Australasian Fire and Emergency Service Authorities Council

Unwanted False Alarms (BCA Classifications 2 & 3)

An Interactive Qualifying Project
submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
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Date: 1 March 2013

Abstract

The Australasian Fire Authorities Council (AFAC) applies an integrated approach to emergency service operations in Australia and New Zealand. With recent increases in unwanted false alarms, AFAC identified kitchen exhaust systems as a potential solution to reduce unwanted false alarms in residential buildings. Our team conducted a cost-benefit analysis on installing kitchen exhaust systems and determined it is cost-effective to install local exhaust in low-rise but not high-rise buildings. Through our findings, we recommend investigation into alternative solutions.

Acknowledgements

Throughout this process, there have been many individuals and organizations that have guided us and lead us to where we are today. We'd like to acknowledge their support, as the success of our project would not have been possible without them.

First of all, our team would like to thank our sponsor, Rob Llewellyn, of the Australasian Fire Authorities Council. His plethora of knowledge, resources, and commitment to enhancing fire safety for the fire brigades and community truly enriched our project.

We are also grateful to Catriona Gauchie of the Australasian Fire Authorities Council for her support and generosity throughout this entire experience.

We would also like to thank members of the Australasian Fire Authorities Council that provided us with the information and advice that was necessary for us to conduct this project.

We would like to give a very special thank you to our project liaison, Dr. Jonathan Barnett, of Olsson Fire & Risk. His vast knowledge and connections were of great assistance to the outcome of our project. Our time in Melbourne would not have been the same without his support.

We would also like to thank Per Olsson and the employees at Olsson Fire & Risk for providing us with a very welcoming work environment. Their resources, advice, and insight were a huge help to the outcome of our project. We will never forget the connections we have shared with them.

Our group would like to express our gratitude to our advisors from Worcester Polytechnic Institute, Professor Paul Davis and Professor Nicola Bulled. Their constructive criticism and recommendations helped mold our project. Their continuous guidance throughout the duration of the project was very much appreciated.

We would also like to convey a special thank you to Professor Holly Ault and the Interdisciplinary and Global Studies Division of Worcester Polytechnic Institute for allowing our group the opportunity to work in Melbourne, Australia on a real-world issue in a real-world environment. We will never forget this experience.

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Executive Summary

Although smoke detectors are highly effective in preventing injury and death from fire, these devices often confuse cooking fumes or steam with real fire conditions, prompting an unwanted alarm. These alarms are not only a nuisance for individuals but also for fire brigades that must respond to these incidents. From 2011-2012, roughly one-third of all calls attended by the Queensland Fire and Rescue Service (QFRS) turned out to be from unwanted alarms (John Harrison, Personal Communication 22 January 2013). Attending unwanted alarm calls has clearly become a common occurrence for fire brigades, wasting their time and resources that could be better spent on real emergencies.

Unwanted alarms also have serious negative impacts on the community. If these alarms occur too often, they can lead to resident complacency, causing an individual to ignore an alarm even when there is a real fire danger. In 2012, for instance, two young women were forced to jump from the fifth floor of their Sydney apartment building to escape a fire; one was killed, the other badly injured. These women failed to evacuate promptly after the alarm sounded, perhaps because of the building's history of unwanted alarms (Cuneo, Klein, and Vidler, 2012). Clearly, unwanted alarms limit the safety of residents and may even lead to injury or death.

In 2011-2012, the Queensland Fire and Rescue Service (QFRS) reported a full cost of nearly $5000 to attend each of its 3,860 unwanted alarms, a total cost in that single year alone of approximately one hundred million dollars (J. Harrison, Personal Communication, 31 January 2013). Fire brigades have implemented charges for each incident to counteract the excessive costs of responding to unwanted alarms and give an incentive for residents to prevent the incident. Although some charges have reached over $1,000, they still fail to reduce unwanted

alarms, resulting in monetary losses for both fire brigades and the community and prompting the need for alternative solutions.

The Australasian Fire Authorities Council (AFAC) has proposed installing kitchen exhaust systems in Class 2 (residential apartments) and Class 3 (hotels, hostels, etc.) buildings to reduce unwanted alarms by removing the cooking fumes and steam. This report examines the cost-effectiveness of installing exhaust systems by assessing the negative consequences of unwanted alarms on fire brigades and the community and conducting a cost-benefit analysis.

The cost-benefit analysis in this report compares the cost of installing kitchen exhaust systems in new Class 2 and Class 3 buildings against the benefits for the fire brigade and the community that occur from the reduction of unwanted alarms. Three different scenarios were used in the analysis to compare potential benefits from the reduction of unwanted alarms.

Scenario 1 accrues the benefits for the fire brigade and the residents. This scenario assumes that the installation of exhaust will reduce 100 % of unwanted alarms due to cooking fumes and steam in new residential buildings. The value of the benefit for the fire brigade from the reduction of unwanted alarms is approximately $273,000 over one year and accrues to approximately $9.9 million over ten years. The value of the benefit for residents in reduction of unwanted alarm charges is approximately $79,000 over one year and $2.8 million over ten years.

The second scenario accrues the benefits for the fire brigade and residents and takes into account the possibility of lack of maintenance reducing the effect of the exhaust system. In the absence of other data, we assume that the failure rate of exhaust systems due to neglect is the same as that of smoke alarms. In comparison to Scenario 1, the value of the benefit to the fire brigade over ten years decreases to approximately $5.8 million. Obviously, the effectiveness of exhaust is limited if the system is not maintained.

Scenario 3 accrues the benefits for the fire brigade and residents, returns to the assumptions of Scenario 1 – 100 % effectiveness of exhaust over ten years – and adds the benefit of annually avoiding one death each year due to reduction in unwanted alarms and therefore complacency. Using the value of a statistical life stated by the Australian government reported as $3.8 million (ABCB, 2012, 28), over one year, the value of this benefit was $3.8 million. Over ten years, the value of this benefit was approximately $26.1 million.

The ten-year analysis indicates that installing kitchen exhaust systems in low-rise residential buildings is cost-effective in all benefit scenarios but not in high-rise residential buildings. These vast differences in cost-effectiveness of low and high-rise buildings can be attributed to the differences in costs to install the local exhaust versus the central shaft ($684 versus $4,600). Due to limitations in the data, this analysis was based on only two building examples from Queensland and cannot necessarily be generalized for the whole building stock of Australia.

This analysis involved acquiring unwanted alarm data from each state, including: the number of unwanted alarms in any given year, causes of unwanted alarms (cooking fumes, steam, etc.), type of detectors that were set off, and the building type in which these unwanted alarms occurred. However, many states were unable to obtain this information, which restricted our findings. In order to address this problem, we recommend that Australian fire authorities look into creating a central database for unwanted alarm statistics and a standardized coding system for fire brigades when recording responses to unwanted alarms.

