 8831 9777
   Website: http://www.bunnings.com.au/
6. RS Infinity

LED Emergency Lighting

1. Cooper
2. Pierlite
3. RS Infinity

Fluorescent Emergency Lighting

1. Cooper
2. Pierlite
3. RS Infinity

Nickel Cadmium Batteries

1. globebatteries.com.au
   Website: http://www.globebatteries.com.au/battery/home.php
2. myshopping.com.au
3. au.mouser.com
   Phone: 852 3756-4700 Email: australia@mouser.com
   Website: http://au.mouser.com/

Nickel Metal Hydride Batteries

1. globebatteries.com.au
2. Dino Direct
   Phone: (86)18938937996 Email: Cs-center@dinodirect.com
   Website: http://www.dinodirect.com/currency-AUD.html?affid=685&daf=yes&source=sem&gclid=CMP419ic4LYCFSRKpgodjhwAqg
3. Portable Power Technology
   Phone: 148 873 161
1. Website: http://www.portablepower.net.au/epages/shop.sf/en_au/?ObjectPath=/Shops/portablepower

Appendix I: List of Sources

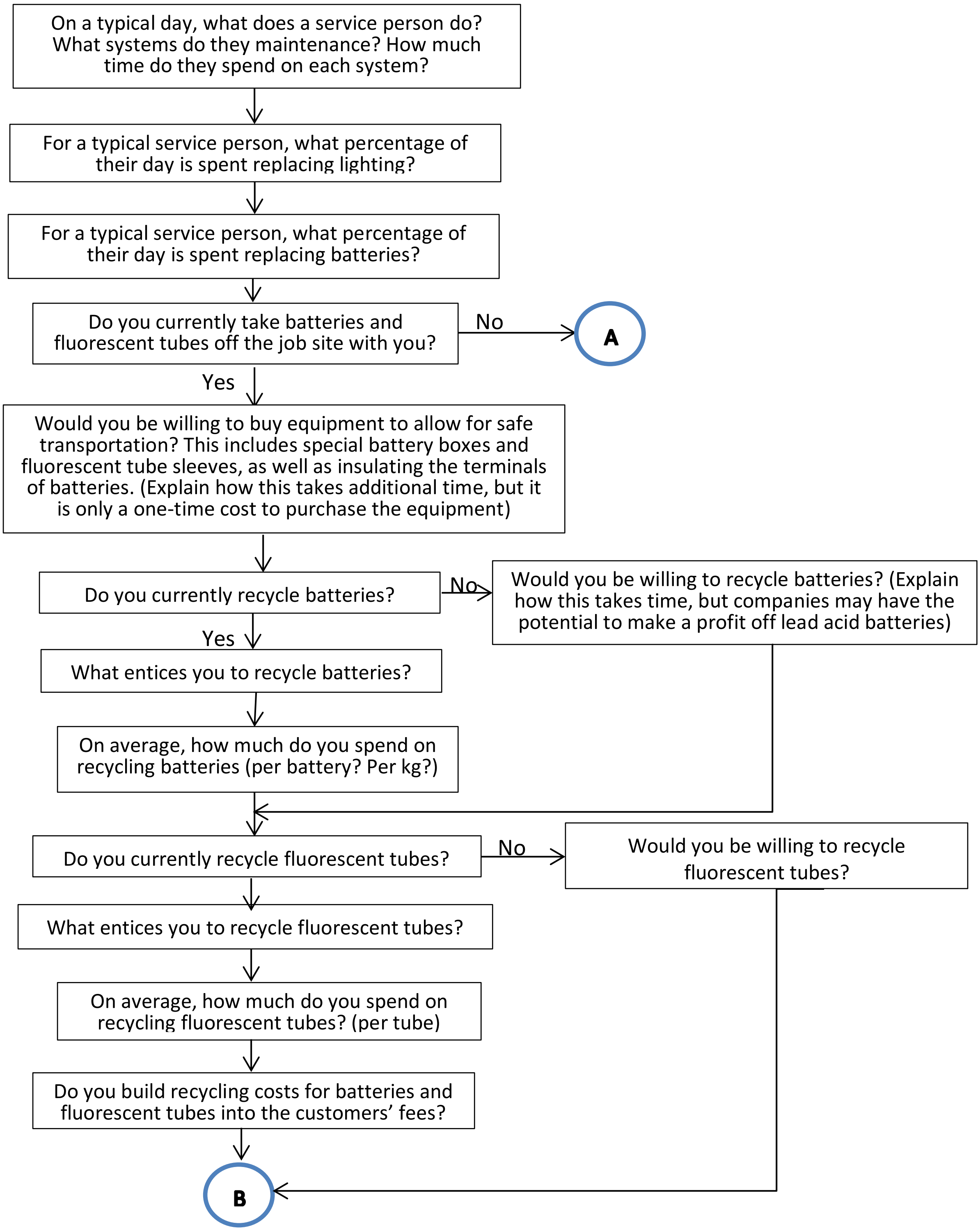
These sources where used to find the average carbon dioxide emissions associated with fluorescent and LED systems.

