Heat Recovery System

For

Domestic Power Flu Gas Fires

The Team	
Marketing manager	Thomas Adair
Project manager	Helen Baxter
Commercial manager	Alex Greenwood
Technical manager	Charis Kourousia
Financial manager	Cuthbert Makondo

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Project Overview

Echo Mission statement.

Our mission is to utilise the wasted heat energy generated by power flue gas fires to heat the home. Our product will transform a power flue gas fire from a costly, mainly, aesthetics feature, into a resource that can potentially save a householder money and reduce the overall amount of energy required to heat the home.

Product description	• A heat transfer system that will capture the heat energy expelled from the back of a power flue gas fire in order to utilise it within the home.
Key business goals	• Develop consumer friendly products. • Allow customers to gain more heat energy within their homes without increasing their energy bills. • Develop a safe and efficient product that conforms to industry standards. • Produce environmentally sustainable products. • Develop a product from which future evolution and development is possible.
Primary market	• Existing power flue gas fire owners • Householders purchasing a new power flue gas fire.
Assumptions and constraints	• Final product cost will be appropriate to our market. • The product will not interfere with or invalidate the guarantee the existing power flue gas fire. • Potential customers will be able to correctly fit the heat transfer system. • It will be possible to source all the component parts of the heat transfer system in a way which satisfies Echo's company ethos. • It will be possible to reach our target market through advertising and an awareness campaign.

Key to Echo's success

A major attraction to the consumer of Echo’s heat transfer system is the potential that it has to save money on household energy bills.

During initial market research there was a strongly positive reaction to Echo's idea of capturing wasted heat so that it can be used rather than just wasted.

People like the idea from the perspective of improving their homes energy efficiency.

Owners of power flue gas fires are particularly aware of the wastage in energy that occurs due to the fires inefficiency. They can actually "see" this happening every time they pass power flue vent, they can feel the warm fumes being expelled. Echo the heat transfer system which gives them a way to do something about this.

The obviousness of the problem of losing heat through the back of the power flue gas fire is something that Echo can take advantage of. We're providing a solution to a problem that people are already conscious of.

Consumers are currently very concerned about the high price of gas and electricity. Echo’s heat transfer system enables them to be proactive in reducing their energy expenditure.

Echo has decided to produce a very specific product aimed at a very specific market segment.

The Echo heat transfer system has been designed specifically to use in conjunction with a power flue gas fire.

This decision was taken because

- Power flue gas fires are inefficient, when working at full efficiency for every kilowatt of energy used only 45% that is returned to the room in the form of heat (http://www.magiglo.co.uk/products).
- Power flue gas fires have an inbuilt safety system which prevents the fire from working if there is any problem with the exhaust gases that the fire produces. Echo can take advantage of this feature, if our heat transfer system causes any obstruction then the power flue gas fire it will automatically stop working. For example, if our system is incorrectly fitted there will be no safety hazard; the system will simply cease to work.
- There is an obvious benefit to the consumer of reclaiming wasted energy.
- The UK government is currently encouraging households to reduce their energy consumption; Echo’s heat transfer system would help to do this.
- A large number of UK households currently own power flue gas fires.
- There is potential for our product to develop and evolve over time, developing new efficiency solutions for different types of gas fires and other heating systems.
- Domestic energy bills are increasing drastically.

SWOT Analysis

	Helpful to achieving objectives	**Harmful to achieving objectives**
Internal origin (attributes of the organisation)	Strengths • Confidence and belief in our product. • Use of existing technology to solve a problem on the domestic scale. • Once the product is installed it is very simple to use. • Product fills an existing market need.	Weaknesses • Team lacks technical design skills. • Requires the customer to be competent to fit the product themselves. • Product cost. • Inability to access all possible sales opportunities.
External origin (attributes of the environment)	Opportunities • UK government currently encouraging householders to improve their homes energy efficiency. • Increasing cost of gas and electricity. • Grants may be available, which would reduce the cost of the product customer. • Increased environmental awareness.	Threats • Development of a direct competitor at a lower price. • New safety legislation being introduced that applies to our product. • The market for our product vanishes, due to power flue gas fire is no longer being produced. • The power flue gas fire manufacturers refuses to honour their guarantee if our product has been fitted.

Team Profile

Title	Team member	Roles within the project
Project manager	Helen Baxter	• organisation • communication • record-keeping • allocation of tasks • presentations • driving the project forward
Commercial manager	Alex Greenwood	• supply chain organisation • purchasing • component sourcing • intercompany communication
Technical manager	Charis Kourousia	• product embodiment • product representation • technical research • technical analysis of competing products • product failure analysis
Financial manager	Cuthbert Makondo	• financial analysis of product • financial analysis of running costs • financial analysis of set up costs • setting product price
Marketing manager	Thomas Adair	• designing market research • undertaking market research • collating market research • identifying market potential • identify market limitations • identifying customer wants and needs • product sales and marketing

Echo's company ethos.

Echo wishes to portray itself as a company with green credentials. Echo's customers should believe Echo to be an environmentally responsible organisation, which produces a product that is beneficial to the environment.

The Echo heat transfer system has been developed in order to reduce household energy consumption by reducing the amount of energy required to heat a household. This environmental benefit underpins Echo's whole ethos.

Echo is an organisation which cares deeply about the broader environment, we are dedicated to reducing the amount of energy consumption required to maintain a comfortable and technologically advanced 21st-century lifestyle.

As a company Echo can employ environmental best practice in many different ways. For a company to make money and sell its product, at a price that is acceptable to the consumer, it is necessary to sacrifice some environmental considerations in order to produce a viable product that will actually sell.

There are three main areas of environmental impact that Echo can control.

- management of the production process and how the company runs on a day-to-day basis
- sourcing and materials used to produce and deliver the product
- environmental benefits of the actual product

Management of the production process and how the company runs on a day-to-day basis.

Echo will employ environmental best practice in the way in which the organisation is managed; it will comply with environmental management standards as outlined for Environmental ISO 14001. Echo business premises will be as energy efficient as possible making sure that the building is well insulated in order to minimise heating costs, where possible energy efficient technologies will be used. This will help minimise Echo’s day-to-day running costs, putting in place environmental best practice management systems and saving on our energy requirements. We will also make sure any waste produced by Echo will be sorted and recycled where possible following the waste hierarchy system of reduce, reuse, recycle.

An additional benefit to Echo of best environmental practice will be to gain an environmental Kitemark® which will link Echo in the consumer in mind with all the positive associations that there are with Kitemark®.