We also investigated alternative solutions that could address the unwanted alarm problem. Some potential solutions include:

- Education-targeted solutions
- Multi-criteria detectors

- Multi-sensor detectors
- Alarm Acknowledgement Facility (AAF)
- Sprinkler systems

These alternative solutions are appropriate because they could address the entirety of the unwanted alarm problem in all types of buildings. Perhaps if more information regarding the demographics, location, and causes of unwanted alarms could be found for all states, a full cost-benefit analysis for each solution could be achieved based on more than the two notional examples we have established in this report. The results from such analysis could lead to more conclusive findings as to which one of these or additional solutions better address the entirety of the unwanted alarm issue.

1 Introduction

In the 2005-2006 fiscal year, the total cost of fire in Australia was over seven billion dollars. Nearly four and one-half billion – 63 % of this total expenditure – was spent in anticipation of fire (Allen Consulting Group, 2008). Clearly, Australia is willing to invest heavily in fire safety and in protecting individuals from fire risk. Despite this major investment, individuals are still at risk because of limitations in one of the most ubiquitous and effective forms of fire safety technology, smoke detectors.

Smoke detectors often confuse cooking fumes or steam with real fire conditions, prompting an unwanted alarm. In 2011-2012, cooking fumes and steam caused 63 % of all unwanted alarms in Queensland’s residential apartment buildings and hotels (J. Harrison, Personal Communication, 31 January 2013). These alarms can lull occupants into complacency of alarms, thereby delaying evacuation when there is a real fire danger. In 2012, two young women were forced to jump from the fifth floor of their Sydney apartment building to escape a fire; one was killed, the other badly injured (Cuneo, Klein, and Vidler, 2012). They failed to evacuate promptly after the alarm sounded, victims perhaps of this building’s history of unwanted alarms.

In 2011-2012, the Queensland Fire and Rescue Service (QFRS) reported a full cost of nearly $5000 to attend each of its 3,860 unwanted alarms, a total cost in that single year alone of approximately one hundred million dollars (J. Harrison, Personal Communication, 31 January 2013). To counteract these excessive costs, fire brigades charge residents for responding to these alarms. However, the number of incidents has declined little, and fire brigades continue to waste millions of dollars every year related to unwanted alarms. That waste is compounded by the costs of resources directed away from genuine emergencies, fire safety education, and other community needs.

The Australasian Fire Authorities Council (AFAC) has proposed installing exhaust systems in residential buildings to reduce unwanted alarms by removing the offending steam or fumes. The goal of this project was to examine the effectiveness of installing exhaust systems in residential buildings in order to reduce the number of unwanted alarms. Our project team examined the causes of unwanted alarms, assessed their negative consequences on fire brigades and the community, and analysed the costs and benefits of installing exhaust systems. This research provided us with evidence that although exhaust systems are beneficial in reducing unwanted alarms, it would not be cost-effective for all residential buildings. Our project group examined several alternative solutions for stakeholders to investigate further, including smarter smoke detector technology, sprinkler systems and educational techniques toward behaviour change.

2 Background

2.1 Unwanted Alarms

The Australian government invests billions of dollars each year for the safety of its citizens by employing fire brigades. A large portion of this investment directly relates to the most important fire brigade duty: responding to all calls and incidents. However, some calls attended by brigades are not real emergencies. Those calls that are false and stem from an automatic fire alarm signal are classified as unwanted alarms (UA).

Responding to these unwanted alarms is a recurring issue for fire brigades. In 2011, the Queensland Fire and Rescue Service (QFRS) responded to roughly 65,000 total incidents. Some states can attribute more than one-third of their total calls to responding to unwanted alarms. As shown in Table 1, the number of unwanted alarms is different in each state.

Table 1: 2011-2012 Unwanted Alarm Statistics in Australian States

State	Total incidents	Total UA	UA in Residential Properties	UA in Residential Properties due to Cooking and Steam
Queensland[1]	63,253	19,900	6,083	3,860
New South Wales[2]	131,553	48,693	11,271	3,261
Western Australia[3]	23,994	11,346	N/A	653
Tasmania[4]	10,914	3,584	439	62

Unwanted alarms occur in all types of buildings. However, a substantial amount of these unwanted alarms are found in residential properties. These types of buildings are classified under the National Construction Code as Class 2 (residential apartments) and Class 3 (hotels, hostels,

[1] J. Harrison, Personal Communication,
[2] C. Herridge, Personal Communication,
[3] P. Ryan, Personal Communication,
[4] J. Knight, Personal Communication

etc.) buildings. All residential building types that must be connected to the fire brigade are commonly referred to as Automatic Fire Alarm (AFA) systems.

Common causes of unnecessary alarms and corresponding fire brigade responses in residential buildings include cooking fumes from the kitchen and steam from the shower. In Queensland, these causes are responsible for nearly two-thirds of all unwanted alarms in residential buildings (Figure 1).

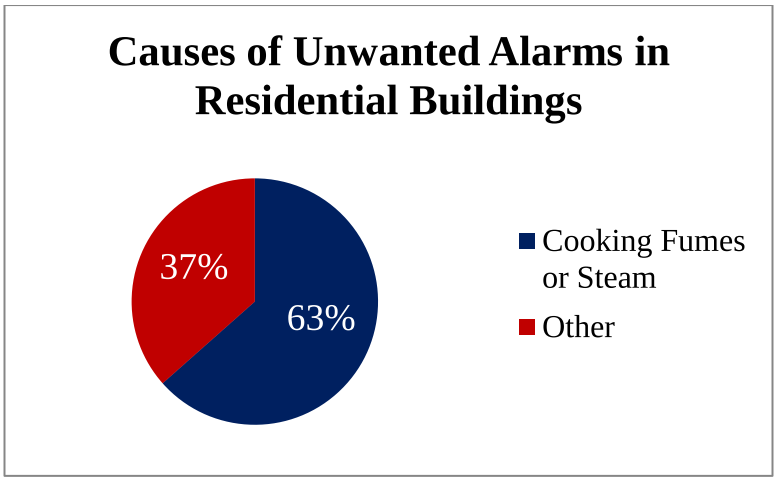

Figure 1: 2011 Causes of Unwanted Alarms in Queensland

Although not as extensive, cooking fumes and steam still account for a large number of unwanted alarms in other states. For example, New South Wales responded to over 3,200 unwanted alarms in residential buildings that were caused by cooking fumes and steam (Figure 2). In a state that responds to over 125,000 annual calls on average, any reduction in the number of unwanted alarms is a relief for the fire brigade and the community.