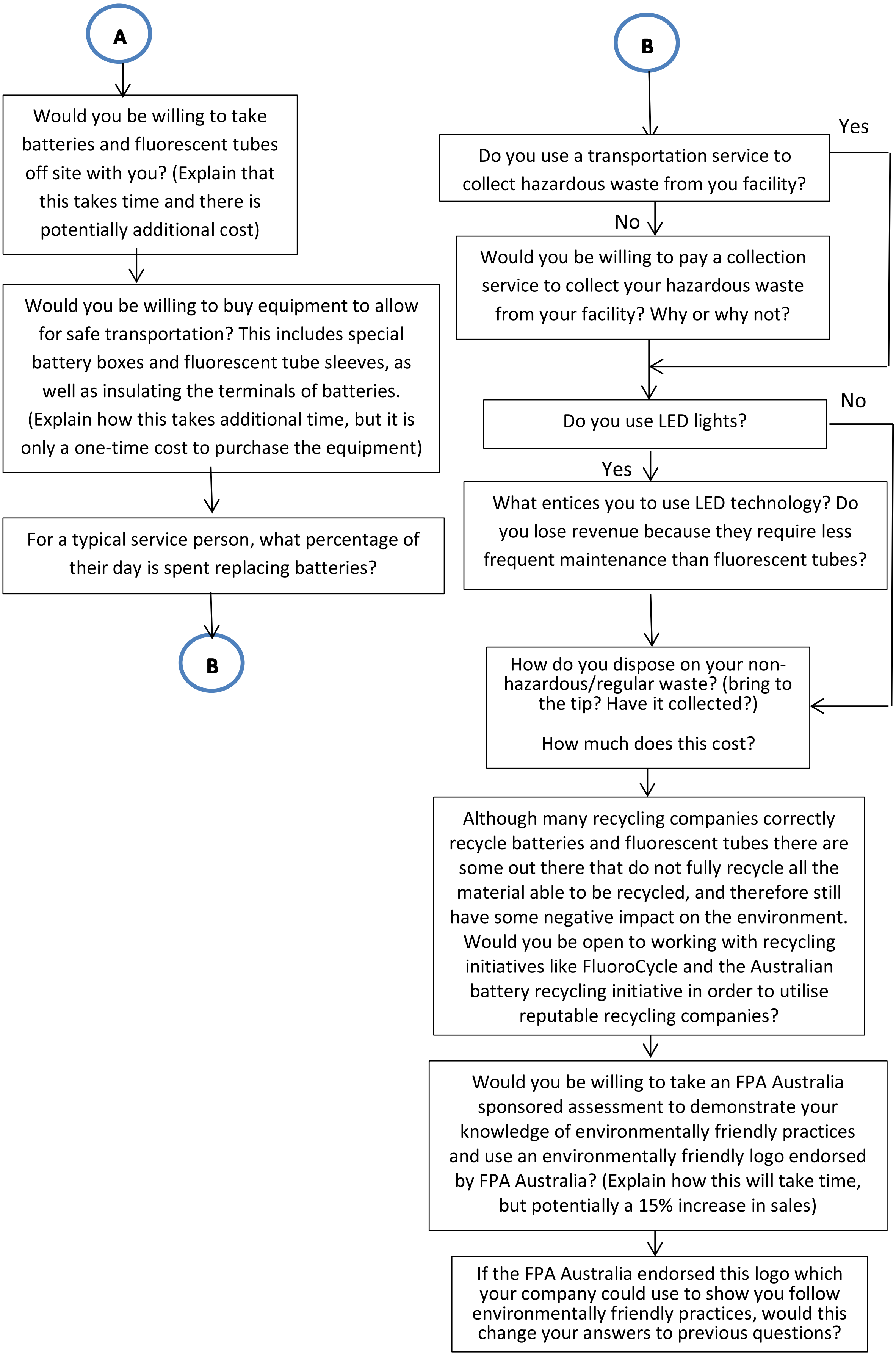
1. PB Works
   Website:
   http://besustainable.pbworks.com/w/page/6401257/Domestic%20energy%20usage
2. Energy Star
   Website:
   http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf
3. Verbatim
   Website:
   http://www.ledlightingcalculator.com.au/
4. Hawaii Energy
   Website:
   http://www.hawaiienergy.com/45/led-exit-signs
5. Commercial Lighting Calculators
   Website:
   http://c03.apogee.net/contentplayer/Files/SPC/pec_comlighting.swf
6. Rowan Engineering
   Website:
   http://www.rowan.edu/colleges/engineering/clinics/cleanenergy/rowan%20university%20clean%20energy%20program/Energy%20Efficiency%20Audits/Energy%20Technology%20Case%20Studies/files/LED%20Exit%20Signs.pdf
7. Opportunity Sustainability
   Website:
   http://www.opportunitysustainability.com/wp-content/uploads/2010/04/StartAtTheExit_Final_300dpi.pdf

Appendix J: Phone Interviews with Fire Protection Maintenance Companies

Method: Structured phone interview questions with fire protection maintenance companies to determine willingness for companies to change practices

"Hi my name is ________ and I'm calling from Fire Protection Association Australia. We are conducting a research study on hazardous waste in the fire protection industry. Would you be willing to answer some questions to help us in our research?"