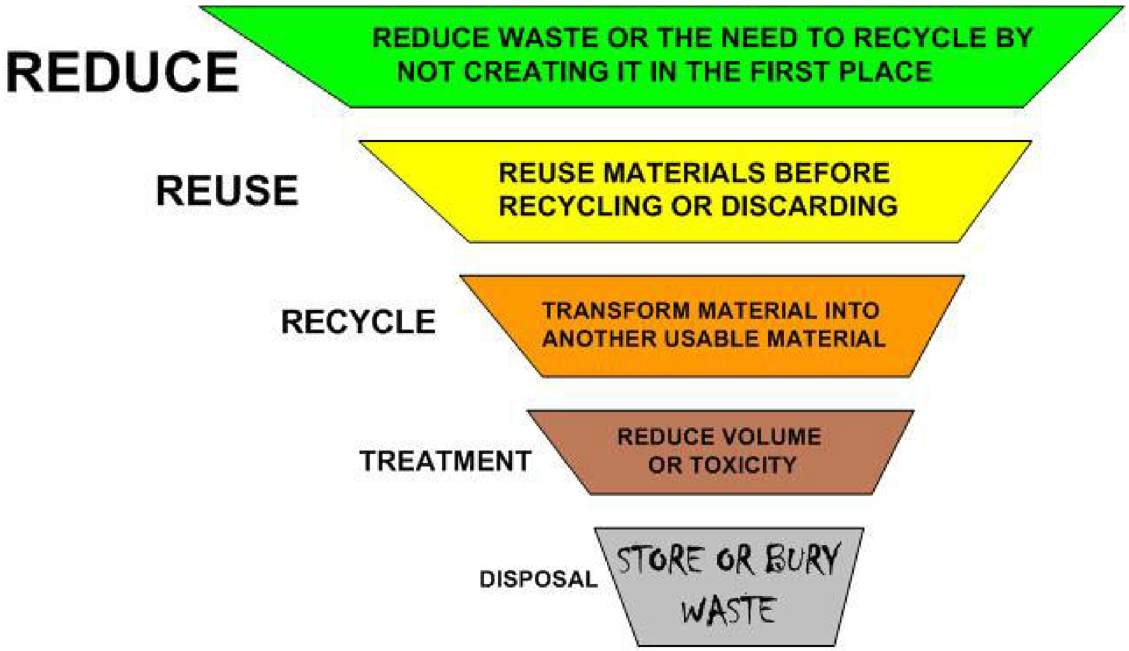


Figure 1 (http://p2.sandia.gov/images/Guide/Hierarchy.jpg)

Sourcing materials used to produce and deliver the product.

It would be possible for Echo to source all the materials that make up a separate component parts of the heat delivery system from highly environmentally sustainable sources. For example using recycled materials to produce the ducting. Fans produced from reclaimed parts and recyclable materials.

Echo has decided that to follow the environmental best practice route would be far too expensive initially, as we strive to break into the market with our product.

We have taken the decision to source quality components at reasonable prices without taking into consideration any broader environmental issues. We hope in the future that we will be able to be more demanding of our suppliers' environmental credentials as our importance to them increases in proportion to the size of our order.

As Echo develops and evolves as a company producing a broader spectrum of products we envisage it being able to demand more from our suppliers in terms of environmental and ethical production practices. Echo recognises that until we move from small scale production of a single product to a larger product base it will be difficult for us to source environmentally friendly components at a price that would be economically viable.

Echo is also aware that the recent legislation regarding product disposal requires the producer of a product to be responsible for its disposal. This will require the consumer to return a product at the end of its life time to Echo. As we envisage our product lasting at least 10 years we do not feel this is something we have to factor in into our costs as yet. Because of the way in which our product is manufactured, being made of the separate component parts, it will be simple for us to dismantle the heat delivery system into its separate components and apply the reuse and recycle elements of the waste hierarchy to our product disposal.

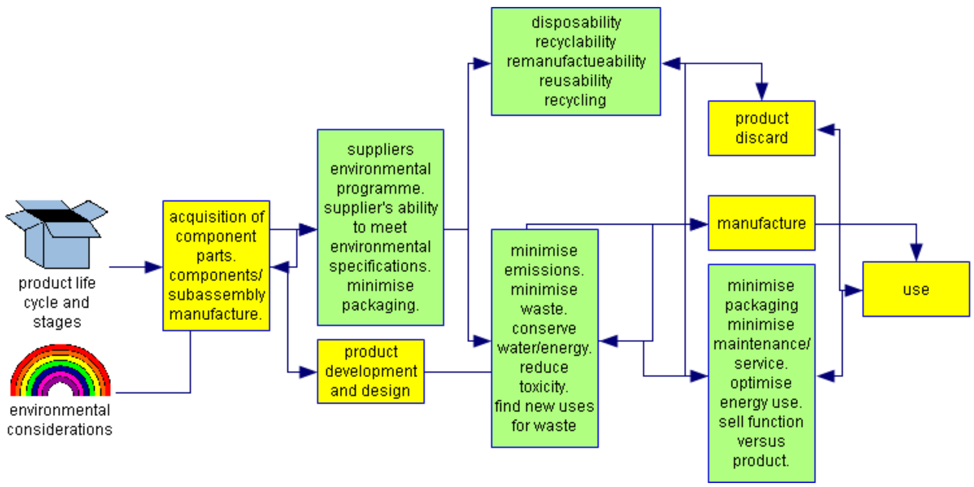


Figure 2 (Adapted from Deanna J. Richards, 1994. Environmentally Conscious Manufacturing. *World Class Design to Manufacture* 1, 3, 22.)

Environmental benefits of the actual product.

Echo belief that its product is of great benefit to the environment. This is because it replaces the need for a householder to buy an additional heater for another room within the home.

It reduces the energy required for heating an additional room within the home, reducing it from 2 kW to 100 W. This is clearly a huge environmental benefit.

It increases the efficiency of a pre-existing heating system, the power flue gas fire, so negating the need for the householder to purchase a new gas fire that is more efficient. This is environmentally beneficial because the old gas fire doesn't need to be disposed of so saving on waste and the energy required to produce a new gas fire.

Less energy and materials are required to produce our system than is required to produce a separate room heater such as a fan heater or storage heater for example.

How Echo see our customer base.

Echo envisage our customer to be the owner of a power flue gas fire wishing to purchase a supplemental heat source for their home, such as an electric heater.

The Echo heat transfer system will present them with the choice between purchasing a 2 kW electric heater for around £50, which will cost on average around £160[1] a year to run, or the Echo heat transfer system which would cost around £150, but with the same running costs but 100 W light bulb.

Through effective marketing and advertising Echo will be able to capture the imagination of our customer base.

We will make them aware of the financial benefits of the Echo heat transfer system.

We will promote the environmental advantages of utilising otherwise wasted energy.

