

Research Report

Client: Pecan Engineering Pty Ltd

Scope: Panoramic Solid Fuel Slow Combustion Heater and App

PECAN170316 Version 1.0

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Abstract

This report outlines the research process undertaken and findings relevant to the design and development of a Panoramic Solid Fuel Slow Combustion Heater and App. The research investigates and defines the parameters required for a combustion heater to enter the marketplace without limiting creative solutions. This was achieved through a number of thorough research methods and resulted in valid and coherent outcomes. Findings from the report uncover key points for consumer needs, patents, standards, design for environment, design for manufacture, competitive benchmarking, and available technology. The development of product needs and target specifications, modern interior design findings, current technology available on the market and the internal dynamics of a combustion heater.

Full exploration, results and recommendations are identified throughout the report.

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2. Introduction

All products are unique and have their own set of complications and qwerks that make it special. In order to design a new product that can successfully emerge onto the marketplace it is paramount to conduct thorough research in all relevant areas to build a knowledge base for clever, coherent design. In order to gain an understanding into the combustion heater industry a variety of research methods have been implemented and explored. These include: personas and scenarios, consumer needs and metrics, competitive benchmarking, legal assessment, market research, design for environment, design for usability, branding and application requirements.

The aim of these methods is to uncover findings which can be implemented in the design and development of a Panoramic Combustion Heater and App. Findings from this research have been collated and summarised to define target specifications and user needs to be fulfilled by the produced product.

3. Personas and Scenarios

Personas are fictitious characters created in order to represent a specific user that may use a product. The aim of a Persona is to consider a Combustion Heater user’s goals, desires and limitations in order to help guide decisions around product features, interactions and design. Five personas with different roles in relation to being a Combustion Heater users were created in order to gain a rounded understanding of impacts on a range of different people.

3.1 In home Customer 1 (Parent)



JACK and Emily

Age: 35, 34

Profession: Accountant and engineer

Hobbies: Camping

Personality: enthusiasm, hospitable, friendly

Housing: live in Parkside

Goals: build their dream house



Jack and Emily are a typical Australian middle-class couple. They have a child now, and are going to have the second after a few years. They work very hard every day, and are very hospitable. They live in Tasmania. It is very cold in Tasmania in winter. They used to keep warm with electric heater which consumes a large amount of electricity and is not effective. As a result, they prefer to use the traditional heating method- fireplace.



Jack and Emily like the furniture of simple style very much. The overall design style of their house is mainly simple. They wish to find a fireplace that is in accordance with the design style of their house. In addition, as they have a child, the fireplace they are looking for can be equipped with the function of electrical monitoring. The data of the fireplace are control by smart phone. Lastly, the door of the fireplace can be locked with child safety key like vehicle doors to ensure the safety of the child.

3.2 In home Customer (Adolescent)



Swaylor Twift

Adolescent User

Age	20
Profession	Full Time University Student studying HR. Also works part time at a local bakery
Hobbies	Going out, seeing friends, clubbing, movies, music and fashion.
Personality	Friendly, confident, social, bubbly and ambitious.
Goals	To finish University, find a full time job and move out of home.



Swaylor is a confident and social 20 year old student living in Adelaide, Australia. She lives with her Mum, Dad and two younger siblings. As a result of being the eldest child Swaylor is always persuaded into helping her old man collect the fire wood from outside and start up the combustion heater in their living room.



She always cries wolf and complains that lugging the timber inside is ruining her clothes and giving her splinters. Her mother then chimes in bringing up the amount of dirt and bugs the fire wood is bringing in from outside. So, the poor father is left on his own to bring in the remainder of the timber and start the fire with Swaylor nowhere to be seen.

Although she constantly complains to her parents about having to help out with the heater, she is quietly proud of her ability to start up a fire. It gives Swaylor pleasure to do this when she is entertaining her Gals or a special male friend in a bit of an effort to show off or impress them.

"Shake it off, shake the dirt off."

3.3 In home Customer 2 (Single Home Owner)



David Eastman

Age:	29
Profession:	Model
Hobbies:	Exercising, Scratching the Decks, Courting Women
Personality:	Outgoing, Charming, Fussy
Housing:	Modern Mansion
Goals:	Get more buff, entertain friends in his home



David wants a stylish heater for his mansion that will fit in with his modern home decor.

He's a bachelor so he likes the romantic ambience a real fire provides.

He wants an efficient heater because it's cool to be environmentally conscious.



"I'm walking away, from unstylish heaters"

3.4 Commercial Customer (Hospitality)



Michael Ingham

Age	24
Profession	Wine connoisseur - works in a small prestigious underground bar in the city
Hobbies	Dining out
Personality	Outgoing, friendly, hospitable, fast paced
Housing	Lives independently in his City Apartment
Goals	Open his own restaurant.

The bar Maybe Mae is situated underground and due to low temperatures often gets to cold for customers. The owners have installed a panoramic slow burning wood heater during recent renovations. The heater fits in well to the premises and is going to add another element of excitement to the bars atmosphere. The bar is open from lunch to late at night so the warmth from the fire is required during the later hours of opening time. However the employee who opens the bar, during the quieter hours of the lunch shift has the duty of building/lighting the fire and stocking up fuel from the storeroom to last the night ahead.

Throughout the night wood needs to be added to the fire to keep it going but it is often forgotten due to the fast pace work environment of the bar. However Michael has downloaded the Nectre App on the bars iPad so now the fire can send notifications to the till system when the temperature gets to low.

At the end of the night Michael stocks up the fireplace with fuel to try and last till the morning. He changes the settings to slow over night combustion in the hope that the bar will still have retained warmth when he returns for the next day.

3.5 Installer (Builders)



Steve Roberson

Age	29
Profession	Combustion Heater Installer
Hobbies	Footy, BBQ's on days off, modifying drift trikes
Personality	Loud, down to earth, hard worker
Goals	Renovate his newly purchased home



Steve arrives at the job dead on 9 am however his work colleague Larry is no where to be found. One hour later Larry finally arrives and claims he had 'car troubles'. Steve doesn't buy it as its the third consecutive day this week.

Today they need to install a large panoramic free standing combustion heater into a modern house east of Adelaide's CBD. They realise the panoramic dimensions of this heater make it difficult to fit through the doors (loading onto sack truck, base side down). In order to fit through the doors the heater must be loaded onto the sack truck on its side. This proves a challenge due to the sheer weight of the object. Steve also is concerned that they could possibly damage the heater and prays that it will remain structurally sound.

The rest of the installation goes to plan and they are done by 3pm. Steve enjoys his job, although he does get annoyed having to work with Larry. He is always late, taking breaks and in general a slow worker. Steve wishes he was able to install the heaters by himself however with current designs this isn't feasible. If Steve were able to work alone he would get paid more and have the capability to complete installations quicker.



4. Product Details

4.1 Literature and Online Research

The history of Nectre and their parent company, Pecan Engineering, was explored in order to gain an understanding into the background and values which have contributed to the success of the company. It is important to define Nectre's Distinctive Assets and consider them, where possible, in any future concept development. The company was first registered in 1970 by Peter Cannon. It's first products was the creation of manufacturing equipment for the fibreglass industry. This developed into both metal and fibreglass manufacturing moving to a rented factory at Edwardstown, South Australia.¹

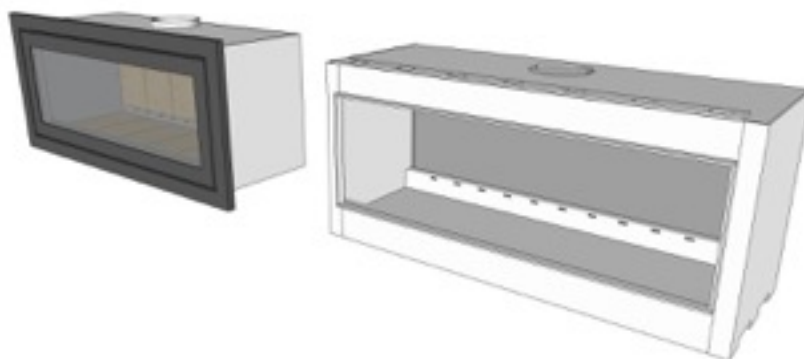
Pecan Engineering transformed into a company in March 1973 and as the business expanded it moved to a new premises in Thebarton. The current factory, located at Dry Creek was acquired in 1990, is where their production techniques and metal forming capabilities were expanded. With this facility, Nectre has been industry leading developers the next generation in efficient, low emission wood heaters.²

It is paramount that future Panoramic Combustion Heater concepts are coherent with these elite standards and aim to satisfy these company goals of being industry leaders in delivering products of the highest quality.