A
Would you be willing to take batteries and fluorescent tubes off site with you? (Explain that this takes time and there is potentially additional cost)
Would you be willing to buy equipment to allow for safe transportation? This includes special battery boxes and fluorescent tube sleeves, as well as insulating the terminals of batteries. (Explain how this takes additional time, but it is only a one-time cost to purchase the equipment)
For a typical service person, what percentage of their day is spent replacing batteries?
B
B
Do you use a transportation service to collect hazardous waste from you facility?
Yes
No
Would you be willing to pay a collection service to collect your hazardous waste from your facility? Why or why not?
Do you use LED lights?
No
Yes
What entices you to use LED technology? Do you lose revenue because they require less frequent maintenance than fluorescent tubes?
How do you dispose on your non-hazardous/regular waste? (bring to the tip? Have it collected?)
How much does this cost?
Although many recycling companies correctly recycle batteries and fluorescent tubes there are some out there that do not fully recycle all the material able to be recycled, and therefore still have some negative impact on the environment. Would you be open to working with recycling initiatives like FluoroCycle and the Australian battery recycling initiative in order to utilise reputable recycling companies?
Would you be willing to take an FPA Australia sponsored assessment to demonstrate your knowledge of environmentally friendly practices and use an environmentally friendly logo endorsed by FPA Australia? (Explain how this will take time, but potentially a 15% increase in sales)
If the FPA Australia endorsed this logo which your company could use to show you follow environmentally friendly practices, would this change your answers to previous questions?

Appendix K: Explanation of Extrapolation

1. Divide data based on size of company

We found that disposal practices different depending on size of company. So we divided company into two groups: 1-5 service personnel (small) and 5-20 service personnel (large). Differences in disposal methods for each type of fluorescent tubes and each type of battery are shown in the tables below.

Table 7: Fluorescent Tube Disposal Method

Fluorescent Tube Disposal	Companies with 1-5 Service Personnel	Companies with 5-20 Service Personnel
Recycle	21%	12%
At the Tip	54%	59%
Customer is Responsible for recycling/disposal	21%	23%
Collected by a third party	4%	6%
Used in Resale	0%	0%

Table 8: Lead Acid Battery Disposal

Battery Disposal	Wet Cell Lead Acid Batteries		Sealed Lead Acid Batteries	
*Size of Company**	*Small*	*Large*	*Small*	*Large*
Recycle	47%	38%	55%	40%
At the Tip	13%	8%	15%	20%
Customer is Responsible for recycling/disposal	13%	15%	10%	15%
Collected by a third party	20%	31%	15%	20%
Used in Resale	7%	8%	5%	5%

Table 9: Battery Disposal Method

Battery Type	Nickel Metal Hydride		Lithium Polymer		Nickel Cadmium	
Size of Company*	***Small***	***Large***	***Small***	***Large***	***Small***	***Large***
Recycle	33%	45%	50%	50%	55%	46%
At the Tip	13%	11%	12.5%	12.5%	9%	9%
Customer is Responsible for recycling/disposal	27%	22%	12.5%	25%	18%	27%
Collected by a third party	20%	22%	12.5%	12.5%	9%	18%
Used in Resale	7%	0%	12.5%	0%	9%	0%

*Small = 1-5 Service Personnel
Large = 5-20 Service Personnel

2. Organised amount in kilograms per year of batteries replaced by size of company and type of battery

Table 10: Weight of Batteries Replaced per Week (kg)

	Wet-Cell Lead Acid		Sealed Lead Acid		Nickel Metal Hydride		Lithium Polymer		Nickel Cadmium	
*Size of Company**	*Small*	*Large*	*Small*	*Large*	*Small*	*Large*	*Small*	*Large*	*Small*	*Large*
None	18	13	10	1	18	14	23	13	20	12
0-50 kg	7	6	15	13	7	1	3	1	5	3
50-100 kg	-	-	1	-	-	-	-	-	-	-
100-250 kg	-	-	-	-	-	-	-	-	-	-
250-500 kg	1	-	-	-	-	-	-	-	-	-
500-1000 kg	-	-	-	-	-	-	-	-	-	-
>1000 kg	-	-	-	-	-	-	-	-	-	-
Number of people who responded to question	26	19	26	14	25	15	26	14	25	15

*Small = 1-5 Service Personnel
Large = 5-20 Service Personnel

Table 11: Number of Fluorescent Tubes Replaced per Week

	Fluorescent Tubes	
Size of Company*	Small	Large
0-5	14	6
5-10	5	3
10-20	4	2
20-50	2	5
50-100	-	-
>100	-	-
Number who answered this question	25	16

Use this data to find the average amount in kilograms per year of batteries replaced per company for each type of battery and size of company. For companies that answered 0-50kg of batteries/week, we average the amount to 25 kg. If the company answered 50-100, we averaged the amount to 75 kg, etcetera.

Example calculation:

Average amount in kilograms of wet cell lead acid batteries replaced per week per small company = (18*0 + 7*25 + 0*75 + 0*175 + 1*375 + 0*750 + 0*1000)/26 = 21 kg/week

We then multiplied by 52 to find estimate in kg/year

Table 12: Average Amount Replaced Per Company

	Average Amount Replaced per Small Company (kg/year)	**Average Amount Replaced per Large Company (kg/year)**
Wet Cell Lead Acid Batteries	1100 kg/year	411 kg/year
Sealed Lead Acid Batteries	900 kg/year	1207 kg/year
Nickel Metal Hydride	364 kg/year	87 kg/year
Lithium Polymer	150 kg/year	93 kg/year
Nickel Cadmium	260 kg/year	260 kg/year
Fluorescent Tubes	421 tubes/year	788 tubes/year

3. Determined that survey sample was representative of the population

   We acquired information regarding the sizes of maintenance companies in the population (all of FPA's member maintenance companies).