We aim to make our customers feel good about themselves, by buying our product they will be contributing to the fight against climate change.

[1] based on 1 kW hour costing £.10 being run for X hours a year

Risk assessment

Potential problem	Potential of occurrence	Impact of occurrence	Consequences of to the company	Outcome	Action
Team members lack necessary skills and experience	High	High	Intolerable	Weak product development.	Research, learning teamwork, consultation with senior management.
Team member not fulfilling their individual role	Medium	Medium	Significant	Place undue burden on other team members, may result in weak areas in the product development.	Product manager to clearly allocate individual tasks
Product misunderstood by an individual team member.	Medium	High	Significant	Areas of weakness within the product development.	Communication between team members and regular updating of product development.
We fail to meet mandatory regulations.	Medium	High	Intolerable	Unable to take the product to market.	Be aware of mandatory standard requirements.
Components are not to required standards	Low	Low	Intolerable	Unable to take the product to market	Make sure all components comply with required standards.
Supplies fail	Low	Medium	Intolerable	Disruption of manufacturing chain, delaying taking the product to market.	Put in place contracts with to ensure delivery. Identify possible alternative suppliers.
Costs change	High	Medium	Would change financial forecasts.	Would require the product priced to be changed.	Contract for an agreed price with suppliers.
Reliance on customer to correctly fit our product fitting our product.	High	medium	May affect our reputation.	The product would fail to function.	Produce easy to understand installation instructions
A similar product is developed by another company.	High	High	Change the market environment.	May reduce our market share.	Reassess our advertising and sales strategy.

Industry standards

The Echo heat transfer system is required to comply, by law, with certain standards. It will be necessary for the Echo system to obtain a CE Mark as it falls within the parameters that have been outlined by the European Union which make marking mandatory.

- The Low Voltage Directive 2006/95/EC
- The Electrical Equipment (Safety) Regulations 1994 (SI 1994/3260)
- DTI Guidance Notes on the Electrical Equipment, UK Regulations (ref. URN 07/616)
- Gas Appliances - 90/396/EEC

To obtain this CE Mark Echo will be required to prepare a technical document outlining our product's compliance with the requirements of each directive. It will also be necessary to get our product independently tested to make sure that it does comply with the relevant legislation. This can be done through certified testing agencies such as the B S I.

It may also be advantageous for Echo to obtain an environmental Kitemark®; Echo can achieve this by complying with the standards for

- Environmental ISO 14001

A Kitemark instantly bestows upon any product that possesses it a high level of confidence within the customer. Upon seeing an environmental standard Kitemark® the customer would know that Echo is an environmentally friendly company that can be trusted.

Echo's company ethos is to minimise environmental harm through the way in which our product is manufactured and our company is managed. It should be a natural progression for Echo to comply with the standards required in order to obtain a Kitemark® for environmental management. To achieve an environmental management Kitemark® is therefore a realistic expectation and should be achievable before we launched the product. We can obtain this type of Kitemark® through BSI by demonstrating to them that Echo complies with the specified processes for controlling and improving an organisation's environmental performance.

Eco also aims to obtain a Kitemark ®for our product as it would bestow a high level of confidence and trust in the safety and functionality of our product.

"Consumers and specifiers trust that products bearing the Kitemark® have passed a rigorous certification process and as such will not only be safer to use but will also be fit for the purpose for which they were designed." http://www.bsi-global.com/en/ProductServices/About-Kitemark/Kitemark-for-Products/

Echo recognises that due to the way in which our product will be sourced and manufactured a Kitemark®, for our product, is a future aspiration which we will work towards as our company develops and it may not be something that we achieve before the product is launched.

Project concept and development.

Initially Echo health brainstorming session in which number of ideas suggested and rejected before our final concept was selected.