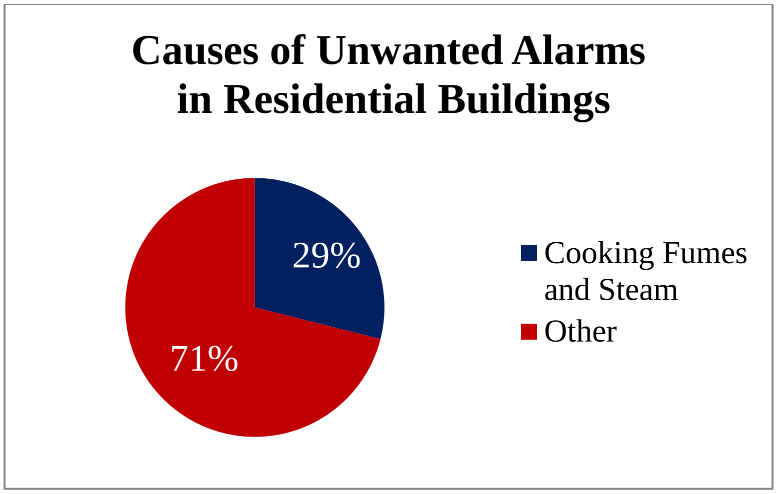

Figure 2: 2011 Causes of Unwanted Alarms in New South Wales

Unwanted alarms in residential units are caused by air pollutants and particles that are large enough to trigger the smoke detector. People are often careless about their methods of cooking and easily disregard actions such as opening windows to clear smoke. This action can help prevent the smoke detector from signalling the fire brigade.

Unwanted alarms waste fire brigade resources. The fire brigade uses equipment and other valuable resources for proper response. The full cost to attend each call varies depending on the state. Queensland and New South Wales full cost to attend in 2011-2012 was an astounding $4,566 and $3,008, respectively. The components of the full cost include operational direct, fire communications, operational preparedness and head office overhead. Operational direct cost includes items such as fuel and equipment, fire communications is the cost for dispatching the fire crews to respond, operational preparedness is having the resources ready at the station for when a crew needs to respond, and head office overhead is administrative expenses (J. Harrison, R. Llewellyn, Personal Communication, 31 January 2013).

Coupling these costs of attendance with the numbers of alarms provided in Table 6, the full cost for fire brigades to attend unwanted alarms in Queensland in 2011-2012 was approximately $90 million, of which $17.6 million were in residential buildings caused by cooking fumes and steam. In the same year, New South Wales spent over $146 million for responding to unwanted alarms. Nearly $10 million of the cost was from responses to residential buildings where cooking fumes and steam were the cause of the unwanted alarm.

Opportunity cost for fire brigades also stems from unwanted alarms. Rather than responding to an unwanted alarm, fire brigades could be engaged in beneficial activities. These activities include having additional resources to respond to a real emergency, additional training for fire fighters, and community education programs to teach fire safety. A reduction in unwanted alarms can help fire brigades to better allocate their resources (P. Considine, Personal Communication, 16 January 2013).

2.2 Negative impacts

A real life risk is associated with responding to unwanted alarms. Fire fighters and members of the community are placed at greater risk for a traffic accident to occur during a response to an unwanted alarm. Reducing the density of unwanted alarm responses could perhaps reduce the life-risk toward fire brigades and the community.

The negative impacts of unwanted alarms also affect residents and building owners. Fire brigades charge residents and building owners for causing unwanted alarms. Charging those who trigger the smoke alarm from cooking fumes or steam has been legislated in all Australian states with the exception of Western Australia.

Table 2: 2011 unwanted alarm charges

State	False alarm charge
NSW[5]	$750
QFRS[6]	$1020.30
TFS[7]	$298
FESAWA[8]	No charge (currently)
NZFS[9]	$1000+GST

The charges can be a burden for residents and building owners if they are constantly producing unwanted alarms. The cost range for these charges is seen in Table 2 above. Queensland issues the harshest charges for responding to unwanted alarms while other states, such as Tasmania, charge much less. In 2011-2012, Queensland and New South Wales residents were charged a total of $4 million and $2.5 million, respectively, for alarms caused by cooking fumes and steam in residential units.

2.3 Occupant Complacency

Unwanted alarms also cause occupant complacency. If there are multiple unwanted alarms in a building, the occupants may become complacent to the alarm which reduces its effectiveness in a real emergency. In 2012, an incident in Sydney resulted in the death of one woman and serious injury of another. A Sydney news station reported that one of the occupants "thought nothing of it when the fire alarm sounded – false alarms were an almost daily occurrence" (Cuneo, Klein, and Vidler, 2012). This real-life event shows how occupants can become numb to the warning signals from smoke alarms. This death, as in any case, can be considered a cost to society. In fact, the Australian government values a statistical life at $3.8

[5] Automatic Fire Alarms. *Fire & Rescue NSW*. 30 January 2013. www.fire.nsw.gov.au/page.php?id=77
[6] J. Harrison, Personal Communication, 31 January 2013
[7] J. Knight, Personal Communication, 24 January 2013
[8] R. Llewellyn, Personal Communication, 18 February 2013
[9] False Alarm Charging. *New Zealand Fire Services*. 30 January 2013. www.fire.org.nz/business-fire-safety/unwanted-alarms/pages/false-alarm-charging.aspx

million (ABCB, 2012). Occupant complacency is a serious problem directly attributable to the unwanted alarms.

2.4 Exhaust Systems

The purpose of exhaust systems is to properly remove the indoor air and exchange it with the outdoor air. This is important in maintaining a low level of moisture and removing any pollutants from the air circulating within the building. A report in *Environmental Design and Construction* explains that "exhaust systems are important because they carry pollutants from the source directly outside, which keeps them from migrating into other areas of the building" (Bryan & Malou, 2004). Exhaust systems play a fundamental role in removing air pollutants from an area in an apartment to the outside.

The effectiveness of exhaust systems at removing air pollutants may be able to reduce unwanted alarms due to cooking fumes and steam in residential buildings. Queensland authorities have already begun testing the use of exhaust as a means of reducing unwanted alarms. For example, exhaust was installed into 18 new residential buildings and compared to 18 similar buildings that did not have exhaust. The old buildings without exhaust produced a total of 1,005 unwanted alarm call-outs in one year while the new buildings generated 192. Queensland has also recently retrofitted a building with exhaust. A reduction from 195 to 3 after exhaust was installed proved that exhaust is effective at reducing unwanted alarms (Reid, 2010).

Design aspects for buildings must be taken into account for installing exhaust. There are two types of buildings used in this report: low-rise and high-rise. A low-rise building is typically less than 25 meters in height and no more than 10 storeys. Exhaust can be ducted above a false ceiling directly to an external wall within the apartment, or sole occupancy unit (SOU). This scenario is the cheapest option for exhaust systems. A high-rise building is usually more than 25 meters in height and over 10 storeys. Installing exhaust is more expensive in this type of building because it requires a central shaft. This component provides an outlet to the roof for local ducting. A cover at the end of the shaft prevents strong winds from pushing cooking fumes back into the apartment. In addition, central shafts are expensive because they require more ducting, extra fans to boost airflow for improved efficiency, and fire dampers to prevent the spread of fire. They also reduce space available for sale or rent.