The responses from our survey followed this distribution:

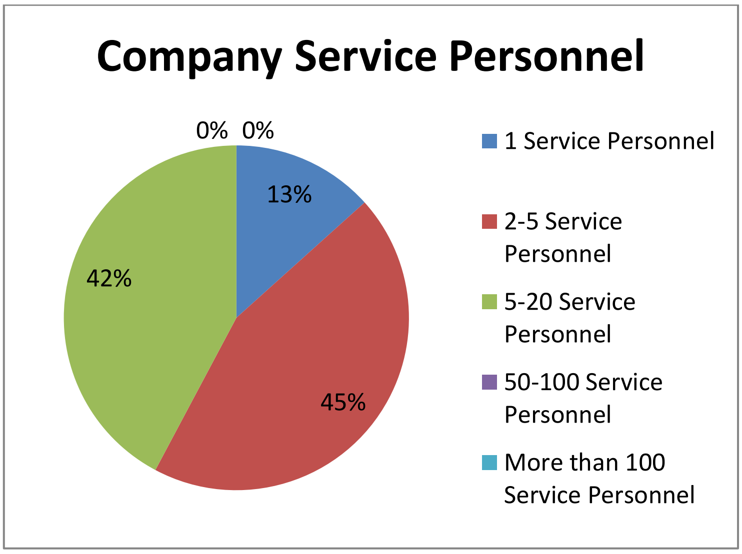


Figure 18: Survey Company Size Distribution

The population follows this distribution:

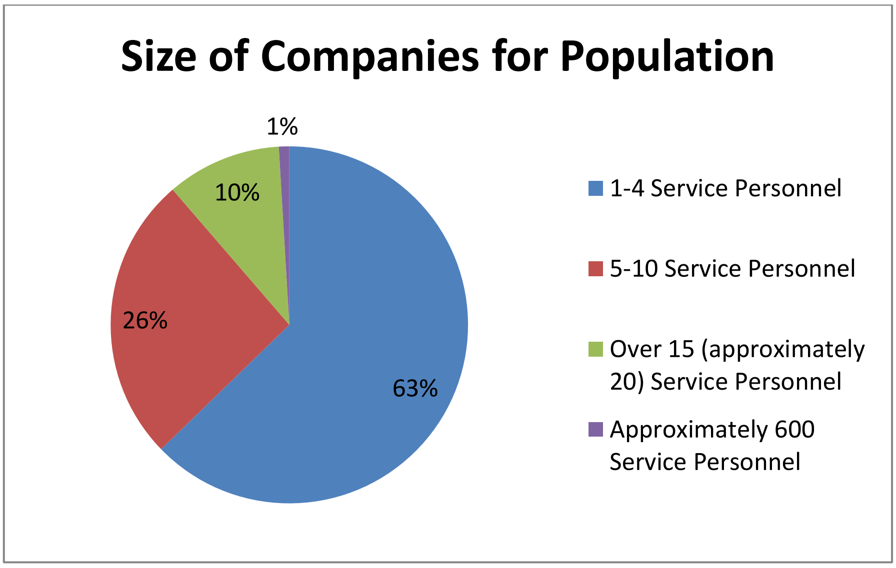


Figure 19: Population Company Size Distribution

We believe that our survey sample is representative of the entire population (421 FPA maintenance companies). For our survey participants, we have 58% of companies have 1-5 service personnel. This is similar to the population which 63% of companies have 1-4 service personnel. Also, for our survey 42% had 5-20 service personnel. This is similar to the population because 36% have approximately 5-20 service personnel. We believe that the respondents from our survey were representative of the population.

4. Extrapolated amount replaced per year by population

Using this information from the population, we can say small companies represent 63% of population and large companies represent 36% of population. This allows us to extrapolate the amount replace per year from the population, FPA Australia’s 421 fire protection maintenance companies.

Table 13: Amount Replaced

	Small Company (per year)	Large Company (per year)	Amount Replaced for Population (per year)
Wet Cell Lead Acid Batteries	290,000 kg	62,000 kg	350,000 kg
Sealed Lead Acid Batteries	240,000 kg	180,000 kg	420,000 kg
Nickel Metal Hydride	97,000 kg	13,000 kg	110,000 kg
Lithium Polymer	40,000 kg	14,000 kg	54,000 kg
Nickel Cadmium	69,000 kg	39,000 kg	110,000 kg
Fluorescent Tubes	110,000 tubes	120,000 tubes	230,000 tubes

5. Extrapolated amount disposed of in landfill per year by population

To determine how much of replaced batteries and fluorescent tubes end up in landfill per year, we continued to keep the small and large companies separate in order to estimate the amount most accurately. Tables 7, 8, and 9 show the amount disposed of at the tip for each type of battery and size of company. Again, using the information that 63% of the population is small companies and 36% of the population is large companies, we can combine the small and large companies to create an estimate for the whole population. It is not realistic to assume proper disposal occurs with the companies who have the hazardous waste collected by a third party or leave for the customer to dispose. So, we estimate the amount that is disposed of in landfill by creating a range. The low end of the range assumes customers and third party collectors properly handle hazardous waste. The high end of the range assumes that customer and third party collectors do not properly dispose of hazardous waste that ends up in landfill. In this step, we also combined sealed and wet cell lead acid batteries, due to their similar composition. We rounded the numbers to 2 significant figures.