4.2 Tech pack

The proposed internal dynamics of a Panoramic Combustion Heater were received from Nectre, with the intention to use this as a basic guideline for air flow and secondary burning. These internal drawings and cross sections can be found in Figures 1 - 4.

Figure 1:



¹ Greg, Nectre Heaters, 2016

² Greg, Nectre Heaters, 2016

Figure 2:

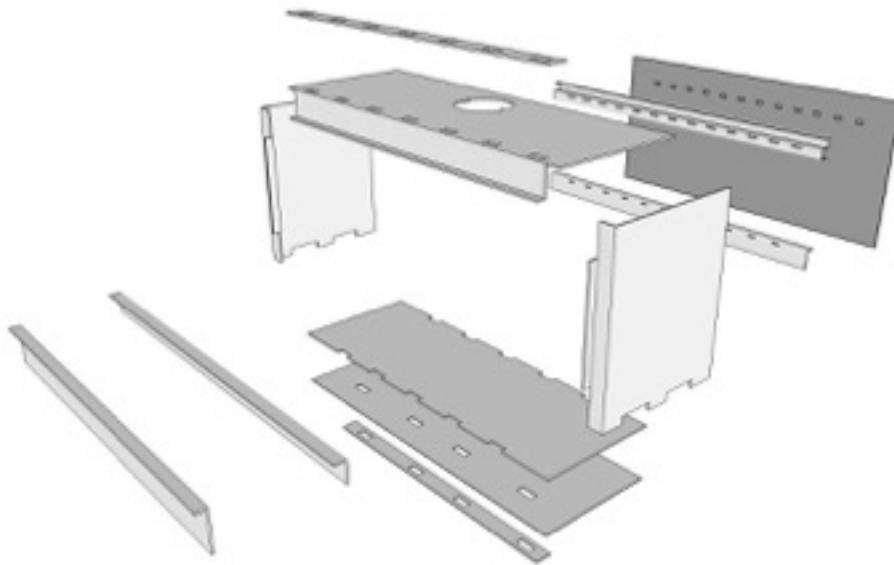


Figure 3:

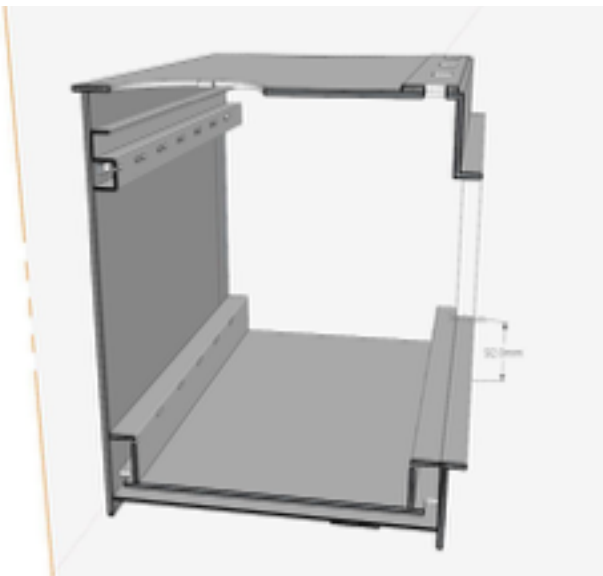
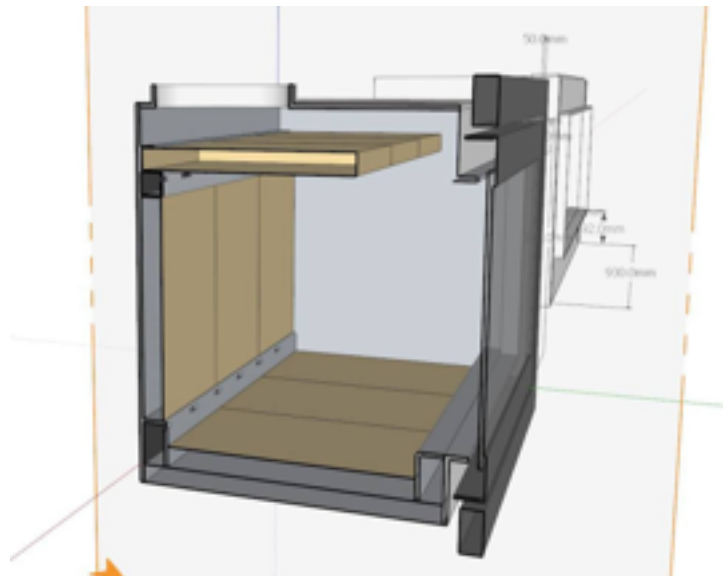


Figure 4:



4.3 Market Research

Price Point

After conducting a competitive benchmarking exercise the price range was found to be in the region of \$2,500 - \$6,000 for competing panoramic combustion heaters. This finding fits in well with the recommended target retail price point, as specified by Nectre, within \$3,000 - \$8,000.

Target Market

After conducting market and user research, the target market for the developed product is aimed towards 40 – 55 year old males and females. This age bracket has a particular focus on middle to high-class homeowners with noteworthy disposable income. The Panoramic Solid Fuel Slow Combustion Heater and App will also appeal to higher end homes and the hospitality industry.

Generally, the production cost per unit is 1/3 of the retail price. Meaning, the heater developed should be able to be produced between \$900 - \$2,666 to satisfy Nectre's proposed retail pricing.

Specific targeted users have been defined below, but are not limited to:

- High income earners - < \$90,000p.a
- Elderly couples with older children
- Middle age home builders and owners
- Premium Hotels with large lobby and dining areas
- High end restaurants
- Interior designers working on commercial and residential fit outs

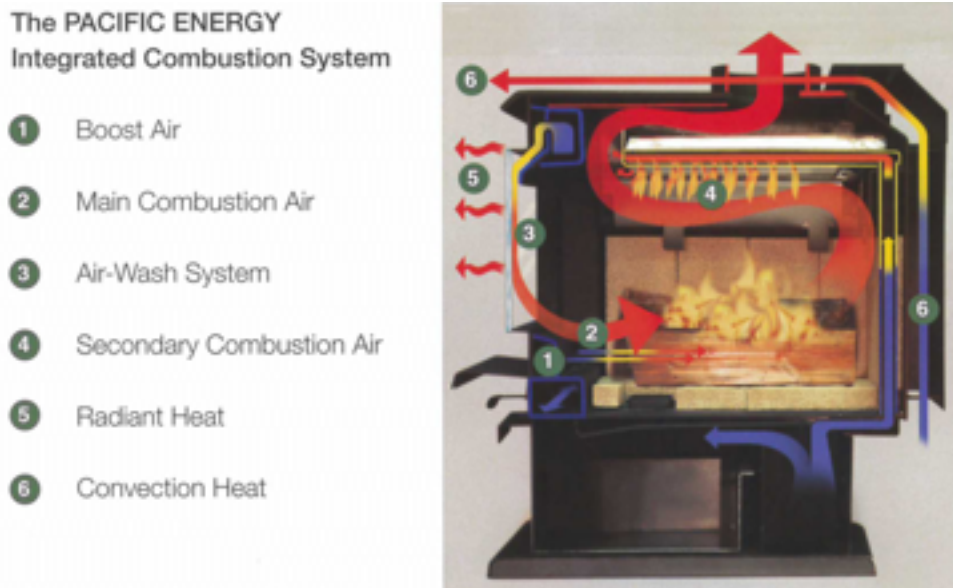
4.4 Functionality

After the exploration of secondary burning (evident in Figure 5) thermo dynamics and emissions/ efficiency we were able to uncover what makes a combustion heater function to the levels required to be coherent with Nectre's high end brand philosophy.