Maintenance of these appliances is very critical for assuring their effectiveness at removing air pollutants. Residents may not maintain their exhaust, and thereby fail to reduce unwanted alarms from cooking fumes and steam.

An AFAC report states that 67% of household fire incidents occurred where the smoke alarm was either disabled or malfunctioned (ABCB, 2012). One could speculate that exhaust systems might experience a similar rate of failure due to neglect or misuse. We will explore that issue in this report. In the absence of other data, we will assume that the failure rate of exhaust systems due to neglect is the same as that of smoke alarms, namely 67%.

AFAC has suggested exhaust systems as a solution to reducing unwanted alarms in residential units due to cooking fumes and steam. In order to assess this solution, our team conducted a cost-benefit analysis to determine if the potential reduction in unwanted alarms, decrease in charges, and decrease in life-risk outweigh the costs of installing kitchen exhaust systems in new buildings.

3 Methodology

A cost-benefit analysis compares the costs of a proposed policy change, such as requiring installation of exhaust systems in residential buildings, to value of the benefits obtained to determine if such a solution is cost-effective. The cost-benefit analysis is based on a series of costs and benefit values where the output is the value of the accrued benefits minus the costs of implementing the solution. If the accrued benefits outweigh the costs over a given time period, the solution is considered cost-effective. Since cost-benefit analyses consider society as a whole, they are governed by the concept of allocative efficiency: it is "impossible to make any one person better off without in the process making someone else worse off" (Commonwealth of Australia, 2006, 18). More crudely, costs and benefit values are compared across the entire community without regard to the distinguishing among the particular segments that might be incurring the costs or enjoying the benefits.

The cost-benefit analysis in this report compares the cost of installing kitchen exhaust systems in new Class 2 and Class 3 buildings against the benefits for the fire brigade and the community that occur from the reduction of unwanted alarms. The fire brigade benefit is the savings from the full cost to attend minus the charge to residents, otherwise known as the true cost. The community benefits from the reduction in charges and the possible prevention of death from complacency, disabled smoke detectors, or traffic accidents. Benefits such as opportunity cost and structural damages were ignored in this analysis because of the difficulty to assign them values.

This report's analysis relies on statistics and estimates from Queensland because of the difficulty of acquiring accurate data from other states. These statistics include the QFRS true cost, charges, unwanted alarm data, the annual increase in building stock, and estimates on exhaust costs. This data may not be representative of any other state, making it difficult to extrapolate the analysis to all of Australia.

The assumptions used in the analysis to acquire a ten-year cost-benefit value include a building growth rate of 2 % per year in Queensland, an inflation rate of 3 % per year, and Net Present Value (NPV) discount rates of 3 %, 7 %, and 10 %. The building growth rate refers to the average annual increase in building stock while the inflation rate is the annual average increase in costs. The NPV compares the value of a dollar today to the value of that same dollar in the future, taking into account inflation, preferences for consumption for today rather than later, and the opportunity cost of capital. The discount rate is the assumed rate of return from today until then (O. Pavlov, Personal Communication, 30 January 2013). Three discount rates are used in the analysis to test the sensitivity of this assumption.

4 Data and Analysis

4.1 Cost of Exhaust/Sole Occupancy Unit

Because low-rise buildings are less complex than high-rise, the cost per SOU of installing kitchen exhaust in a low-rise residential building is about one-seventh the cost in a high-rise residential building. The cost components of kitchen exhaust in a low-rise residential building includes the range hood (Blanco Appliances), ducting, and installation. The total cost per SOU is approximately $684 (J. Saffery, Personal Communication, 15 January 2013). The cost break down is shown in Table 3 below. The cost components of kitchen exhaust in a high-rise residential building includes the range hood, ducting, a central shaft, fans, fire dampers, and installation. The total cost per SOU is approximately $4,600 (K. Ng, Personal Communication, 1 February 2013). The cost break down is shown in Table 3 below.

Table 3: Cost components of installing exhaust systems

Component	Low-Rise[10]			High-Rise[11]		
	Cost	SOUs	Total	Cost	SOUs	Total
Range Hood	$449	12	$5,388	$449	100	$44,900
Ducting	$115	12	$1,380	$1,000	100	$100,000
Central Shaft	-	-	-	$750	100	$75,000
Fans	-	-	-	$250	100	$25,000
Inline-Support Fan	-	-	-	$500	100	$50,000
Fire Dampers	-	-	-	$150	100	$15,000
Labour	$120	12	$1,440	$1,000	100	$100,000
Misc. Costs	-	-	-	$500	100	$50,000
Total Building Cost:			**$8,208**			**$459,900**
Total per SOU:			**$684**			**$4,599**

[10] Costs based on a notional three storey building with four SOUs per storey.
[11] Costs based on a notional ten storey building with ten SOUs per storey.

4.2 Total Exhaust System Cost

Since we have no data on the mix of low- and high-rise buildings in new residential construction in Queensland, we will analyse two extremes: the assumption that all new AFA connected residential buildings are either all low-rise or all high-rise. The average number of new AFA connected residential buildings built each year in Queensland is fifty-one. A notional low-rise building was used in the analysis to acquire the minimum cost to install exhaust systems. This building was three storeys with four SOUs per storey. With a total of twelve SOUs, the total building cost to install exhaust systems is approximately $8,200 (Table 3). The minimum total cost to install exhaust in one year is approximately $419,000, assuming all new buildings are low-rise (Table 4). A notional high-rise building was used in the analysis to acquire the maximum cost to install exhaust systems. This building was ten storeys with ten SOUs per storey. With a total of 100 SOUs, the total building cost to install exhaust systems is approximately $460,000 (Table 3). The maximum total cost to install exhaust in one year is approximately $23.5 million, assuming all new buildings are high-rise (Table 4).

The total cost over ten years to install exhaust in all new low-rise buildings is nearly one-fifty-sixth of the total cost to install exhaust in all new high-rise buildings. Since the building stock increases at approximately 2 % per year, the total number of new residential buildings built with AFAs over 10 years is 558. Assuming all 558 new buildings are the notional low-rise, the minimum total cost to install exhaust over 10 years is approximately $3.1 million (Table 4). Assuming all 558 new buildings are the notional high-rise, the maximum total cost to install exhaust over 10 years is approximately $175 million (Table 4). These total costs assume an inflation rate of 3 % per year and a NPV discount rate of 10 %.