Table 14: Amount Disposed of in Landfill

Type	Amount Replaced (per year)	Amount Disposed in Landfill* (per year)	Amount Disposed in Landfill** (per year)
Lead Acid (Combined Sealed and Wet Cell)	780,000 kg	130,000 kg	420,000 kg
Nickel Metal Hydride	110,000 kg	17,000 kg	76,000 kg
Lithium Polymer	54,000 kg	7,000 kg	23,000 kg
Nickel Cadmium	110,000 kg	14,000 kg	68,000 kg
Fluorescent Tube	230,000 tubes	140,000 tubes	210,000 tubes

*Assumes customer and third party collector properly dispose of hazardous waste
**Assumes customer and third party collector improperly dispose of hazardous waste

6. Estimated amount of hazardous material in landfill per year

Each lead acid battery is 70% and 20% lead and hazardous electrolyte solution by weight, respectively. Each nickel metal hydride, lithium polymer, and nickel cadmium battery is 20%, 16%, 18% hazardous electrolyte solution by weight. Fluorescent tubes range from 3.5mg to 15mg of mercury per tube. So we created a range of mercury that could be ending up in landfill. The low end of the range assumes the customer and third party collector does not dispose of the mercury in landfill and that there are 3.5 mg of mercury per tube, while the high end of the range assumes the customer and third party collectors disposes of the fluorescent tubes in landfill and each tube contains 15mg of mercury. We multiplied the percent of hazardous material by the weight disposed of in landfill in order to estimate how much hazardous material ends up in landfill per year.

Table 15: Hazardous Waste Disposal Estimates

Type	Amount of Batteries/ Tubes Replaced (per year)	Amount of Batteries/Tubes Disposed in Landfill* (per year)	Amount of Batteries/Tubes Disposed in Landfill** (per year)	Amount of Hazardous Material in Landfill* (per year)	Amount of Hazardous Material in Landfill** (per year)
Lead Acid (Combined Sealed and Wet Cell)	780,000 kg	130,000 kg	420,000 kg	120,000 kg	380,000 kg
Nickel Metal Hydride	110,000 kg	17,000 kg	76,000 kg	3,300 kg	15,000 kg
Lithium Polymer	54,000 kg	7,000 kg	23,000 kg	1,100 kg	3,700kg
Nickel Cadmium	110,000 kg	14,000 kg	68,000 kg	2,600 kg	12,000 kg
Fluorescent Tubes (in tubes/year)	230,000 tubes	140,000 tubes	210,000 tubes	503 – 2200 g	750 – 3200 g

*Assumes customer and third party collector properly dispose of hazardous waste
**Assumes customer and third party collector improperly dispose of hazardous waste

Appendix L: Distance from Maintenance Companies to Recyclers

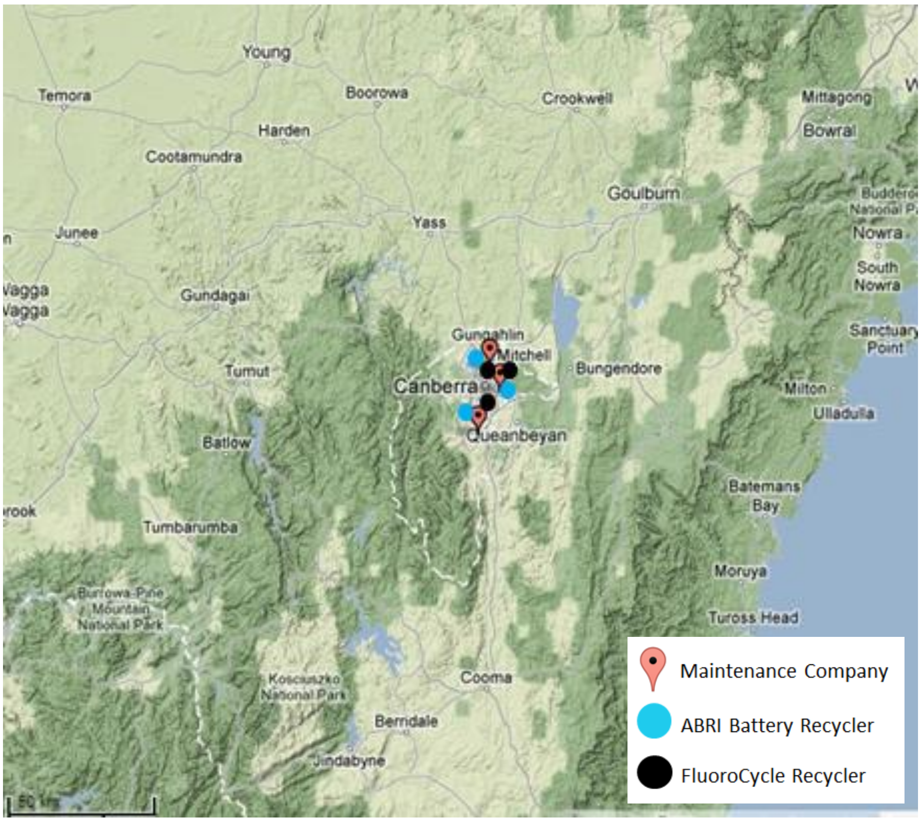


Figure 20: Australian Capital Territory Distribution of Fire Protection Maintenance Companies and Recyclers