The key findings from this section include:

- Making the chimney as hot as possible to avoid cold air being sucked down
- Place the chimney at highest point of roof, so the exit of flute is exposed to the hottest air possible
- A second platform for omissions to pass through increases efficiency

Figure 5:



5. Consumer Needs and Metrics

5.1 Surveys

A questionnaire was conducted to gain a qualitative understanding of the Panoramic Combustion Heater industry and users attitude towards it, a questionnaire was conducted. Approximately 5 people were involved with the aim to grasp as broad of a demographic as possible with the aim to uncover what works, what doesn't work and if they could suggest any improvements to their current heater. As all ages and genders were investigated, emphasis was put on answers from the target demographic of 40 – 55 year olds. This added insight and credibility to findings. The questionnaire was uploaded to Survey Monkey, a free online survey creation tool, and shared through social networking websites such as Facebook and Twitter.

This research method revealed what type of heater users owned, their likes and dislikes towards it, and whether they would be open to the idea of a combustion heater. A full example of the survey and results can be found in Appendix 7.1.

5.2 User needs metrics

Establishing consumer needs metrics is the second step in the Concept Development Process. The development of User Needs Metrics have been derived from the questionnaire data, customer statements and bench marking of competitors products in order to target key features. These appear in Figure 6. The Personas and Scenario were also considered in order to create specifications that would suit the fictional user. These needs have been categorised by level of importance with 10 being most important and 1 being the least.

Figure 6:

No.		Need	Importance/10
1	The Heater	is of superb quality	10/10
2	The Heater	will last for a minimum of 10 years	10
3	The Heater	feels expensive and durable	10
4	The Heater	does not sacrifice function or durability for cost	10
5	The Heater	is safe for the everyday person to use without excessive caution	10
6	The Heater	can be used by people of ages 15-75	8
7	The Heater	encourages organisation of heater fuel, tools and accessories	5
8	The Heater	is quiet enough to use comfortably	8
9	The Heater	appeals to upmarket customers/users	10
10	The Heater	incorporates cognitively/physically ergonomic interactive elements	10
11	The Heater	can be stacked 'one on top of the other' when in storage	8
12	The Heater	is not unnecessarily difficult or costly to produce	10
13	The Heater	has a timeless style	8
14	The Heater	is effective and efficient in heating a room	10
1	The App	incorporates design concinnity with the heater	10
2	The App	adds real value to the heater's user experience	10
3	The App	is intuitive to use	10
4	The App	assists the user in 'controlling' the fire (i.e. instructions for lighting)	10
5	The App	encourages the user to be environmentally responsible (KWh saved?)	6
6	The App	assist in creating a romantic mood	4

6. Competitive Benchmarking

6.1 Existing Design Comparison

Competitive benchmarking is the process of comparing a products specifications and features with that of its most successful competitors. Investigating competitor’s benchmarks for a product assists in the creation of needs metrics as a means to measure performance against industry standards. For five competing products, their manufacturer, price point, specifications and features were researched through visiting product websites and visiting retail stores. This information was collated into a full table, visible in Figure 7.

Figure 7:

					
	N60	Nectre Mega	Riva Studio 2	Montrose	Inserto 100
Manufacturer	Nectre	Nectre	Stoves (UK)	Agency (USA)	La Nordica (Italy)
Orientation	Traditional	Traditional	Panoramic	Panoramic	Panoramic
RRP	From \$2,990	From \$2,675	From \$3,897	\$5,359	\$2,799 (Converted from Euros)
Website	Click Here	Click Here	Click Here	Click Here	Click Here
Dimensions	581mm(w) x 1037mm(h) x 508mm(d)	790mm(w) x 826mm(h) x 540mm(d)	500mm(w) x 440mm(h) x 350mm(d)	1097mm(w) x 801mm(h) x 448mm(d)	1000mm(w) x 550mm(h) x 500mm(d)
Clearances	100mm Rear/ 100mm sides	200mm rear/ 870mm sides	n/a	Zero Clearance	n/a
Fan Available	No	Yes	No	Yes (up to 2)	Yes
Efficiency	84%	82%	75%	82%	78.20%
Emissions	0.00g	1.5g	n/a	3.2g	n/a
Burn Time	8-10 Hours	8-10 Hours	n/a	n/a	2.8kg per hour
Heat Output	13kW	10kW	10kW	n/a	12.1kW
Coverage	13Mq	10Mq	n/a	100-mq (no fan)/ 200mq (with fans)	40mq
Max Log Length	420mm	380mm	400mm	780mm	800mm
Wall Thickness	6.0mm	6mm/8mm	Various	5mm	Various
Firebox Volume	0.044m ³	0.080m ³	n/a	0.06m ³	0.9m ³
In Wall or Free Standing	Free Standing	Free Standing	Both Available	In Wall	In Wall
Warranty	10 years	10 Years	3 Years	15 Years	Unlimited
Additional Features	Options for curved sides or square sides	Option for legs (pictured) or pedestal base	Offers a variety of frame/ styling options	Removable door handle tool	100% made in Italy

6.2 Customer Reviews/ Statements

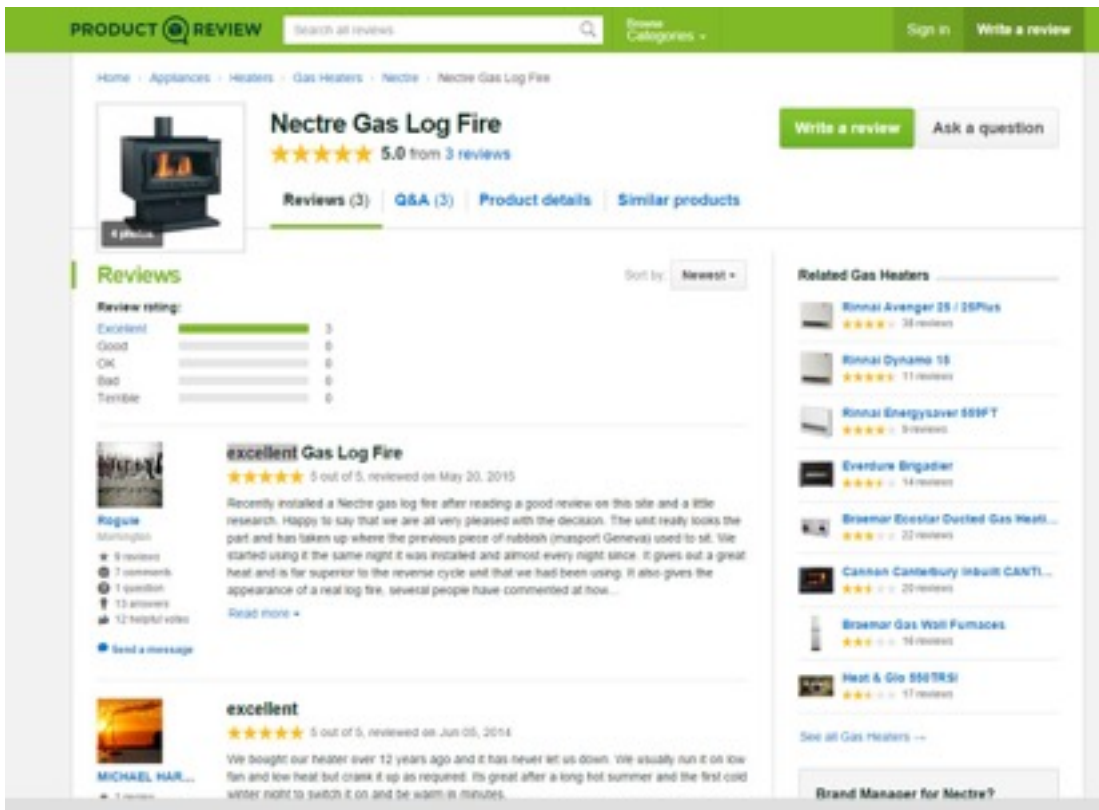
With most heating stores and manufacturer’s websites integrating a Product Review section, consumer’s thoughts on current competing Panoramic Combustion Heaters and Nectre’s own products on the marketplace were investigated. The aim of this was to uncover reasoning behind a user’s pleasurable or non-pleasurable experience with competing products on the market.