Table 4: Total cost of installing exhaust systems over one and ten years

	One Year Cost	Ten Year Cost
Notional Low-Rise	$418,608	$3,117,958
Notional High-Rise	$23,454,900	$174,701,380

4.3 Benefit Scenarios

Calculating the value of the benefits for the fire brigade and residents relies on several assumptions. The first assumption is that the new residential building stock will remove about seventy-seven unwanted alarms each year as a result of installing exhaust. In the 2011-2012 fiscal year, there were 3,860 unwanted alarms due to cooking fumes and steam in residential buildings in Queensland. Since the building stock increases by 2 % each year, 77 of these unwanted alarms can be attributed to new residential buildings (1.51 UAs per building). Another assumption is that each ten year benefit value assumes a building growth rate of 2 % per year, an inflation rate of 3 % per year, and a NPV discount rate of 10 %.

Three different scenarios were used in the analysis to compare potential benefits from the reduction of unwanted alarms. Scenario 1 accrues the benefits for the fire brigade and the residents. This scenario assumes that the installation of exhaust will reduce 100 % of unwanted alarms due to cooking fumes and steam in new residential buildings. The value of the benefit for the fire brigade uses the true cost to attend for each unwanted alarm. This value is approximately $273,000 over 1 year (Table 5). Over 10 years, the value of the benefit is approximately $9.9 million (Table 6). The value of the benefit for residents uses the charges issued by the fire brigade for each unwanted alarm. This value is approximately $79,000 over 1 year (Table 5). The value of the benefit over 10 years is approximately $2.8 million (Table 6). Refer to Table 5 and Table 6 to see the total value of accrued benefits for Scenario 1.

Scenario 2 considers a 67 % reduction in exhaust effectiveness after the initial two years of installation because of the potential lack of maintenance as discussed in the background. The value of the benefit for the fire brigade and residents is the same as Scenario 1 over one year (Table 5) because it is assumed the exhaust systems will remain 100 % effective for the first two years. In comparison to Scenario 1, the value of the benefit to the fire brigade over ten years decreases to approximately $5.8 million (Table 6). The value of the benefit to residents decreases to $1.7 million. Refer to Table 5 and Table 6 to see the total value of accrued benefits for Scenario 2.

Scenario 3 returns to the assumptions of Scenario 1 – undiminished reduction in unwanted alarms over the ten years of analysis – and adds the benefit of annually avoiding one death due to an unwanted alarm. This scenario assumes one death related to unwanted alarms is prevented each year. This assumption may be reasonable since the average number of residential fire related deaths is about fifty-two per year (ABCB, 2012, 55). The Australian government reported that the value of a statistical life is $3.8 million, regardless of age (ABCB, 2012, 28). Over one year, the value of this benefit is $3.8 million (Table 5). Over ten years, the value of this benefit is approximately $26.1 million (Table 6). Refer to Table 5 and Table 6 to see the total value of accrued benefits for Scenario 3.

Table 5: Value of benefits in each scenario over one year

	One Year			
	Value of Benefit For Fire Brigades	**Value of Benefit For Residents**	**Value of Death Prevention**	**Total Accrued Benefits**
Scenario 1	$273,042	$78,540	-	$351,582
Scenario 2	$273,042	$78,540	-	$351,582
Scenario 3	$273,042	$78,540	$3,800,000	$4,151,582

Table 6: Value of benefits in each scenario over ten years

	Ten Years			
	Value of Benefit For Fire Brigades	**Value of Benefit For Residents**	**Value of Death Prevention**	**Total Accrued Benefits**
Scenario 1	$9,850,796	$2,833,583	-	$12,684,379
Scenario 2	$5,806,431	$1,670,229	-	$7,476,660
Scenario 3	$9,850,796	$2,833,583	$26,128,066	$38,812,445

4.4 Cost-Benefit Analysis

Each new building will have an initial investment to install exhaust but accrue the benefits of exhaust (reduction in unwanted alarms) in every subsequent year. Each building will invest in exhaust in year one and accrue the benefits then and each year thereafter. In year two, the new buildings built then will invest in exhaust while benefits continue to accrue from the buildings built in year one. This process is repeated for each year, resulting in the benefits stacking upon one another. An example is shown in Figure 3 below.

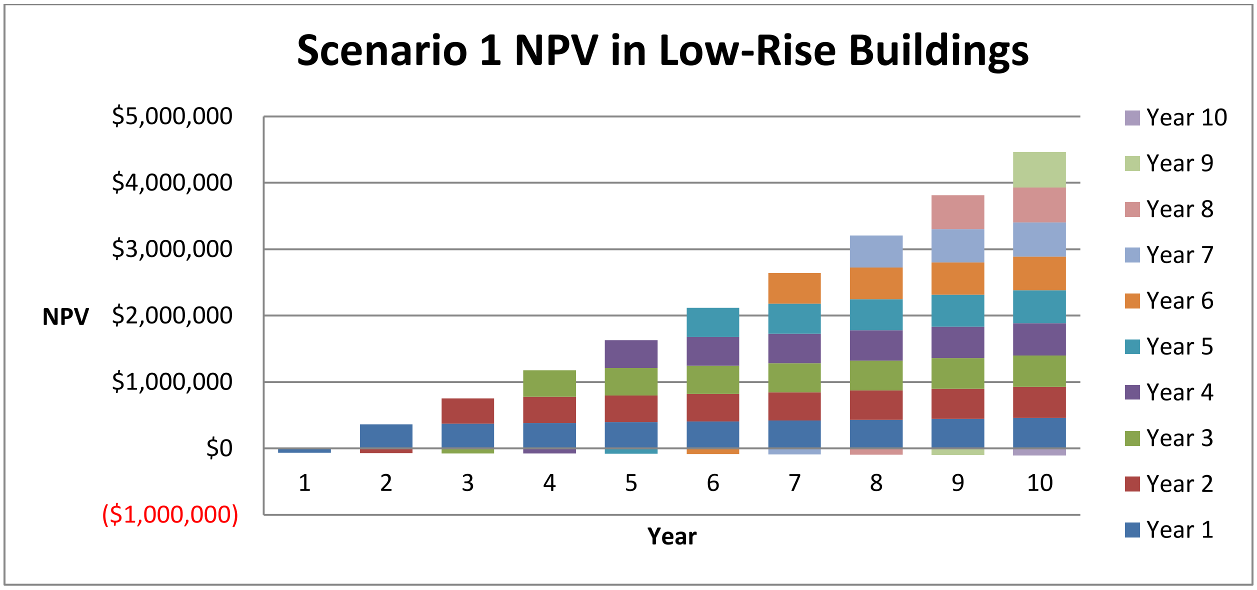

Figure 3: Scenario 1 NPV in Low-Rise Buildings Over Ten Years

The ten year analysis indicates that installing kitchen exhaust systems in low-rise residential buildings is cost-effective in all benefit scenarios. Each scenario has a positive NPV as shown in Table 7 below. Figure 4 shows the cost of installing exhaust in low-rise buildings against the benefits in each scenario.