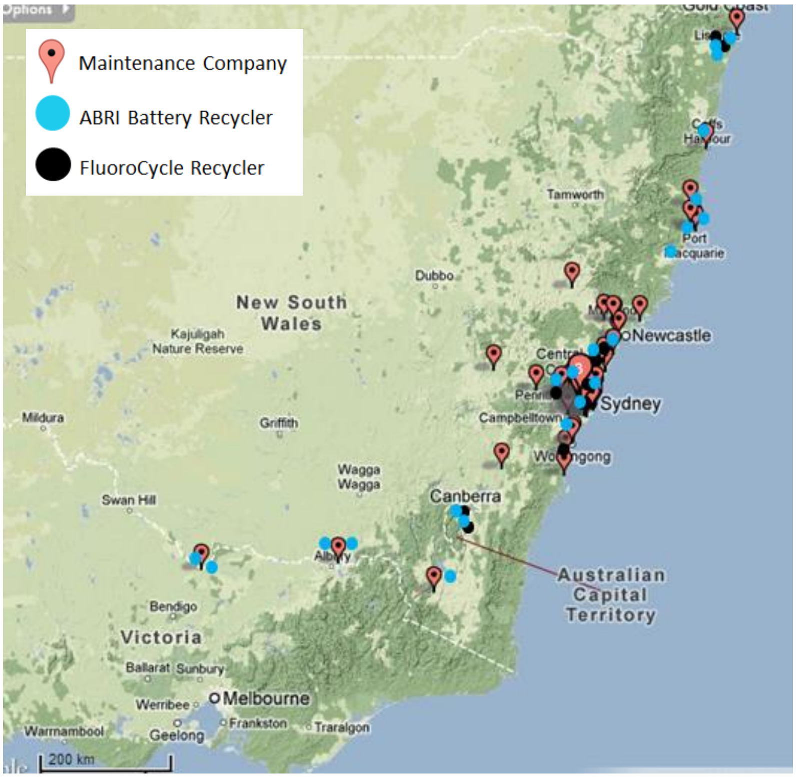


Figure 21: New South Wales Distribution of Fire Protection Maintenance Companies and Recyclers

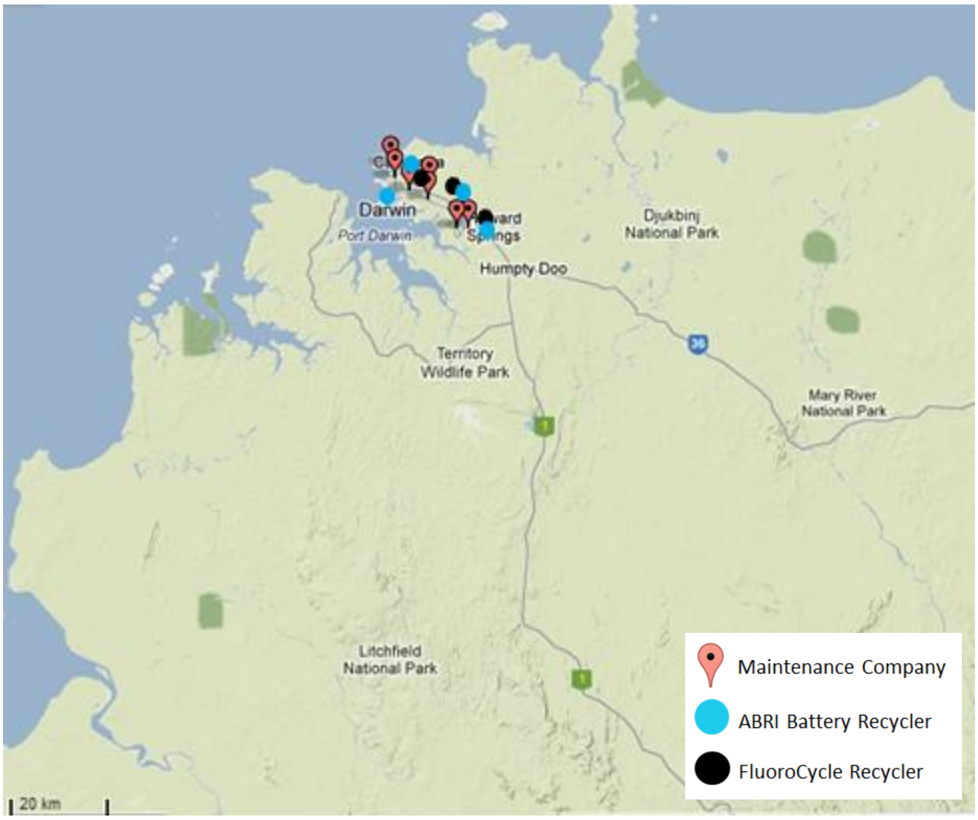


Figure 22: Northern Territory Distribution of Fire Protection Maintenance Companies and Recyclers