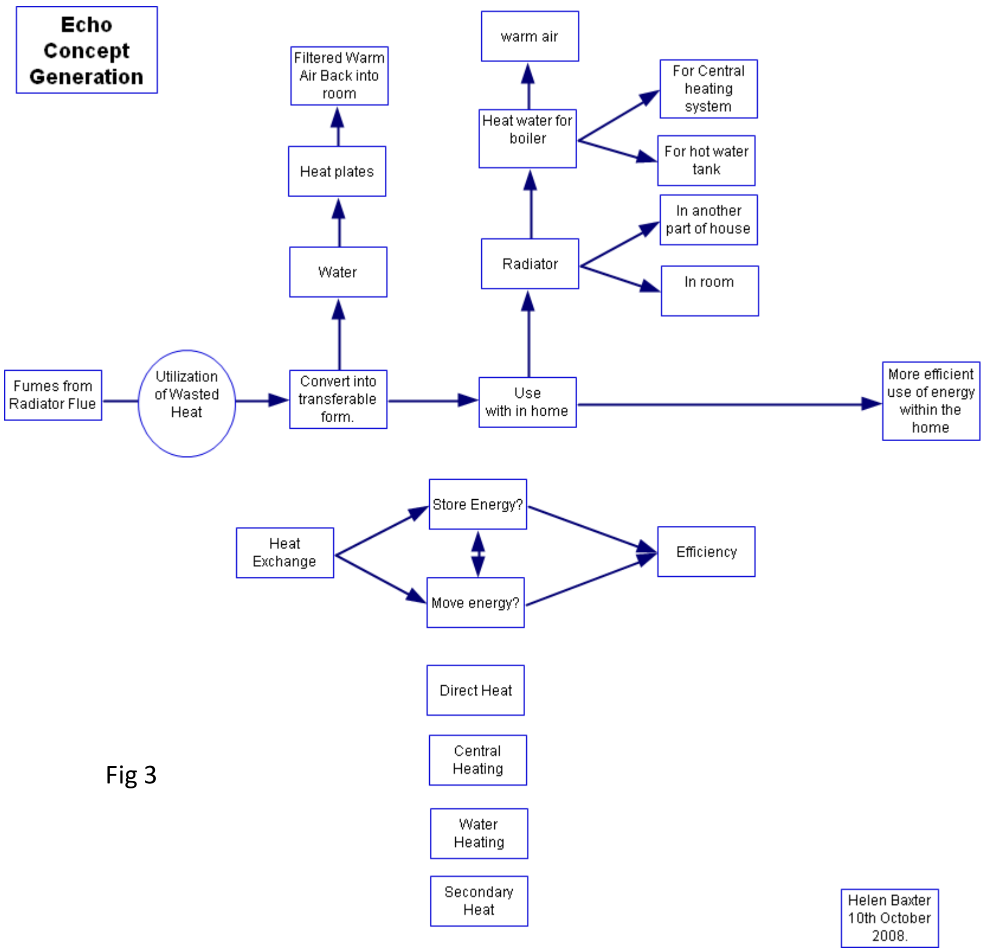


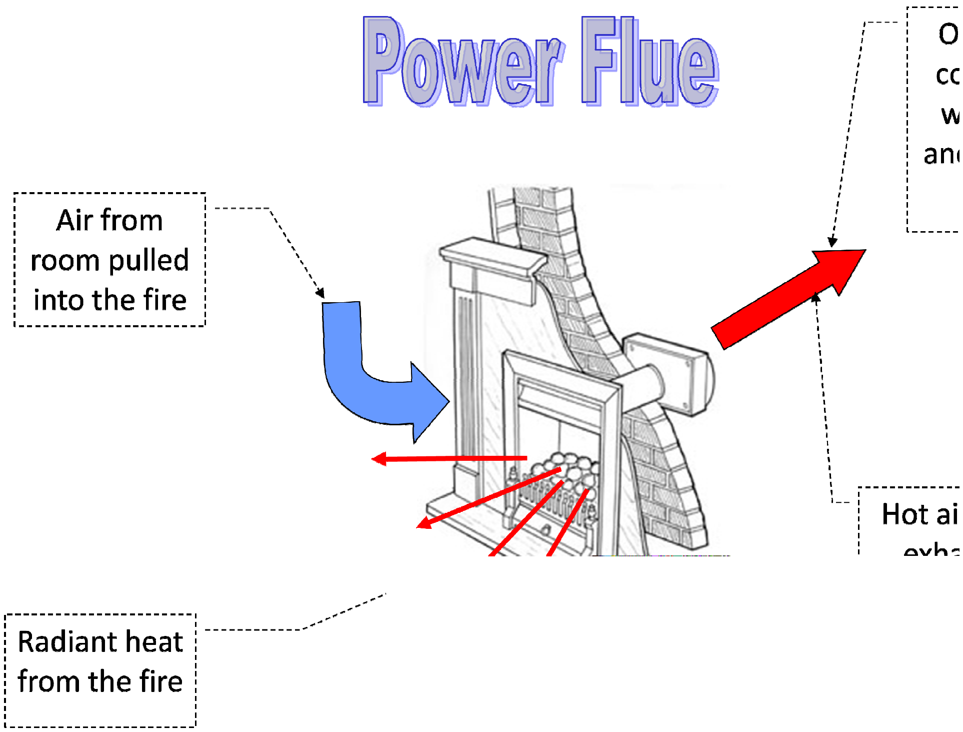
Fig 3

It was decided that we would focus upon trying to find a way utilise the heat that is lost through the back of gas fires when they are running. several suggestions of ways in which this can be done were sugested.

i. Using the heat as a supplemental to the boiler system, this wasted energy could be used to heat water that was already being used in the house. This would mean that the existing boiler wouldn't have to work as hard to heat water as it would already be as being heated by the gas fire, whenever it was running.
ii. Using the energy to heat water through a radiator base system, which could be placed into any location within the home.
iii. Using the wasted energy for a oil based radiator system.
iv. Creating some sort of system using the fire surround to reinject the heat directly back into the room in which the fire was located.

v. Creating a of storage heater of some type so that the heat created when the g could be used at different time.

Initial market research was conducted based around the idea of utilising wasted heat a within the home.



We conducted a number of interviews with members of the general public based on si questionnaire (see appendix xxx) and a grammatical representation of our initial idea.

This initial market research is useful because it enables us to gain an initial reaction to which was in general positively received. It also gave us an understanding of how muc would be willing to pay for such system and whether they could see the benefits of the themselves.

Process of concept generation was then gone through, the number of concepts was th down from 30 to 5.

The seven criteria used

1) ease of installation
2) efficiency
3) durability (implicitly)
4) ease of manufacturer
5) ease of use
6) money-saving potential
7) safety

Further analysis was undertaken using quality function deployment analysis (QFD), this was based upon further market research. (See Apendices)

The concept Echo finally decided to develop was one of using an air delivery system.

What our product will deliver.

The Echo heat transfer system will use the heat that is currently expelled from the back of a power flue gas fire to heat air, using a heat exchanger, so that the air can be used to heat another part of the house.

Echo Product Design Specification.

29 October 2008.

Wasted heat capture and redistribution system, for domestic gas fires.

- **Forward.**
  Natural flame effect gas fires are very popular, and until recently people have been willing to tolerate inefficiency. The current increase in domestic fuel bills means that people are less tolerant of this waste. Yet they still wish to maintain a real flame effect gas fires with its aesthetic appeal.
- **Introduction.**
  Echo intends to design a system that will capture this wasted energy and use it within the home. Echo will focus initially on the power flue gas fire, as this is among the most inefficient type of flame effect gas fire.
  As the power flue gas fire has its own internal safety system, which prevents fumes from re-entering the home and has a venting system which lends itself more easily to heat capture. It was felt that this would enable Echo to harness the wasted heat more effectively and safely.
- **Scope.**
  The product to be designed will be limited to recovering heat from living flame power flue gas fires.
- **Definitions.**
- Power flue -- this is a system where combustion takes place this is a system which enables an opening gas fire in use in a room without a chimney. The exhaust fumes that result are drawn out of the room by a fan. There are a number of safety systems to prevent flue gases escaping into the room.
- Natural flame (real coal fire effect) -- this is a gas fire that mimics as closely as possible a real fire. The fire is open to the room.
- Wasted energy -- the power flue not only extracts the toxic exhaust gases that it draws from the room and the fire large amounts of heat that could otherwise be used to heat the room.
- Capturing wasted heat -- a system to collect wasted heat and use it within the home.
- Passive System—The system interacts indirectly with the power flue and should require no external energy input.

Market.

- **Evidence of actual or potential customer demand**
  A brief market research exercise conducted by Echo had very positive responses to the basic idea of making gas fires more efficient will stop
  Power flue gas fires are only around 60% efficient, this means that if there was a way to capture some of that lost energy and use it, the customer would benefit from this new source of heat within the home.
- **Markets and market segments aimed at**

The market that we will be focusing upon is the domestic one. Specifically people who already own a power flue gas fire. This product could be marketed towards people who wish to have a more efficient gas fire but find the cost of buying a new fire prohibitive. They could instead invest in this system as a less expensive way to increase their gas fire's efficiency. It could also be aimed at household who wish to be greener as it could be seen as a way of reducing household energy requirements. Its major benefit is seen as saving money on fuel bills.