Generally, consumers were happy across the board with their Combustion Heater, with most giving 4 or 5 star reviews.³ The few 1 or 2 star ratings came from users who had issues with staff at certain stores or were not experienced in the building and maintaining of fires. It became evident that as there is no stand out product in terms of features that customers have never really expected much more than an operational and aesthetically pleasing product. I believe that the added features we are exploring in the concept development phase of the project and especially application integration could raise the bar in regards to users expectations of what their combustion heater can deliver.

An example of a 5 star rating for a current Nectre Heater on the market is visible in Figure 8. Full findings from this research section and specific customer statements can be found in Appendix 9.1.

Figure 8:

³ “Nectre Gas Log Fire Reviews,” Product Review



7. Materials and Processes

7.1 Materials

The aim of research into materials and processes is to select and use materials in the most cost efficient way for Nectre, without compromising on function or product reliability. Materials with characteristics of being lightweight, durable and having a high melting point are paramount for the Panoramic Solid Fuel Slow Combustion Heater. The focus will be on different grades of steel, however, other metals and organic Materials will be explored in order to not limit innovative or creative solutions.

Materials researched, steel plate, glass, copper, cortex steel were researched, full breakdown of these materials can be viewed in Appendix 8.1.

7.2 Manufacturing Processes (DFM)

The manufacturing processes available to consider in concept development have been defined by Nectre, with the recommendation to focus on sheet metal and casting techniques. A range of other processes have been explored to not limit design outcomes. Expanding on this, manufacturing decisions will also be centred around the Australian Manufacturing market’s strengths and capabilities.

CNC Machining, pressure die casting, laser cutting, metal folding/ pressing/ forming, sand casting, welding were looked at in depth and a full break down of their production economics, sustainability, advantages and disadvantages can be found in Appendix 8.2. This knowledge base is a good platform for concept development as we now have a greater understanding in what is aesthetically and economically possible.

7.3 Engineering

An array of hinges, locking mechanisms, latches and wood storage features were analysed and collated on current Combustion Heaters on the market. These findings were collated into multiple charts visible from Appendix 2.1.

The full analysis was collated from online and physical in store investigations specifically aimed towards engineering mechanisms mentioned earlier on ovens, appliances, doors, vents, cabinets and fridges. A number of usable systems were derived from this research and can be used to solve problems appropriately where needed in further product development, in particular a parallel hinging system for upwards opening doors.

Figure 9:



8. Legal Assessment

Australian Standards relevant to a Panoramic Combustion Heater have been explored through online database SAI Global and in conjunction with Nectre representatives. A patent search with IP Australia was also conducted with the aim to seek out design patents for competitors to ensure future concepts are legally sound.

8.1 Standards

The aim of research into appropriate standards is to ensure safety, reliability and consistency in a product to perform the way it is supposed to.

The heater designed must adhere to or exceed AS/NZS 4012:2014 and AS/NZS 4013:2014 Standards.

- AS/NZS 2918 - Domestic solid fuel burning appliances - Installation⁴
- AS/NZS 4012 - Domestic solid fuel burning appliances - Method for determination of power output and efficiency⁵
- AS/NZS 4013 - Domestic solid fuel burning appliances - Method for determination of flue gas emission⁶

8.2 Patents

On the basis of information received directly from Nectre, as wood combustion heaters have been around for centuries, there seems to be no patents that are likely to be infringed.

It is also evident that many manufacturers, including Pecan Engineering, have recently patented new baffle systems, which are mostly used for marketing purposes. Although, Nectre have stated that if generated designs or concepts were patentable they would consider protecting it.

9. Design for Environment

9.1 Environmental Impact (DFE)

The aim of Research into the environmental impact of a Combustion Heater delivered some interesting insights into recyclability, assembly, smart material selection and emissions. Although, many of these areas have already been covered in Australian Standards, Functionality and Materials sections of this report.

A combustion heater's efficiency is measured by the particulate matter released in to the air during operation. g/kg is the measurement or grams of particulate in the air in relation to the kilograms of wood being burnt. By 2019 the standards will be updated and require tighter regulations meaning that new heaters will be required to comply with 1.5 g/kg compared to the current 4.0 g/kg.⁷

In terms of the recyclability and life cycle of the heater, it is important to be mindful when make design decisions to deliver a product which is easy to disassemble however is able to last 20, 30 or even 40+ years.

⁴ "AS/NZS 2918 Standard," SAI Global

⁵ "AS/NZS 4012 Standard," SAI Global

⁶ "AS/NZS 4013 Standard," SAI Global

⁷ "Proposed changes to AS/NZS 4013 – Determination of particle emissions factors", environment.Gov

10. Design for Usability

10.1 Ergonomic issues/usability

It is important that the Panoramic Combustion Heater is simple and enjoyable to use. An analysis into user operation was conducted in order to gather information on how customers interacted with their heaters. Key findings from this illuminated a desirable design target where the consumer could open, close and lock the heater door easily with one hand. This would allow them to carry their timber fuel and load it onto the fire with the other spare hand.

Sufficient shielding from potential hazards such as heat or burning will be considered as some users reported slight burning on their fingers when touching parts of the heater. Expanding on this, assumed affordances such as handles or the opening and closing of the heater must be safe and obvious to operate for the user.

11. Branding

Nectre and the team at Pecan Engineering pride themselves on their products being designed and manufactured in Australia. The three pillars of their products encompass are tradition, quality and timeless design. As a result of this information, the design developed will aim to adhere to the brand values of company. and include corporate logos and general product aesthetics to be coherent with the companies other products.

Research into the use of the 'Australian Made' logo was also conducted and would cost the company a licence fee equalling 10% of the volume of units sold.⁸ This could be a powerful marketing tool and enhance their products value to customers.

11.1 Product aesthetics

Product Aesthetics of Nectre have been studied to investigate the use of colour, material and shape. Nectre's products were commonly black. The use of this colour, although driven by material selection and lowering costs, offers an subtle, elegant finish, without drawing away from the beautiful flames inside.

Nectre have expanded their repertoire in terms of shape but adding a curved, portrait oriented product in the N60.⁹ With their other heaters following the traditional geometric, practical and square design of fireplaces.

The brand design philosophy of Nectre has been summarised to include:

- Decorous feeling
- Practicability
- Reliability

⁸ "About the Logo," Australian Made

⁹ "Nectre N60," Nectre Heaters

11.3 Modern Architecture

An investigation into Modern Architecture was conducted in order to illuminate forecast future aesthetic trends of living areas and heater styling. Findings from this section can be applied in concept development to deliver a fashionable and beautiful product coherent with current trends and attempt to not seem outdated any time soon. Jahvanra Taylor, an Interior Designer at The Limery was interview and illuminated interesting insights stating that the focus of modern interiors include clean lines, small quality details and great finishes.¹⁰ She also mentioned that simplistic design in this area is paramount with the focus on the elegance of how beautiful fire looks through the glass.

Key points from the interview with Jahvanra include:

- The use of Black stainless steel is becoming more popular than ever preferred to the shiny silver metal appliances and finishes that were seen in allot of houses built between 2005-2010.
- Fireplaces are being designed to be more than just to heat well. It should be the beautiful and efficient heart of any home- a functional piece of art.
- Raw materials are being used in current designs such as the use of concrete, un-sealed timber and marble.
- Traditional recessed fireplaces becoming more and more dated.

The full interview can be found in Appendix 5.2 and an example image of a fire place in a modern living space is visible in Figure 11.

Figure 11:



¹⁰ Jahvanra, Taylor, The Limery, 2016

12. Application Requirements

12.1 Current existing technology

As a key portion of the project is to develop a mobile application that will allow the user to monitor and control certain features and functions of the heater - the existing technology available to display and transmit information, control options and application development software was explored. This was conducted with the aim enhance the users experience with the most relevant and accurate information possible and put it in the palm of their hand.

One interesting sensor that found was the Igrill 2 Bluetooth Thermometer¹¹ pictured in Figure 12. This device is an example of what could be used to monitor the temperature inside the heater. As it is wireless it allow a digital display to be mounted anywhere on the heater with out being restricted by wires and cables.