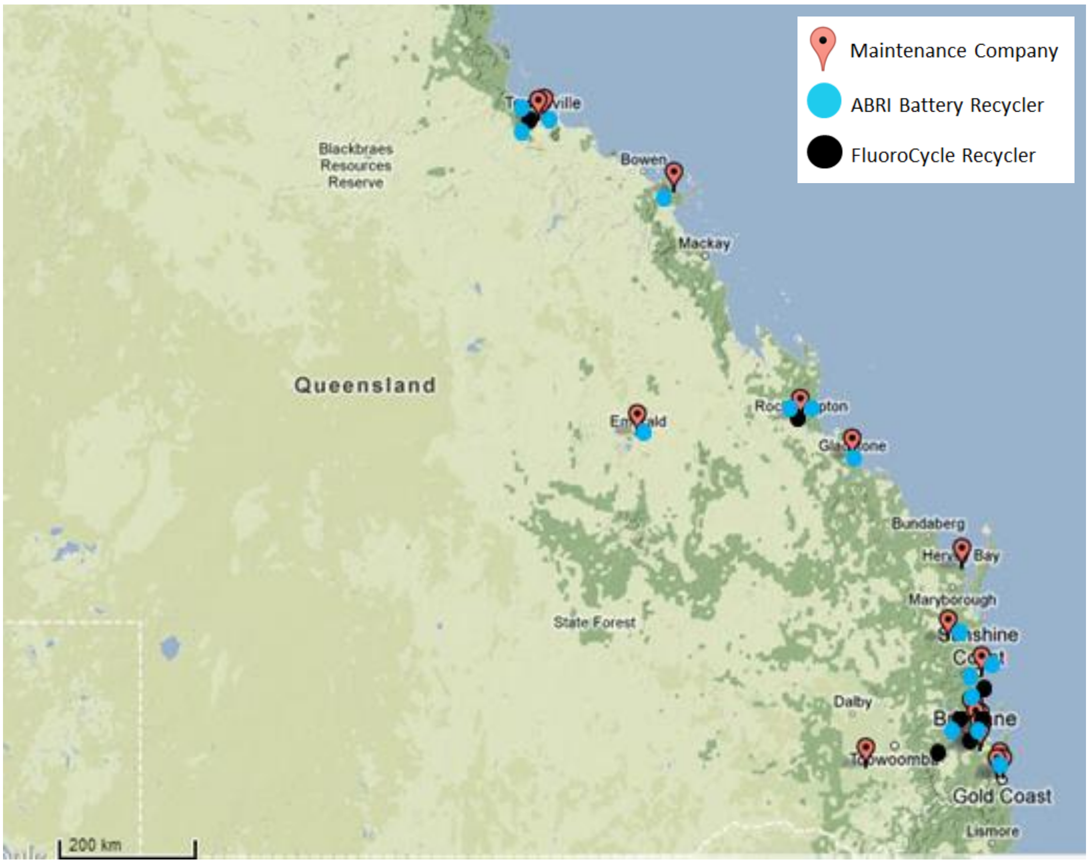


Figure 23: Queensland Distribution of Fire Protection Maintenance Companies and Recyclers

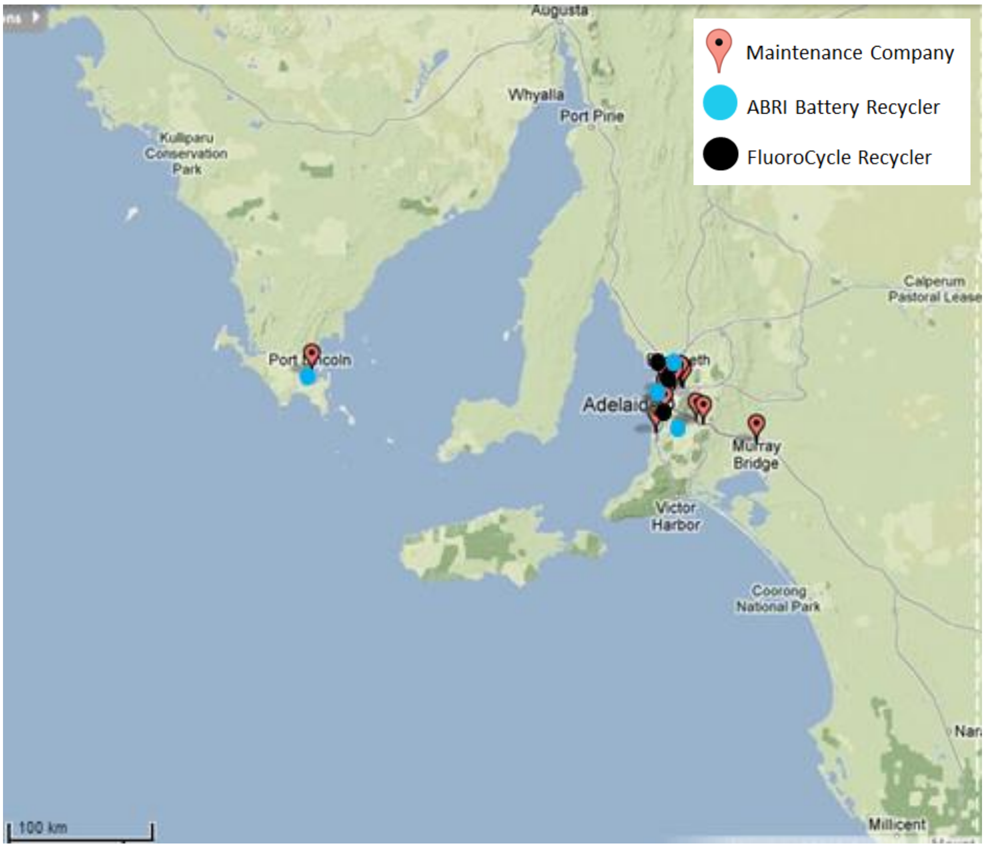


Figure 24: South Australia Distribution of Fire Protection Maintenance Companies and Recyclers