- **Advantage over competing products**
  We are currently unaware of any domestic scale heat exchange system on the market that is being used for the purpose of utilising wasted heat from domestic power flue gas fires. Buying and installing a more efficient gas fire would be more disruptive than more expensive than buying and installing our system. The more efficient gas fires do not have the same aesthetic appeal as power flue fires so our system would combine a more efficient fire with without compromising aesthetics.
- **Market share targets against competition**
  Our main competition would be from people buying a more efficient new gas fire and possibly people buying an electric heater to supplement their gas fire. A 20% share of this market would be considered to be a major success. More research is required on the number of power flue gas fires that are currently in use.
  Most of these flame effect gas fires are used as secondary heating so a benefit of this system would be to convert a secondary system into a primary system within a single room.

- **Special or unique features of the products**
  The design brief calls for a passive system that can be retro fitted by a reasonably competent D.I.Y. person. At a cost commensurate with the savings made by the system.

Performance requirements/specifications

- **Basic performance requirements**
  It needs to be efficient enough to save the customer money on their fuel bill. It needs to capture enough heat so that can be usefully used within the home. It should be easy to use. It should be easy to fit and install.
- **Target costs and selling price**
  This depends very much on how much *can* be saved on fuel bill. Our current aim is to produce something for around £150. Echo's market research found people would be willing to invest in a system that would pay for itself in 18 months to 2 years given current changes in energy costs a reassessment needs to be made of the possible cost benefits.
- **Compatibility with existing products**
  It is imperative that our product does not interfere with the power flue fire in any way as this may have implications for the fire's manufacturer's guarantee as well as safety issues.
- **Guidelines on appearance style and image**
  Our system should be as unobtrusive as possible. If we go down the route of using a radiator type system, then based on initial market research, a conventional looking radiator appeared to be preferred. Although this may be revised on further analysis. Externally, appearance should be compatible with existing power flue fittings.

- **Relevant legislation standards and codes of practice**
  We need to investigate whether our system will be affected by any gas safety implications. We wish to design a system that will not have any interaction with the actual gas fire unit but only the vented gases. Avoiding the necessity for a Corgi registered fitter to fit it.
- **Requirements for reliability and durability**
  the system will be required to last at least as long as the gas fire to which it is partnered with(approximately 20 years is a reasonable estimate). It will have to be durable in order to withstand the outside elements that the external heat exchanger will be exposed to. Internally it will have to reach the same standards as any domestic heating system.
- Recommended **materials composed and quality of finish**
  The materials used will depend upon which technology are utilised for both the external and internal system. This needs to be investigated further.
- **Requirements economics and safety**
  The economics of this product are vital. It needs to save the consumer money otherwise there is little point in investing in it. This will be a key element in deciding the price of the product as well as production costs of the system. Safety issues are paramount.
- **Use of standard components and assemblies**
  We will be using existing technology and adapting it for domestic scale use. As well as marrying together different standard components such as radiators insulated pipes and components found in central heating systems.
- **Product requirements and constraints**
  This system has to be efficient enough to carry heat collected from the gas fire vents back into the home in a useful form. It has to be shown that this system will pay for itself through savings made on domestic bills within a reasonable timescale (our market research suggested that this time period would be a year to 18 months).
- **Packaging maintenance and servicing requirements**
  As this will be aimed at a DIY market packaging and presentation will be an important feature.
  As the intention is for a passive system maintenance requirements should be minimal and be able to be undertaken by a reasonably competent householder.

Time and cost

- **Project budget**
- **Timetable on launch day**
- **Potential future evolution**
  A satisfactory system devised for a power flue could then be further developed to take in conventional flues and balanced flues.

Other aspects

- **Manufacturing requirements**
  The system should be able to be assembled from existing available standard parts.
- **Operational requirements**
  The system should operate automatically whenever the gas fire is turned on.

- **Accepted standards**
- **Disposal**
  As far as possible all items used should be recyclable.

Commercial Overview

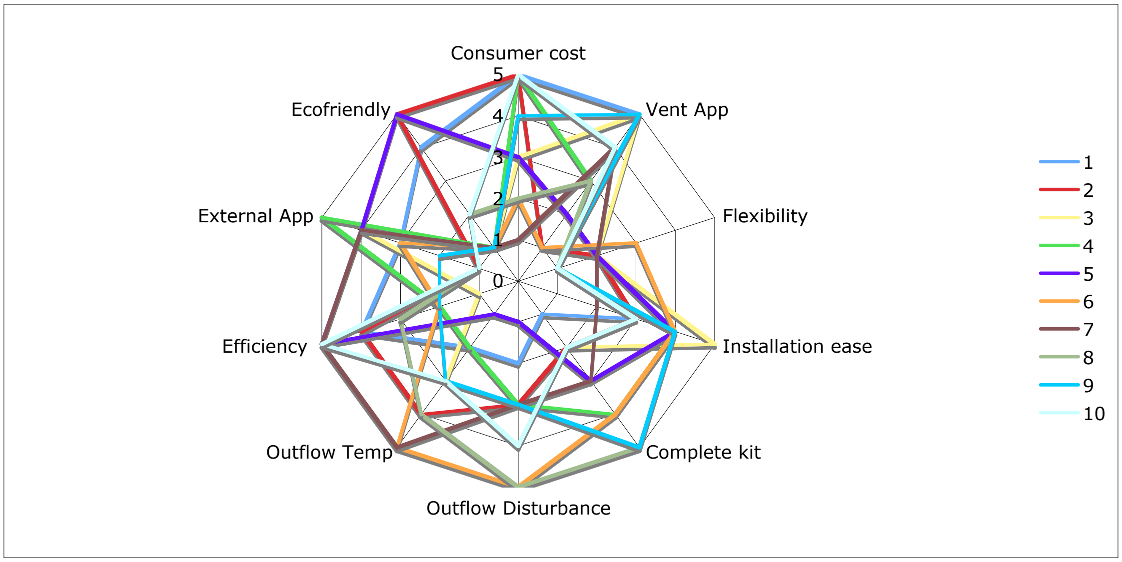


Figure 5 – showing customer feedback on attribute importance. Scale from most important (5) to least (1).

From data obtained from 10 questionnaires carried out by members of a focus group the star diagram above was produced. With reference to our proposed product 9 different attributes were listed and the focus group members were asked to give each a ranking from 1-5 on what they felt were the most important features of the product, they were allowed to allocate each score to only 2 criteria to ensure that an overall picture of what potential customers deemed important when debating whether to purchase such a system. This assisted us greatly in deciding what to focus on in our initial product development. From this data a number of key findings were made:

- Flexibility scored poorly and it was deemed important that a complete kit was provided, therefore when sourcing the components for the kit we can concentrate on getting the best parts not necessarily common parts.
- Both the internal and external appearance of the system when installed scored highly in our survey, this means when sourcing the components that will make up the kit extra detail should be paid to the vents and the heat exchange appearance, possibly even if it means greater cost to the customer.