Table 7: NPV of low-rise exhaust cost vs. accrued benefits

Ten Years			
Scenario	**Low-Rise Cost ($)**	**Accrued Benefits ($)**	**NPV ($)**
1	$3,117,958	$12,684,379	$9,566,421
2	$3,117,958	$7,476,660	$4,358,702
3	$3,117,958	$40,433,486	$35,694,487

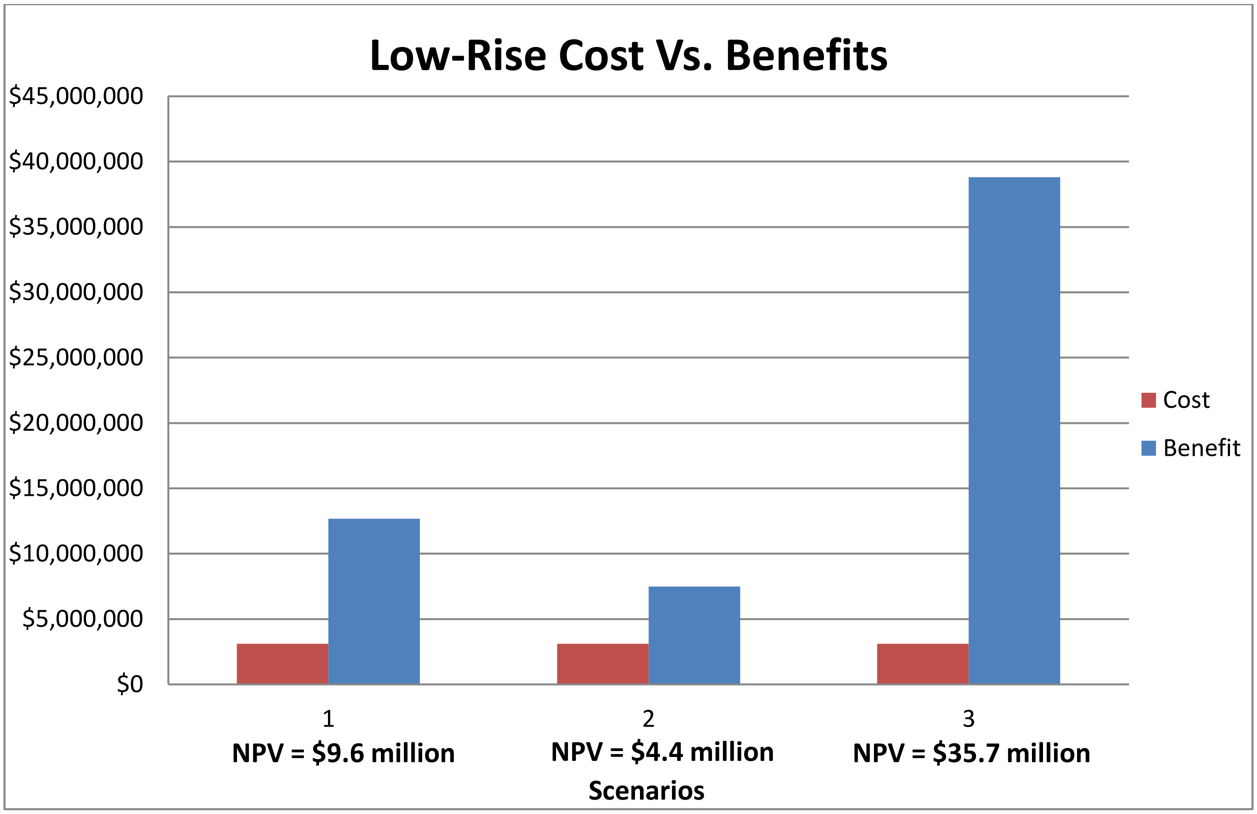

Figure 4: NPV of low-rise exhaust cost vs. accrued benefits

The ten year analysis indicates that installing kitchen exhaust systems in high-rise residential buildings is not cost-effective in any benefit scenario. Each scenario has a negative NPV as shown in Table 8 below. Figure 5 below shows the cost of installing exhaust in high-rise buildings against the benefits in each scenario.

Table 8: NPV of low-rise exhaust cost vs. accrued benefits

Ten Years			
Scenario	**High-Rise Cost ($)**	**Accrued Benefits ($)**	**NPV ($)**
1	$174,701,380	$12,684,379	(-) $162,017,030
2	$174,701,380	$7,476,660	(-) $167,224,720
3	$174,701,380	$40,433,486	(-) $135,888,935