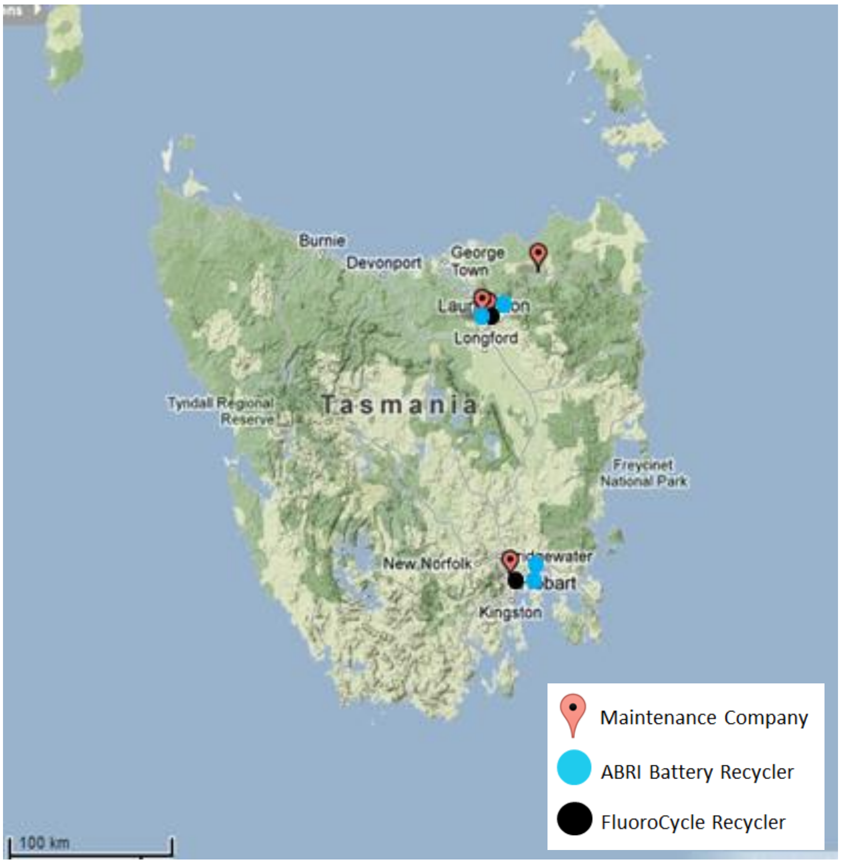


Figure 25: Tasmania Distribution of Fire Protection Maintenance Companies and Recyclers

Appendix M: Adoption and Use of AS 1851

Table 16 : Adoption and Use of AS 1851

Jurisdiction	Use of AS 1851-2012	
Australian Capital Territory	Yes	Based on interpretation of fire safety policy 05 which references the suite of AS 1851 standards without actually mentioning a year. It could be argued that AS1851-2012 is a "suite" of standards consolidated into a single document.
New South Wales	Yes	No restrictions.
Northern Territory	Yes	Prescribed building in accordance with the Northern Territory Fire and Emergency Regulations.
Queensland	No	MP6.1 specifically states that maintenance of prescribed fire safety installations must comply with AS 1851:2005 Amendment #1 with the exception of passive fire safety installations which must comply with Schedule 1 in MP 6.1.
South Australia	No	Buildings are required to be maintained in accordance with the maintenance standard listed in SA76 at the time of building rules consent. Current version of SA76 lists pre-AS 1851-2005 editions.
Tasmania	Yes	Only building constructed prior to 2004.
Victoria	Yes	Only building constructed prior to 1994.
Western Australia	Yes	No restrictions.

Fact Sheet: Environmental Impact of Batteries and Fluorescent Tubes

Fire Protection Association Australia Life Property Environment

Students from Worcester Polytechnic Institute of Worcester, Massachusetts, USA came to Melbourne to complete a project for FPA Australia to reduce the environmental impact of batteries and fluorescent tubes from the fire protection maintenance industry. The students created an environmental position statement and two best practice guides relevant to batteries and fluorescent tubes for FPA Australia to distribute to member companies.

The Problem:

Large quantities of hazardous materials from batteries and fluorescent tubes are improperly disposed of in landfill by the fire protection maintenance industry. See Table 1. These toxins not only harm plants and animals, but can also lead to severe health problems in humans including brain damage, kidney damage, child development damage, miscarriages, and cancer. FPA Australia has recognised that there is no coordinated or consistent approach within the fire protection industry for the responsible and sustained environmental disposal of batteries and fluorescent tubes.

Table 1: Research Findings: Amount of Hazardous Material*

Hazardous Material	Amount (per year)
Lead	120,000 – 380,000 kg
Cadmium	1800 – 8400 kg
Hazardous Electrolyte Solution	5700 – 25,000 kg
Mercury	500 – 3200 g

*Estimates of hazardous materials from batteries and fluorescent tubes disposed of in landfill per year by the fire protection maintenance industry.

Recommendations:

1. **Transition from Fluorescent Tubes to LED Technology:** Light emitting diodes (LEDs) last 4 times longer than fluorescent tubes, contain no hazardous material, and can result in long term cost and energy savings for the customer.
2. **Safe Equipment Handling:** Using battery boxes and fluorescent tube sleeves will decrease the risk of fire, explosion, and exposure to mercury.
3. **Recycle Batteries and Fluorescent Tubes:** Recycling is the most environmentally friendly practice and follows the FPA Australia Code of Practice. Recycling will reduce the amount of hazardous waste in landfill.
4. **Utilise Free Recycling Initiatives:** Use the Australian Battery Recycling Initiative and FluoroCycle in order to find reputable recyclers.