The requirements for technology researched was facilitate features such as:

- Ensuring the combustion heater is burning efficiently and monitoring this
- Signal when soot tray is full with a particulate matter sensor or other devices
- Remote controlling vents
- Opening and closing doors
- Relay of information to mobile applications

All applicable sensors, thermo actuators and transmitters was collated and is accessible during the product development stage of the project are visible in Appendix 3.1. A list of DIY application design software which is listed in Appendix 4.1.

Figure 12:



¹¹ "Igrill 2 Bluetooth Thermometer," iDevice Sinc

13. Conclusion and Recommendations

In conclusion, the findings of the report are significant in the product development process of the Panoramic Slow Fuel Combustion Heater and Application as they build foundation and parameters to propel to project further. Although there were some limitations in particular areas of research, overall the method was in depth and productive in its aim to investigate the product without limiting creative solutions. To deliver a heater that appeals to the target market, has application integration and fulfilled targeted specifications outlined in the report is paramount for success and profitability. The data gathered in all relevant areas is able to be incorporated into concepts during the ideation and conceptual stage of the project.

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15. Appendices

Appendix 1.1 - Interview with Nectre

1. List of standards that combustion heaters must comply to?



- AS/NZS 2918 - Domestic solid fuel burning appliances - Installation
- AS/NZS 4012 - Domestic solid fuel burning appliances - Method for determination of power output and efficiency
- AS/NZS 4013 - Domestic solid fuel burning appliances - Method for determination of flue gas emission

2. Current/expired patents of interest?

As wood combustion heaters have been around for centuries there are not really any patents that we will likely infringe on. Although many manufacturers (including Pecan Engineering) have recently patented new baffle systems, they are mostly used for marketing purposes. However, if you guys were to generate a patentable design we would definitely do what we can to protect it.

Appendix 2.1 - Engineering Mechanisms





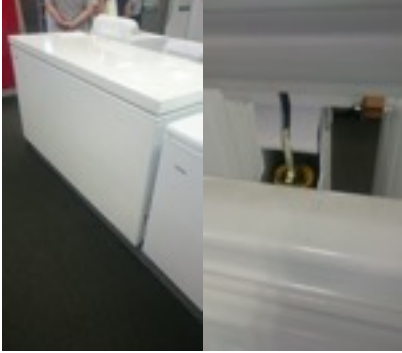
Hinges on Current Combustion Heaters





	<p>Almost all have simple bolt pivoting hinge</p>
	<p>External Hinge, make it a feature?</p>

	<p>Opens upwards via a pulley system. Very clunky and heavy to use.</p>
--	---

Hinges on Current Oven/Appliances

	<p>Latch operated via foot? Energy is transferred through a steel wire to hinge</p>
	<p>Oven door (folding down)</p>
	<p>Spring loaded hinge adds a nice amount of weight to a otherwise light weight door/lid.</p>

	<p>Mechanism allows the door to be left slightly open Which is ideal for starting a fire as you want to leave the door lightly open to allow for sufficient air flow.</p>
	<p>Slightly different to the one above but has ability to 3/4 close.</p>
	<p>Main mechanism dishwashers have.</p>
	<p>Magnetics on the internals of the door allow the slide out draw to slide out when the door is opened. Once the door is opened past 45 degrees the magnetic connection is broken and door can be fully opened.</p>
	<p>Spring assisted door hinge allows large heavy door to be opened.</p>

	<p>Simple door stay</p>
	<p>A ball bearing fits into each of the dimples and locks the door at that position.</p>
	<p>Piston assisted fridge door, nice weight/feel, controlled opening.</p>
	<p>Had a really nice click when pressed in.</p>

Hinge 'Google' Search



<http://www.hunthings.com/products/medical-appliance-hinges.htm>



<https://www.architectureanddesign.com.au/suppliers/angle-shoe-products/pivot-hinges-with-hand-tool-installation-by-angle>



Could be used to open door upwards
<https://www.architectureanddesign.com.au/suppliers/hettich-australia/sensys-concealed-hinges-from-hettich-feature-new-f>



<http://www.woodcraft.com/product/27C11/soss-nonmortise-hinge-for-12-panels.aspx>

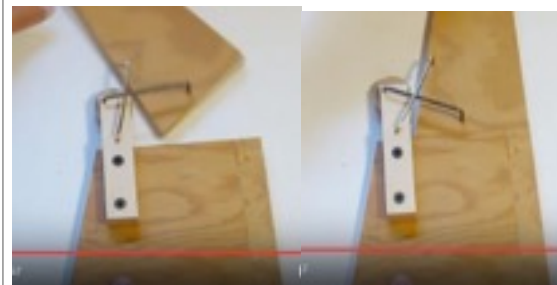
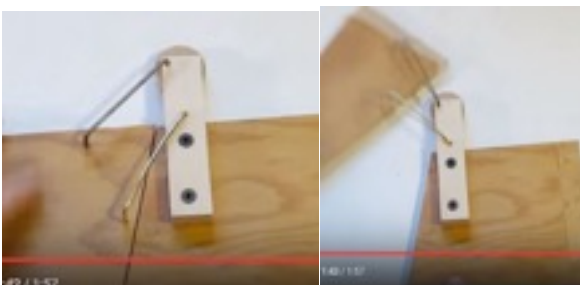
<http://www.woodcraft.com/category/su108-14/hinges.aspx>
(has a large range of hinges to choice from)

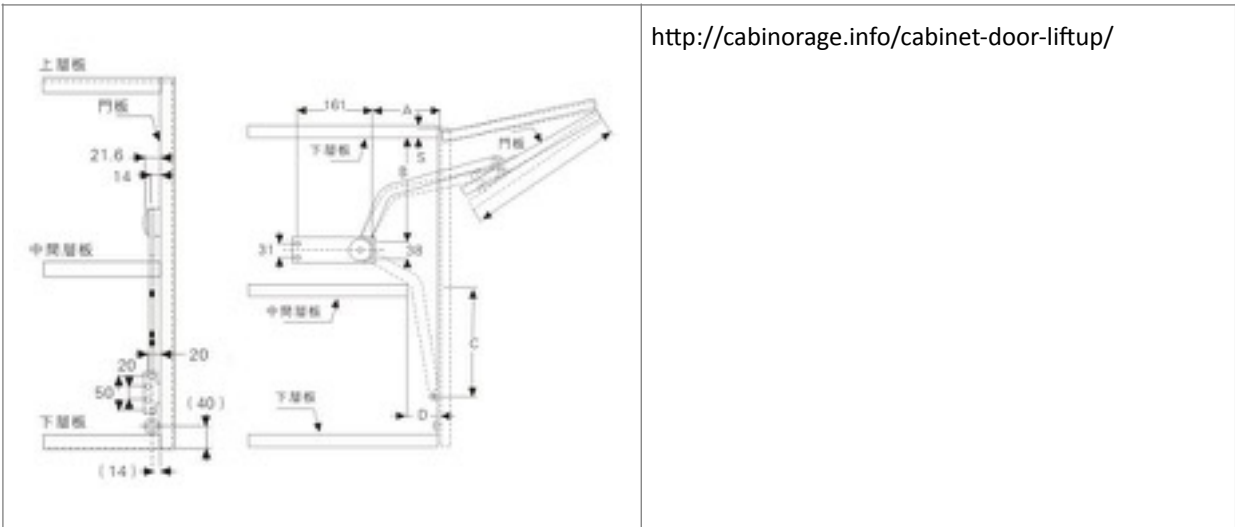


<http://www.woodcraft.com/product/145291/brusso-38-x-134-offset-hinge-pair.aspx>










Door stays
<https://www.architectureanddesign.com.au/suppliers/doric-products/adjustable-friction-stays-and-restrictors-from-dor>









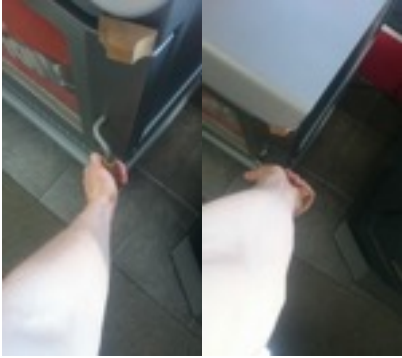
Upward Opening doors 'Google' Research

	<p>http://www.cargurus.com/Cars/2011-Mercedes-Benz-SLS-Class-Overview-c22221</p>
	<p>Lamborghini Doors http://www.wikihow.com/Install-Lambo-Doors</p>
	<p>http://www.hardwarefurnitures.com/Article/helps-09550109141_1.html</p>