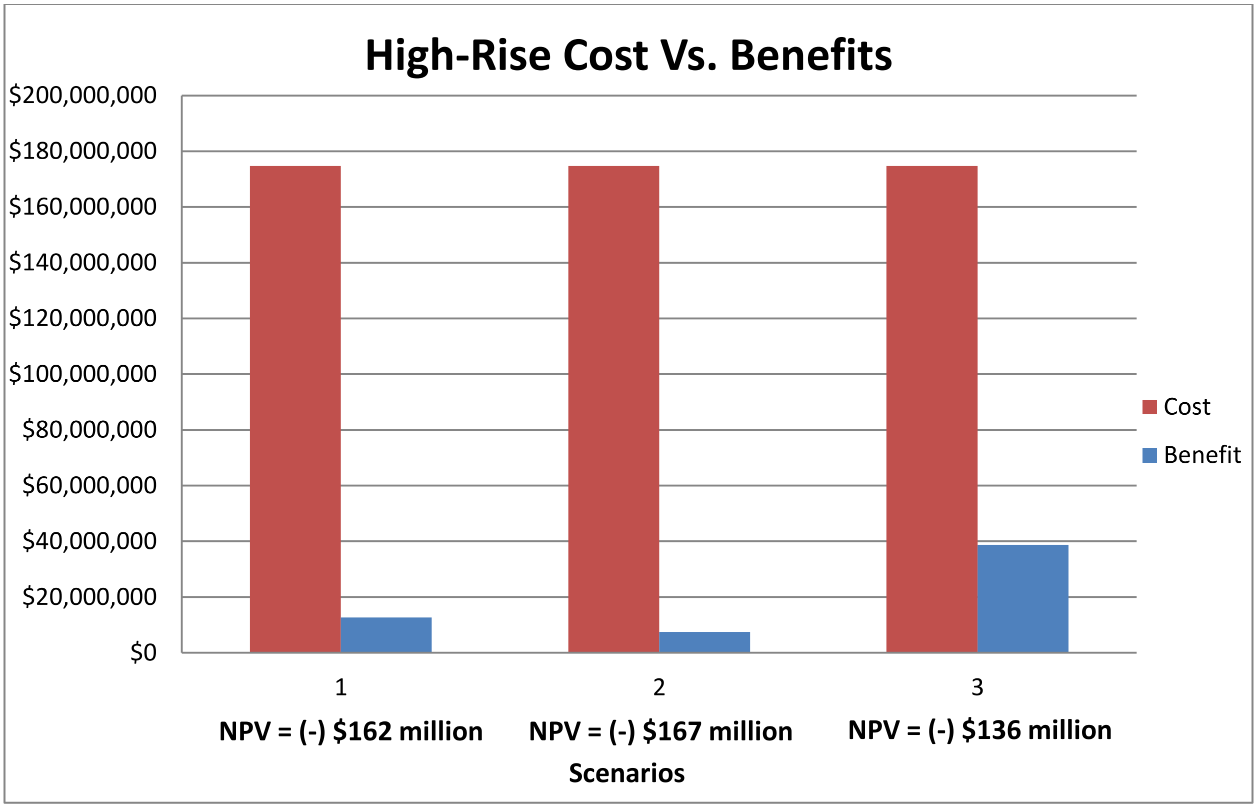

Figure 5: NPV of high-rise exhaust cost vs. accrued benefits

4.5 Sensitivity Analysis

The Australian government's Office of Best Practice Regulation (OBPR) recommends testing the sensitivity of the assumed discount rate used in a cost-benefit analysis. Since this report uses a discount rate of 10 %, a sensitivity analysis was conducted to test the NPV results using discount rates of 7 % and 3 % as shown in Table 9 and Table 10 below. The sensitivity analysis reveals that the choice of discount rate does not affect the overall results since the signs of the net present values do not change (OBPR, 2008).

Table 9: Discount rate sensitivity analysis for low-rise buildings

	NPV for Low-Rise Buildings		
	10 % Discount	**7 % Discount**	**3 % Discount**
Scenario 1	$9,566,421	$11,679,584	$15,467,339
Scenario 2	$4,358,702	$5,271,875	$6,897,887
Scenario 3	$35,694,487	$41,740,876	$52,312,225

Table 10: Discount rate sensitivity analysis for high-rise buildings

	NPV for High-Rise Buildings		
	10 % Discount	**7 % Discount**	**3 % Discount**
Scenario 1	(-) $162,017,030	(-) $186,619,034	(-) $229,094,447
Scenario 2	(-) $167,224,720	(-) $193,026,707	(-) $237,663,899
Scenario 3	(-) $135,888,935	(-) $156,557,706	(-) $192,249,560

5 Alternative Solutions

Alternative solutions that potentially reduce unwanted alarms were also investigated. The other solutions that were considered were:

- Education-targeted solutions
- Multi-criteria detectors
- Multi-sensor detectors
- Alarm Acknowledgement Facility (AAF)
- Sprinkler systems

5.1 Education-targeted Solutions

Education-targeted solutions could make the community more aware of the unwanted alarm issue. Educating the builders and residents on proper installation of smoke detectors and the importance of maintenance could reduce unwanted alarms. Informing residents about the dangers of unwanted alarms could reduce the possibility of disablement and complacency.

While educating the community of fire safety is vital, it is a limited solution due to its dependence on changing human behaviour. Fire brigades already invest into educating the community on fire safety, yet unwanted alarms and disablement are still an issue. Despite requirements to have properly working smoke alarms, 67 % of home fires from 1999-2006 occurred in homes with disabled devices (ABCB, 2012). Fire brigades should continue to educate the community, but other solutions should also be examined.

5.2 Multi-criteria Detectors

Multi-criteria detectors can be programmed in two different ways to perform in different situations. One design for multi-criteria detectors is pre-programming the device for certain environments. The particular environment can be selected based on the type of building it is installed in, such as a hospital or chemical plant. The detector can also be programmed to adapt to its surroundings. Based on its observations over time, it can determine if a sudden change in the environment is due to real fire conditions or other causes (M. Schreiner, Personal Communication, 5 February 2013).

Multi-criteria detectors could benefit the community, but there are also several limitations. Since these devices are compatible with many different environments, multi-criteria detectors could work in all types of buildings. These detectors could therefore potentially reduce unwanted alarms caused by all sources, not just cooking fumes and steam. Reducing unwanted alarms benefits the community because it reduces the possibility of complacency and disablement. However, the detectors with preprogramed parameters based on environmental conditions are limited since every environment is not exactly the same. The detectors that adapt to the environment could also be problematic in apartments and hotels since the environment changes frequently. With every new occupant, the detectors would have to be reprogrammed to learn the new environment.

5.3 Multi-sensor Detectors

Multi-sensor detectors use a combination of sensors to better determine real fire conditions. For example, a multi-sensor detector could consist of a local sounder, a photo-optical sensor, and a heat sensor. When smoke activates the photo-optical sensor, it sets off the local sounder to alert the occupant. If both sensors are activated, the fire brigade is notified since real fire conditions are likely to trigger the heat sensor (I. Chiron, Personal Communication, 13 February 2013).

Multi-sensor detectors have several benefits and limitations. The dual-sensor alarm system is designed to reduce the possibility of unwanted alarms caused by cooking fumes. However, if unwanted alarms still occur, the occupant may disable it since the detector includes a local sounder base. Another limitation is that these detectors add an additional connection to the fire brigade, which increases the chance of an unwanted alarm call.

5.4 Alarm Acknowledgement Facility (AAF)

An Alarm Acknowledgement Facility (AAF) gives the occupant time to clear smoke from the area before the fire brigade is notified. If smoke activates the detector within the SOU, the occupant has thirty seconds to hit the AAF button or the fire brigade will be notified. If the AAF button is hit, the resident has ninety seconds to clear the smoke before the fire brigade is notified (I. Chiron, Personal Communication, 13 February 2013). This additional time allows the resident to clear the smoke to prevent the signal from reaching the fire brigade, reducing the number of unwanted alarms.

The Alarm Acknowledgement Facility is limited as a solution to reduce unwanted alarms. The effectiveness of the AAF is dependent on occupants activating it and clearing the smoke. If the resident does not perform this action, the fire brigade will still be notified. Since a detector is required in the SOU with an AAF, an additional connection is made to the fire brigade, increasing the chance of an unwanted alarm call.

5.5 Sprinkler Systems

Sprinkler systems increase the life safety of occupants by extinguishing fires. Sprinkler systems use a heat sensor to detect fire conditions. If the environment reaches a fixed temperature, the sprinkler system will activate. Since sprinkler systems use a heat sensor, there is no possibility for an unwanted alarm to occur from cooking fumes or steam. One benefit that needs to be investigated is the Victoria Standard H103.1. The standard states that for low-rise residential buildings, a sprinkler system may be installed in place of smoke detectors (R. Llewellyn, Personal Communication, 18 February 2013). Most importantly, sprinkler systems save lives. A New Zealand research report that studied the cost-effectiveness of requiring domestic sprinklers in the U.S. found that from 1985 to 1996, "automatic sprinkler systems had a direct role in saving eight lives and there has not been a fire-related death in any sprinklered property" (BRANZ, 2003).