- The highest scoring attribute of the product is the final cost, therefore every effort must be made to reduce the cost of all the components, these costs can be reclaimed from reducing the flexibility, installation ease and eco-friendliness if the product as these are things that came out as being of low importance to potential customers.
- Other attributes of the product that people considered to be of moderate importance are the outflow disturbance and temperature of the product as well as the efficiency. Therefore components relating to these areas will be sourced carefully, however reducing costs will limit to what extended these things can be achieved.

Component	Strengths	Weaknesses
Heat Exchange		
Fan	○ Guarantee from manufacturer. ○ Certified to operate within desired temperature range. ○ Economical – Low power input to relatively high output. ○ Quiet and small – discrete.	○ Moving parts create a chance of mechanical breakdown. ○ Not able to be recycled.
Ducting	○ Insulated providing minimum heat loss. ○ Approved to M1 fire standard. ○ Static working temperature -30^{o}c to 150^{o}c. ○ Maximum working pressure 3000Pa. ○ Maximum air velocity 30m/sec.	○ Glass wool insulation is used when other more environmentally friendly forms of insulation are available. ○ Expensive.
Vents	○ Ideal size and shape for adequate heat distribution. ○ Able to be painted. ○ Cheap – reducing cost passed on to customer, allowing addition vents to be bought to customer taste. ○ Durable and Fire safe. ○ Recyclable.	○ Not very aesthetically pleasing. ○ Requires drilling to be fitted.
Boxes	○ Double wall for additional strength. ○ Recyclable. ○ Low cost. ○ Easy to source.	○ Strength limited by the properties of the material. ○ Although recyclable material source is still unsustainable. ○ Can be subject to water damage.
Stickers	○ Recyclable. ○ Eye catching and display details to customer clearly and concisely.	○ Limited durability. ○ Can be subject to water damage.
Tape	○ Cheap and durable.	○ Not recyclable – could affect recycling potential of the whole box if not fully removed.
Leaflets	○ A4 – providing room for information to be displayed to potential customers. ○ Easy distribution.	○ Not a particularly cost-effective advertising method – easily ignored.
Packing Material – Shredded paper	○ Free from local councils. ○ Good packing material – protecting goods in the box.	○ Not as effective at protecting goods as other materials.

Initial ideas

Our team was originally tasked with the job of developing an economically viable product to bring to market within 3 months, as a number of our team had backgrounds in environmental sciences we felt this was good direction to pursue when designing a product. It was also felt that the new eco-conscious culture of consumers at this time meant we might be able to using the boom in environmental products as a good starting point to establish ourselves in the market. With this in mind we considered a number of different areas for witch a product could be developed providing both environmental and economic gain:

- Waste and grey water, re use or treatment.
- Increased energy efficiency in homes.
- Renewable alternatives to throw away items (carrier bags etc).

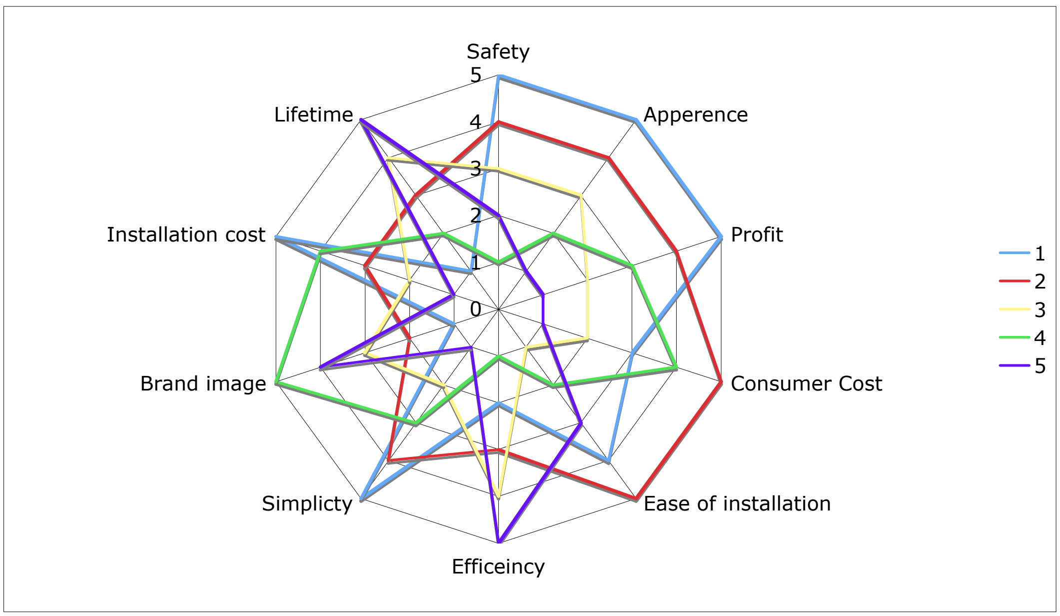
From these areas we chose to develop a product relating to increasing energy efficiency in homes as we felt this would be the most attractive prospect to potential customers due to the increasing costs of utilities as well as energy security issues present in today's political climate. A table was created showing areas in a home where savings could be made and whether such products already existed:

Table 1 – Potential household savings

Item/system	**Potential problems to be solved**	**Does an existing product already exist? Potential problems**
Fires	○ Recovering lost heat. ○ Increasing efficiency.	No – however problems may arise dealing with gas fires.
Central heating	○ Improved insulation. ○ Reduce heat loss. ○ Improve efficiency.	Yes – More economical boilers and more effective insulation available. Too big a system for us to re design.
Hot water	○ Improved insulation. ○ Reduce heat loss. ○ Improve efficiency.	Yes – More economical boilers and more effective insulation available. Too big a system for us to re design.
Waste/grey water	○ Reduce amount of water used. ○ Use wastewater for other household processes.	Yes/No – basic methods for capture of outdoor water exist. But not internal – may be too complex to modify plumbing.

This basic analysis of possible savings led us to consider both fires and waste water as areas for which a product could be designed. With fires we chose to immediately disregard coal and wood burning fires as these operate in a very basic way and modification is difficult, therefore only gas fires were considered. The conservation of heat and reduction of gas consumption we felt was also of much greater importance to potential customers and the use of waste water systems as they are often stigmatised as 'dirty'. There is also a greater potential for financial savings from reduction of gas usage as oppose to water as gas fires are on average 50% efficient providing a large scope for improvement. For these reasons our team focused its product development around savings associated with gas fires, specifically power-flue fires and we felt this was the easiest system to modify and were the most common type of fire throughout the UK.