	<p>http://www.hardwarefurnitures.com/Article/helps-09550109141_1.html</p>
	<p>http://www.kitchenfittingsdirect.com/shop/products.aspx?i=114306&c=7102&n=Lift-up-fitting-for-</p>
	<p>http://www.national-garage.com.au/automatic-garage-door-openers-melbourne</p>
	<p>https://en.wikipedia.org/wiki/Garage_door</p>


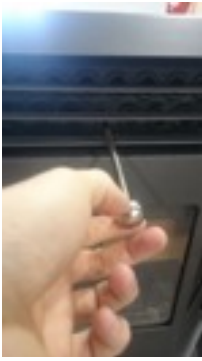
Handles on Current Combustion Heaters

	<p>Most common type (spring like handle)</p>
	<p>Numerous different shaped timber handles (went a dirty brown/black colour, sweaty/dirty hands)</p>
	
	<p>Favourite type of handle/latch mech. Much easier to use, less force required, more natural movement, etc.</p>


	<p>All the handles of current heaters needed to be pulled upwards to open the door. This is a good idea as you can lock your elbow out and pull up using your whole body. Engaging more of the larger muscles and requiring less effort. **Important as door mechanisms normally require a lot of force to open as they must be air tight.</p>
---	---

Vents on Current Combustion Heaters


	<p>Vents are normally located at the top of the heater. However the location of the control varies.</p>
	<p>This timber handle needs to be more secure, it had a lot of 'play'.</p>
	<p>The foot slider seems more like a tripping hazard.</p>


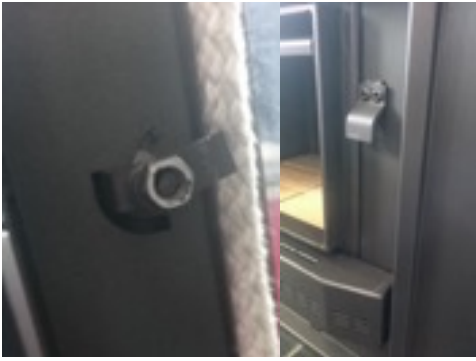
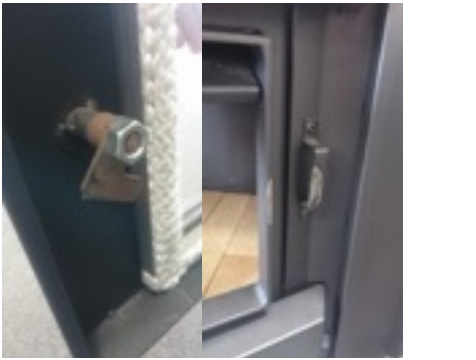
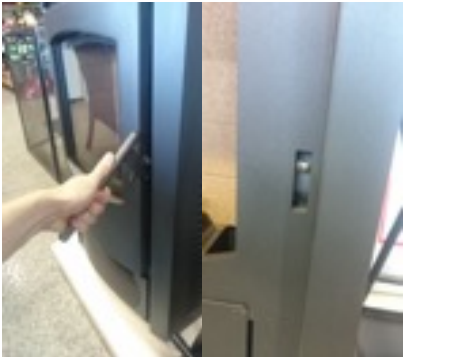
	<p>Knob handle of the slider felt the nicest.</p>
	<p>This control slide outwards (pellet combustion heater)</p>

Vents Current Ovens/Appliances






	<p>Neat exhaust vent</p>
---	--------------------------





Latches on Current Combustion Heaters

	
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	<p>Has a channel which restricts handle rotation 90 degrees</p>
	
	<p>Different orientation to most, nice movement.</p>

Latches on Current Ovens/Appliances

	<p>Pizza Oven</p>
	<p>Typical washing machine latch</p>
	<p>Typical Dish washer latch</p>
	<p>Handle is lifted up slightly which pushes a pin that pushes on the main body. This assists the initial opening movement.</p>
	<p>Same concept as the mechanism above.</p>

	<p>This latch made a really nice sound and feel when it released. Pleasurable experience</p>
	<p>Esky lid latch</p>
	<p>Esky lid latch</p>
	<p>Slides into hole (like an extendable tent pole)</p>

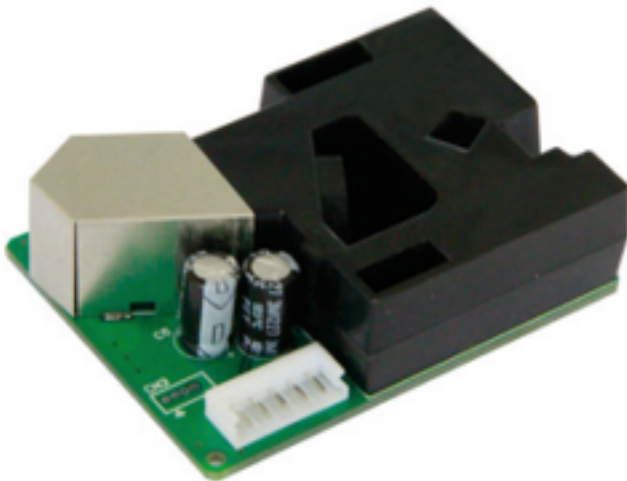
Appendix 3.1 - Sensors and Monitoring

Igrill pro Ambient probe.

The Pro-Level Ambient Temperature Probe is a must have for mastering your smoker. Simply set your minimum and maximum temperatures within the free iDevices® Connected app and receive alerts if your smoker or grill gets too hot or too cold! This wireless probe is heat resistant and could be used in a combustion heater and could be programmed to connect to an application to monitor ambient heat inside the fire box.

Led Dust Sensor Module

- Measurement principle Light scattering method
- Measurement particle particles larger than 1 μm
- (particle size can be set by potentiometer, such as PM2.5)
- Measurement range 0-28,000pcs/liter
- Pre-heating time 60s
- Response time 10s
- Weight 25g
- Power supply DC5V \pm 10%
- Power consumption 90mA
- Output PWM
- Working temperature 0-50
- Working humidity 0-95% RH non-condensing



Thermal Actuators

Available in a variety of sizes and configurations, thermal actuators all function through thermal expansion. Thermal actuators can be utilized in limitless applications from miniature to heavy duty. Fast acting self-actuating actuators provide precise pushing forces and accurate travel distances. Our patented high performance expansion material and willingness to blend you any temperature you want sets us apart from our competitors' inflexible policies and limited thermal abilities. With our actuators you are in complete control over what temperature range they perform at and to what degree. Every actuator we design is for the customer and to the customer's specifications. The graphed performance curve below demonstrates what you would see on a typical thermal actuator performance curve.

The variables on the performance curve are: Temperature Range, Extension Stroke, & Return Stroke. Please keep in mind that the products on this page reflect standard actuator functions & features that may not fit directly into your application and will require modifications; this is normal and is to be expected. We also can accommodate any fastening method you need, standard threads, snap rings, custom design etc. If you are unsure of what you need simply let our team of engineers work with you to solve your problems. Prior to any commitment we can provide samples for you to evaluate and qualify, giving you the confidence needed to move forward with your project.

Lesjöfors develop and manufacture springs designed for demanding environments with high or low temperatures and aggressive conditions,

Applications include:

- Oil and gas exploitation
- Heating processes
- Marine environments
- Space and aircraft industry
- Power production
- Chemical processes
- Petrochemical industry

Disc springs and washers, material dimensions up to 20 mm

Compression springs, wire dimensions up to 25 mm

Torsion springs, dimensions up to 25 mm

Tension springs, dimensions up to 25 mm

Leaf springs, material dimensions up to 10 mm

In difficult areas, unique materials, the so called super alloys, are needed. They are often nickel or cobalt alloys. For selection of the best material, knowledge and experience of these materials is crucial. Lesjöfors are able to advise the suitable material options based on the application and environment, design the spring and produce to order.

Appendix 4.1 - Application development.

According to Clutch.com the top 5 best DIY app development software for 2016 is:

-Bizness Apps

A DIY app development software aimed at SMBs with powerful CMS

-Appinsttute

An app builder with strong drag and drop tools and mobile marketing integrations.