Sprinkler systems do not have many limitations. One limitation is that the system may cause an unwanted alarm if it malfunctions from loss of water pressure or improper installation. However, maintenance personnel can easily fix these system malfunctions. Another limitation of sprinkler systems is if there is a smouldering fire. Smouldering fires only produce smoke that could potentially result in a loss of life. In most cases, not enough smoke is produced to cause a loss of life before it would catch flame. Once it catches fire, the sprinkler system would extinguish it (P. Olsson, Personal Communication, 28 February 2013).

6 Conclusions and Recommendations

Based on the analysis, exhaust systems are cost-effective for low-rise buildings but not for high-rise buildings. This analysis, in section 4.4, shows that in low-rise buildings the Net Present Value of the benefits is approximately $9.6 million in Scenario 1. Scenarios 2 and 3 have NPVs of $4.4 million and $35.6 million, respectively. Conversely, the costs to install exhaust in high-rise buildings outweighed the overall benefits by over $130 million in all three scenarios, shown above in Figure 5. These vast differences in cost-effectiveness of low and high-rise buildings can be attributed to the differences in costs to install the local exhaust versus the central shaft ($684 versus $4600). For the particular situation of Queensland analysed in Scenario 1 of this report, the break-even mix of low- and high-rise is 95% low-rise and 5% high-rise; that is, given such a mix of new residential construction over a ten year period, costs of installing exhaust systems are balanced over ten years by the accrued value of the benefits of reduced unwanted alarms from those buildings. Due to limitations in the data, this analysis was based on only two building examples from Queensland and cannot necessarily be generalized for the whole building stock of Australia.

A uniform system for classifying unwanted alarms is needed to draw more concrete conclusions. This analysis involved acquiring unwanted alarm data from each state, including: the number of unwanted alarms in any given year, causes of unwanted alarms (cooking fumes, steam, etc.), type of detectors that were set off, and the building type in which these unwanted alarms occurred. Many states were unable to obtain this information, which restricted our findings. In order to address this problem, we recommend that Australian fire authorities look into creating a central database for unwanted alarm statistics and a standardized coding system for fire brigades when recording responses to unwanted alarms. For example, this database could help identify if most of the unwanted alarms in residential buildings due to cooking fumes and steam originate from regions that attract many tourists. Additionally, there is a need to identify individual buildings that generate multiple unwanted alarms. Another key question is why Queensland has such a higher percentage of unwanted alarms in residential buildings due to cooking fumes and steam compared to the other states. A central database that can record the type of building, specify the building, type of detection system, the cause of the unwanted alarm, and the city or region in which it occurred could easily answer these questions.

Implementing exhaust systems would only reduce a small portion of the total unwanted alarms. Table 1 in Section 2.1 reflects the statistics on unwanted alarms in Queensland, New South Wales, Western Australia, and Tasmania. In 2011-2012, cooking fumes and steam caused 63 % of unwanted alarms in residential buildings in Queensland. However, these causes only account for 19% of the total unwanted alarms. The percentage of unwanted alarms in residential buildings caused by cooking and steam is even less in other states such as New South Wales, Western Australia, and Tasmania, where these sources only account for 7 %, 6 %, and 2 % of all their total unwanted alarms, respectively.

We also investigated alternative solutions that could address the unwanted alarm problem. Some potential solutions include:

- Education-targeted solutions
- Multi-criteria detectors
- Multi-sensor detectors
- Alarm Acknowledgement Facility (AAF)
- Sprinkler systems

These alternative solutions are appropriate because they could address the entirety of the unwanted alarm problem in all types of buildings. Perhaps if more information regarding the demographics, location, and causes of unwanted alarms could be found for all states, a full cost-benefit analysis for each solution could be achieved based on more than the two notional examples we have established in this report. The results from such analysis could lead to more conclusive findings as to which one of these or additional solutions better address the entirety of the unwanted alarm issue.

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Appendix A – Low-Rise Scenario 1 Cost-Benefit Analysis

Ten Year Trend For Exhaust Cost, Fire Brigade Benefit, and Resident Benefit								
Cost-Benefit Analysis			Cost of Exhaust/SOU:		$684		Value of the benefits:	
Scenario 1: Low-Rise			Number of SOUs:		12		Charge to resident avoided per UA	
			Cost of Exhaust/Building:		$8,208		$1,020	
							Net full cost of FB response avoided per UA	
							$3,546	
Year of construction	New buildings	Exhaust cost per building	Total exhaust cost	New UAs avoided	Resident UA charge	New UA charge	FB UA response cost	New FB response avoided
1	51	$8,208	$418,608	77	$1,020	$78,540	$3,546	$273,042
2	52	$8,452	$439,661	79	$1,050	$82,490	$3,651	$286,774
3	53	$8,703	$461,774	80	$1,081	$86,639	$3,760	$301,197
4	54	$8,961	$484,998	82	$1,114	$90,996	$3,871	$316,346
5	55	$9,227	$509,391	83	$1,147	$95,573	$3,986	$332,256
6	56	$9,501	$535,010	85	$1,181	$100,380	$4,105	$348,967
7	57	$9,784	$561,918	87	$1,216	$105,428	$4,227	$366,518
8	59	$10,074	$590,179	88	$1,252	$110,730	$4,352	$384,951
9	60	$10,373	$619,861	90	$1,289	$116,300	$4,482	$404,312
10	61	$10,682	$651,037	92	$1,327	$122,149	$4,615	$424,646
		Cost NPV:	**$3,117,958**					

Ten Year Trend NPV For Low-Rise

	UAs avoided:		1.51		(per building with exhaust system)					
	Construction growth rate:		2%							
	Inflation rate:		3%							
	Discount rate:		10%							
	Net benefit									
Year >>	1	2	3	4	5	6	7	8	9	10
	($67,026)	$362,024	$372,776	$383,848	$395,248	$406,987	$419,074	$431,521	$444,337	$457,534
		($70,397)	$380,232	$391,524	$403,153	$415,126	$427,456	$440,151	$453,224	$466,684
			($73,938)	$399,355	$411,216	$423,429	$436,005	$448,954	$462,288	$476,018
				($77,656)	$419,440	$431,898	$444,725	$457,933	$471,534	$485,538
					($81,562)	$440,535	$453,619	$467,092	$480,964	$495,249
						($85,664)	$462,692	$476,434	$490,584	$505,154
							($89,972)	$485,962	$500,395	$515,257
								($94,497)	$510,403	$525,562
									($99,250)	$536,074
										($104,242)
Yearly Benefit:	($67,026)	$291,627	$679,070	$1,097,071	$1,547,495	$2,032,311	$2,553,598	$3,113,550	$3,714,479	$4,358,829
Total Benefit:	$19,321,005									
NPV	**$9,566,363**									

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