-Como

A DIY app builder solution with many features focussed on customer loyalty.

-App pie

An app maker with extensive drag and drop app creation tools

-Mobincube – Mobimento Mobile

An app builder with the ability to easily customize and monetize user apps

Appendix 5.1 - Modern Architecture Research Examples





Appendix 5.2 - Interior Designer Interview

Interview with Jahvanna Taylor, Interior Designer at The Limery.

“Modern interiors focus on clean lines, small quality details and great finishes. For a space to succeed in a minimalistic style everything needs to be of the highest standard and quality. Permanent structures such as kitchens, bathrooms and cabinetry are either white or neutral for a clean timeless feel. The use of wood has increased quite substantially for kitchens and flooring but the use of lighter timber to create a more open and bright space.

The use of Black stainless steel is becoming more popular than ever preferred to the shiny silver metal appliances and finishes that were seen in allot of houses built between 2005-2010. The trend is stemming from designers and architects wanting to create a sophisticated space that will remain timeless and also suit different people’s style.

Raw materials are being used in current designs such as the use of concrete, un-sealed timber and marble. Gone is the use of plastic and artificial materials, people are wanting their houses more eco-friendly and sustainable as the awareness of climate change grows. Building companies are starting to advertise the use of sustainable and eco-friendly materials as there is an industry demand.

Many new homes being built have solar panels fixed to their roofs. The use of electric heating has increased as people are finding it cheaper to use and more sustainable. There is still a huge demand for wood fire heaters to be installed in new homes as people still desire an open fire place.

We supply fireplaces from a company called Invicta who are based in France. The modern designs are a perfect accent to any modern or traditional home. Simplistic design focusing on the elegance of how beautiful fire looks through the glass. Recessed fireplaces are a little dated now, with simplistic design the fireplace can be a feature of the living space. Everything exposed is a real industrial feel which works well in modern homes. Seeing the flue run all the way to the ceiling gives you a sense of space rather than having it inbuilt which can look chunky and take up too much space.

Fireplaces are being designed to be more than just to heat well. It should be the beautiful and efficient heart of any home- a functional piece of art. Suspended fireplaces are hugely popular because it looks good and has formidable heating power but also creates a statement both aesthetically and functionally. Many fireplaces are designed to rotate 360degrees so that you can enjoy your fireplace from all angles of your home. The suspended fireplace design creates for a clean lines with no need to have slate or concrete under the floor to protect.”

Example Images from Jahvanra on the next page.





Appendix 6.1 - User Research

Field Observation

User testing was performed using a chiminea, fireplace and combustion heater, and a combination of different fuels and fire starting accessories.

Starting

- How do you scrunch up the newspaper?
- Dirty hands
- Very fast burning, very hot quite quickly
- A fire starting 'kit' would be useful, rather than gathering all the separate implements and being without a place to store them

Maintaining

- When to put a log on? Maybe a part of the app, driven by a temp gauge.. - More smoke when a log goes on
- The shape and place of the fire is very organic
- Manly-man make fire

Cleaning

- On knees the entire time
- Inefficient tools for scooping ash
- What do you do with the ash?
- Could you vacuum to clean the ash out?

- Horrible aesthetics - scraping, screeching noises - Fires seem to be an inevitably messy process

General

- Tending to the fire is impossible while standing, kneeling required at all times
- The aesthetics - textures and especially noises are very rustic/uncomfortable, dark and dirty, not at all luxurious
- The excitement of a fire fizzles out after 30-40 minutes and becomes a bit of a chore
- There's a distinct feeling of a lack of control with an open fireplace, this is where the app would act as a bridge for feedback/information and control over how the fire burns.
- Can you roast marshmallows comfortably?
- Storage means with flat surfaces gather crap

Ergonomic issues/usability

- Fuel (storage, traditions, types)
- Firestarters
- Seem like a really useful tool but in reality don't add much if the kindling is set properly Paper
- Newspaper burns faster/hotter than cartridge paper
- Wood
- - Softwoods or less dense wood - pine
- - Hardwoods or more dense woods (red gum, maple)

Appendix 7.1 - Survey Example and Results

1. What type of heater do you own?

Ducted

Gas-Powered

Wood-Powered

Split-Cycle/Plug-in

Other (please specify)

2. How is your heater performing?

Not Good Good Great Really Great

3. Why do you use this type of heater?

4. Would you consider buying a combustion heater to replace your current heater?

Yes

No

5. What do you like about combustion heaters?

6. What do you NOT like about combustion heaters?

What do you like about combustion heaters?

Answered: 4 Skipped: 0

● Responses (4) ▲ Text Analysis 📁 My Categories

PRO FEATURE
Use text analysis to search and categorize responses; see frequently-used words and phrases. To use Text Analysis, upgrade to a GOLD or PLATINUM plan.
[Upgrade](#) [Learn more »](#)

Categorize as... Filter by Category Search responses

Showing 4 responses

The natural feel of a fire, I also like that it won't explode!
4/26/2016 3:41 PM [View respondent's answers](#)

Efficiency
4/26/2016 9:43 AM [View respondent's answers](#)

They look mad and they're cleaner and more efficient than fireplaces
4/26/2016 9:27 AM [View respondent's answers](#)

The heat, the atmosphere and the appearance
4/19/2016 9:41 PM [View respondent's answers](#)

Why do you use this type of heater?

Answered: 4 Skipped: 0

● Responses (4) ▲ Text Analysis 📁 My Categories

PRO FEATURE
Use text analysis to search and categorize responses; see frequently-used words and phrases. To use Text Analysis, upgrade to a GOLD or PLATINUM plan.
[Upgrade](#) [Learn more »](#)

Categorize as... Filter by Category Search responses

Showing 4 responses

Convenience.
4/26/2016 3:41 PM [View respondent's answers](#)

More eco friendly, adds theater
4/26/2016 9:43 AM [View respondent's answers](#)

Cause it's the shiznit
4/26/2016 9:27 AM [View respondent's answers](#)

Because I enjoy the atmosphere the fire place creates
4/19/2016 9:41 PM [View respondent's answers](#)

What do you NOT like about combustion heaters?

Answered: 4 Skipped: 0

● Responses (4) ▲ Text Analysis 📁 My Categories

PRO FEATURE
Use text analysis to search and categorize responses; see frequently-used words and phrases. To use Text Analysis, upgrade to a GOLD or PLATINUM plan.
[Upgrade](#) [Learn more >](#)

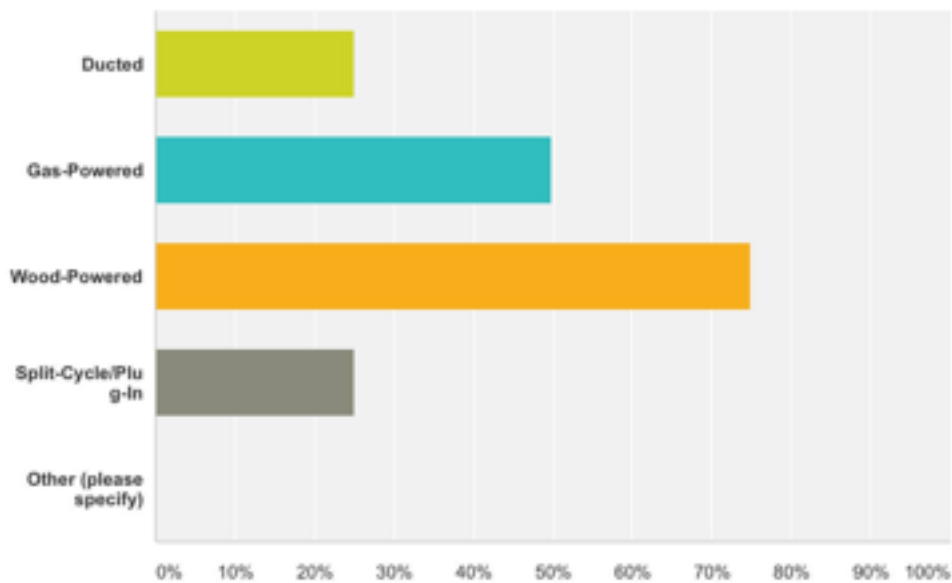
Categorize as... Filter by Category Search responses

Showing 4 responses

The work towards making a fire, cutting wood, stacking, lighting the fire.	4/26/2016 3:41 PM	View respondent's answers
Fire is contained in box, don't feel apart of it. Wouldnt suit house decor.	4/26/2016 9:43 AM	View respondent's answers
You can't just flick a switch to turn them on.	4/26/2016 9:27 AM	View respondent's answers
Bits of burning wood that can fall out when opening the door	4/19/2016 9:41 PM	View respondent's answers

What type of heater do you own?

Answered: 4 Skipped: 0



Appendix 8.1 - Materials

Steel Plate

- Laser cut, Casting, folding, welding, water jet cutting
- Pecan can cut and fold thicknesses from 0.2-6mm

Glass

- Water jet cutting
- 5mm pyrolytic glass needs to be used to seal the firebox
5mm toughened glass should be used as a secondary / aesthetic layer if heat is to penetrate through it
- Rectangular forms are desirable, but not compulsory
- Alternative forms can be achieved through water jet cutting (Refer to Chevron PDFs for specifics in appendices)

Copper

- Laser cut, Casting, folding, welding, water jet cutting • Transfers heat well
- Higher Melting point than Aluminium
- May not be suitable for majority of parts

Corten Steel (Weathering Steel)

- Laser cut, folding, welding, water jet cutting
- Comes in the form of sheets
- Forms an adherent protective rust 'patina', that inhibits further corrosion
- No painting required
- Low maintenance
- Economical in maintenance but initially more expensive than structural steel

Appendix 8.2. - Manufacturing Processes

Metal Folding/ Pressing/ Forming

- Range of angles possible
- Thicknesses for bending
- Range of movement

Welding

- MIG Welding is accessible at Pecan For Mild Steel
- TIG Welding is used for Stainless Steel
- Robo/c welding Should be utilised where possible
- Open areas are required for robo/cs to work

Sand Casting

“Sand casting, the most widely used casting process, utilises expendable sand molds to form complex metal parts that can be made of nearly any alloy. Because the sand mold must be destroyed in order to remove the part, called the casting, sand casting typically has a low production rate. The sand casting process involves the use of a furnace, metal, pattern, and sand mold. The metal is melted in the furnace and then ladled and poured into the cavity of the sand mold, which is formed by the pattern. The sand mold separates along a parting line and the solidified casting can be removed. The steps in this process are described in greater detail in the next section.” - custompart.net

- Basic casting principles/rules apply relating to wall thickness & draft.

Physical Features:

- Strong solid parts
- Complex metal parts
- Thin walled enclosure possible high tolerances • Rough surface finish
- Post processing required for clean up

Typical Applications:

- Engine blocks
- Engine manifolds
- Transmission cases

Production Economics:

“The material cost for sand casting includes the cost of the metal, melting the metal, the mold sand, and the core sand. The cost of the metal is determined by the weight of the part, calculated from part volume and material density, as well the unit price of the material. The production cost includes a variety of operations used to cast the part, including core-making, mold-making, pouring, and cleaning.” - custompart.net

Laser Cutting

- 3 Axis Machine
- Machine Constraints
- Advantages
- Can produce very large parts
- Can form complex shapes
- Many material options
- Low tooling and equipment cost • Scrap can be recycled
- Short lead time possible
- Disadvantages
- Poor material strength

- High porosity possible
- Poor surface finish and tolerance
- Secondary machining often required • Low production rate
- High labor cost

Pressure Die Casting - Aluminum

‘Die casting is a precise method of forming parts from metal. This high speed process uses pressure to force molten metal into reusable steel moulds, to create intricate and complex 3-dimensional geometries.’ – Thompson, R

Physical Features:

- Strong
- Complex metal parts
- Thin walled enclosure possible high tolerances
- Typical Applications:
- Automotive parts, mechanical parts • Furniture, Lighting
- Jewellery, Kitchenware

Production Economics

Process is only suitable for high volume production. Due to expensive tooling materials that need to withstand molten alloys. Labour costs are low due to finished parts having good surface quality and finish touches can be automated.

Process Sustainability

- Amount of molten material is pre determined so not much material is wasted
- Any wastage material and recycled metals can be added to molten material in most products
- Process used great levels of energy to melt alloys and keep them at high casting temperatures

Advantages

- High surface finish
- Produce large parts
- Variable mechanical properties
- Low unit cost
- Versatility
- High production speed (automated)
- Low labour costs
- Complex castings
- Thin wall sections due to liquid material being injected under pressure

Disadvantages

- High tooling cost
- Large capital investment
- Only suitable for one material and form
- Limited die life
- Long lead time
- Properties
- Low density
- Low weight
- High strength
- Good malleability
- Easy machining and formed
- Corrosion resistant
- Good electrical conductive (60% of copper) • Recyclable
- Non combustible
- Ductile

CNC Machining (Milling & Lathing)

- Outsourced
- 3 Axis Machine
- Gardiner Engineering Co. - Dry Creek

Appendix 9.1 - Customer Reviews

Stovax – Riva Studio 2

2/5 Stars – Continual Problems

“I have wished I had taken notice of others reviews! I am having the same problems as others which include broken fire bricks in first winter, smoke filling the home, thermostat failing & wood burning out quickly. The Stovax looks great but the issues I have had and the lack of service from Mount Barker Landscape Centre is astonishing. Castorks the supplier is even worse with every excuse under the sun. [name removed] at Castworks is an absolute jerk so don't expect any support from the distributor. By the time all the bits are purchased my Stovax cost me close to \$10K”

5/5 Stars – Designer Fire

“My interior designer showed me this heater for our holiday house, it was love at first sight. All the other heaters we saw had such a big and clunky frame around them. We've had it installed for a year now, I love sitting around it on those cold winter nights, absolutely brilliant!”

1/5 Stars - Don't buy a Stovax Riva Studio 2

"I loved the look of this fire, and bought one through Pivot Stoves in Dandenong, but it has been nothing but a disappointment. Firstly, when returning for the flue kit, the people at Pivot said, they hoped I had put tiles around it when installing it, because when lit, the heat cracked the walls. This information is not in the installation instructions, either on the internet, or the set inside the box. I didn't want tiles, so it had to be reinstalled to put fire proof material behind the plaster (it's meant to be a zero clearance fire!), (more expense!). Secondly the instructions on installation on the internet where wrong (the correct ones were inside the fire, which was inside a box, which was inside a wooden crate.) Consequently the space prepared for the fire had to be redone as well (also at my expense!). So ... it was in and looks great, if extremely expensive. However, although it does heat well, it only does so for about 4 hours. There is no difference when the baffle is open or closed and wood burns extremely quickly. It can't be shut down. Breezes come through, and make the room cold when it is out, the chimney rattles and as the other chap said, smoke billows out. I got no satisfaction from Pivot, because after they had a few cracking wall issues, they stopped selling them, and Castworks were of no help whatsoever. To sum up... an expensive disaster. Don't go near them."

5/5 Stars – Brilliant Fire

"Had a Riva Studio installed last year (not from Woodpecker) and the fire is brilliant, I do very little to it and it heats the room. Wish I had of installed one years ago"

5/5 Stars - European Quality ... Low Maintenance Heating

"I installed my Stovax Riva Studio 3 prior to winter 2014 and quickly established a routine that keeps our house warm, day and night, with little effort. The long burn time allows us to load up the fire prior to bed time and still have hot coals (and a warm house) in the morning. [name removed] from Castworks was knowledgeable and obliging, both before and after our purchase."

1/5 Stars - Ghastly, awful, poor warranty, bad product and no customer service

"Purchased a Stovax studio 3 in June this year. Within 12 burns the fire-bricks broke, the new walls cracked, the fire goes out after 5 hours or so. Neither woodpecker or castworks have been any help at all, if i could give any advice it would be don't buy from either!"

Regency – Montrose

Review by Pivotstove.com.au

"When it comes to flames, the Montrose has it all - you do need to fill the firebox to get the most from this heater. The door catch is good, locks the door closed every time & the glass is very clean. The ducting kit is a must if you want some serious heat from this heater, but if you just want a wide glass with flames - the Montrose is perfect. Our heater score 7/10."