Product development



<u>Fig 6– Star diagram showing scores given to 5 concepts involved with improving the efficiency of power- flue fires.</u>

The next stop in the development of our product was to develop a number of different concepts and these were all done centering around the use of an air-to-air heat exchange on the flue pipe of these fires. Then 10 categories were used to evaluate which concept best met what we wanted our product to achieve. The categories were chosen from initial market research and also what we felt was most important to customers, and the different concepts were ranked against each other. The 2 best concepts on this scale were 1 and 2 (Fig xxx). Here we went back to the drawing board and our final design became an amalgamation of both these 2 concepts providing what we felt was the best product to the customer, whilst maintaining a healthy profit margin for us as a company.

Brand image

Now with our final product in mind it was necessarily to both name our company and produce a company logo (Fig xxx), we felt this was very important as this had to be something that could be instantly recognisable in the market whilst summing up our company ethos and actions. The name we chose was ECHO ltd, we as a team felt this encapsulated our products ability to almost 'reflect' lost heat back into the home, whilst also representing an organic process demonstrating the companies desire to be in symbiosis with nature as it provides a beneficial environmental solution within the home.

Fig 7 – Echo company brand logo

Operations

Specialist companies manufacture all the components of our product globally to ensure the best product available for the customer; these are all ordered into out head office in Hull, UK. The office provides a number of key services for all the staff to work from, these include:

- Website maintenance and control of online ordering.
- Telephone sales.
- Product assembly and distribution*.
- A centre for all company directors to meet and work from.
- A professional space to meet and present out product to corporate buyers.

* distribution will be carried out by ParcelForce© worldwide.

Product Future

At echo we feel that initial selling through our website and through telephone sales from the promotional leaflets in gas fire showrooms is adequate for the first five years until we have established ourselves in the market. By this point we hope to have enough capital to facilitate expansion of the business and scaling up of product construction, this will help to lower the cost of the product and provide funds for additional product testing and development. We also hope to sell our product through a number of hardware wholesalers such as B&Q and Homebase, is it understood that doing this will detract from profit made per unit but will improve the selling potential.

Marketing Report

Marketing is a vital part in any new product development that goes into operation, marketing takes place before, during and after a new product has been conceived. Products that do not certain marketing criteria may not succeed in the real world of a sales environment.

Initial Market Research

The market research for the proposed product was gathered using various methods to maximise the results, this was done as opposed to using just one method of gathering information about the market place. The research was done to find out if there was a gap in the market for our proposed product, the 1st step in doing this to find out if there was already a product currently existing that matched or closely resembled out proposed product; this step was done and the results were that there was no current products that resembled out idea for a new product.

The following is a list of what we needed to find out by market research:

Is our product safe to use.

Would you need to be a corgi registered engineer to install the product.

How many people in UK have gas fires.

Are these people in rural area or urban areas or both.

What are the different types of gas fires available.

What are the prices ranges for gas fires.

How much do people pay an average for their gas bills.

How much would people be prepared to pay for this new product.

The market share of gas fires in UK.

The market share of electric fires in UK.

Potential Customer Market Research

A number of members of the public were asked Questions about gas fires and their overall gas usage.

Below is the Questionnaire that was used:

	A	B	C	D	E
1	Question	**Questionnaire for Gas Fires**			
2	1	Do you have a gas fire?	Yes	No	If no - Q10
3	2	How often do you use your gas fire?			
4	3	How much is your gas bill?	£		
5	4	Would you use your gas fire more if it was more economical?			
6	5	Do you have a gas cooker?	Yes	No	
7	6	How much would you spend on a more economical system?	£		
8	7	Would you want a simple system or more advanced one?	Simple	Advanced	
9	8	Do you like the idea of a 2nd heat source?	Yes	No	
10	9	What do you value more - aesthetically pleasing or efficiency?	Aesthetic	Efficiency	
11	10	Are you planning to get gas fire?	Yes	No	If no - Q11
12	11	Does the cost put you off getting gas fire?			If yes - Q12
13	12	Would you consider a gas fire if it was more economical?	Yes	No	
14	13	Note here anything else of interest that person says that is not covered by above,			

This Questionnaire was used with members of the public in a shopping centre, I also used the questionnaire with some friends.

The Questionnaire was only the first step in our market research, it did have its limitations as the options were rigid and more in-depth answers could not be obtained through this method. We could not go into too much detail with members of the public during the Questionnaire as they would not want to stand in the street giving a detailed interview as they had others things to be getting on with.

The next thing was to do a focus group were we could ask people more in depth Questions and get their feedback on various aspects of our new product.

Below is an example of some of the Questions that were asked to people in our focus group:

- Ease of installation.
- Do they want to buy a complete kit, or do they want to be able to buy the different components separately?
- Does noise from the fans matter to them?
- The appearance of the external heat exchanger, how much will this influence their decision to buy?
- What would they like in the kit?
  Do they want tools to help them fit it, or just the elements of the system?
- Would you prefer metal or plastic pipes?
- What style of fans would you prefer?
- What colour of fans do you prefer?
- Would you prefer it with or without insulation?

The Questions above were done to allow for far more interaction between members in the group.

Results from Potential Customer Market Research

Average Gas Bills (per Quarter).

The results clearly show us that customers are paying a lot of money out for the gas usage:

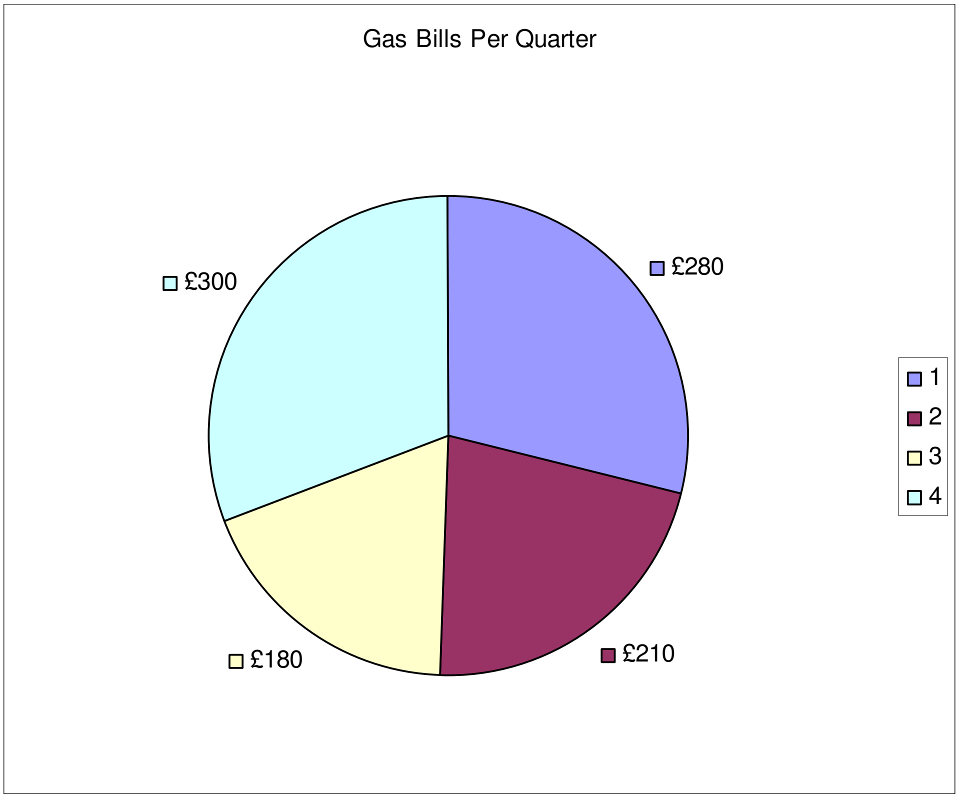


Fig 8

The graph above shows the Quarterly average gas bills that people who answered our Questionnaire

How much would you pay on more economical system?

This Question was asked in the Questionnaire to try find out how much people would be prepared to pay for our new product. This was important information as it allowed us to price how much we would be able to spend on each product to be made, we then added a profit margin to this figure.

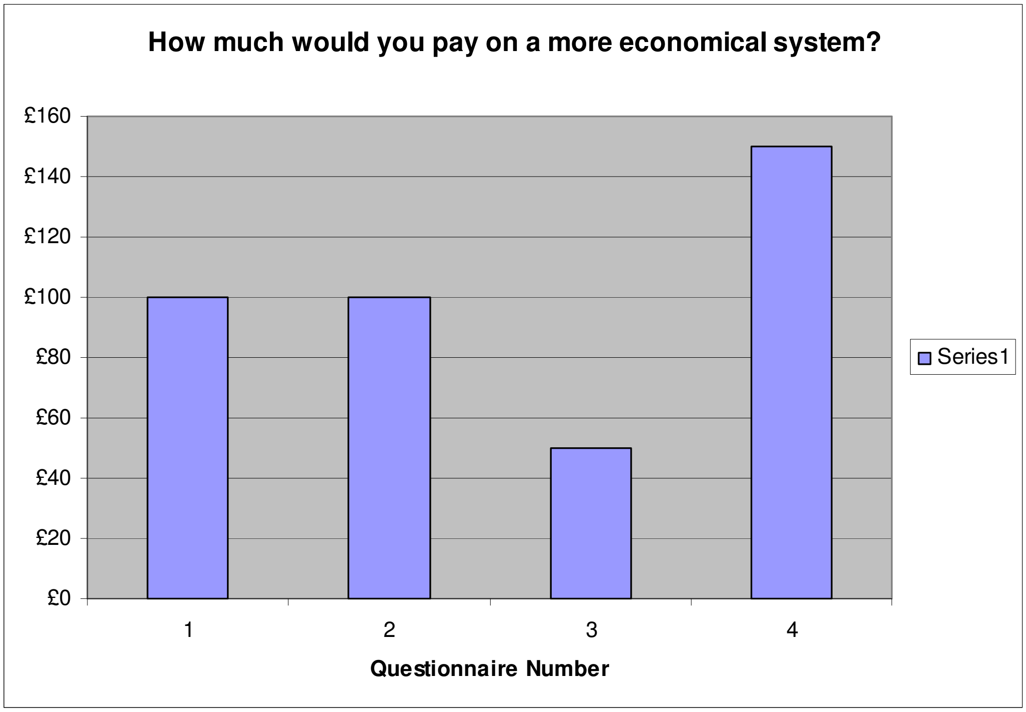


Fig 9

Some of the results we got from the focus group was also helpful as it allowed us to add and change some features of our product. Just to recap, below is an example of the main Questions that were asked to people in the focus group:

1. Ease of installation.
2. Do they want to buy a complete kit, or do they want to be able to buy the different components separately?
3. Does noise from the fans matter to them?
4. The appearance of the external heat exchanger, how much will this influence their decision to buy?
5. What would they like in the kit?
   Do they want tools to help them fit it, or just the elements of the system?
6. Would you prefer metal or plastic pipes?
7. What style of fans would you prefer?
8. What colour of fans do you prefer?
9. Would you prefer it with or without insulation?
10. Would you buy such a new product?

Now below we will look at some of the main responses to each Question that was asked:

1. All people Questioned would want a system that was easy to install that could be done by themselves.
2. All the people would prefer to buy the components separately.
3. Most people were not very concerned about the noise that would come from the air input fan, as they pointed out that the TV is always on in the room, and that the fire makes noise also. They said as long as it is not too noisy it would be fine.
4. They wanted to know if they spare parts.
5. Most people would be happy to use their own tools to install the system.
6. Everyone said they would prefer plastic pipes.
7. People were not concerned about the style of the fans, but some did say they would want them imbedded in the wall and not sticking out.
8. Some people were not concerned about the colour of the fans, but others wanted to know if they could have clip on plastic vent covers in colours to match their wallpaper.
9. Everyone Questioned would like insulation over the pipes.
10. Most people said they would buy such a product if the price was right, everyone said they would be prepared to pay £100-£200 max for this product.

Overall most people did like the idea of our product as long as it was at a reasonable price that they would be willing to pay.

Research into the Competition

Research into the market place for gas fires and accessories has been carried out and it has been found that there is no current product that even resembles our new product. The only thing that comes close is on an industrial level, whereas they have innovations to save waste heat from gas powered power stations. So in short, there are no competitors for our new product.

Results from Market Research

Electric Fires

Pound stretcher has 338 stores in the UK. I went into pound stretcher in the morning and checked their stock of electric fires, and then I went back 10 mins before they closed in the evening to see how many they sold. I counted that 10 sales of electric were made that day.

The following is a brief calculation that I made:

4 x 338 x 360 = 486,720

4 average sales per day all year round

338 stores in UK

360 days per year

Obviously they would not sell 10 fires per day in summer time, so I took 4 sales as an average all year round.   I also x by 360 to take in account public holidays when pound stretcher is closed.

If we estimate that pound stretcher is 20% if the market share that makes 486,720 x 5 =,2,433,600 sales of electric fires in UK annually.

The percentage % of UK households that buy electric fires annually are:

2,433,600 / 22,800,000 x 100 = 10.6%

Gas Fires

Homebase have 310 stores in the UK. I spoke to a friend of mine who works at homebase about their sales of gas fires, he told me that they sell about 30-35 per month in winter and 5 a month in summer time. The following is a calculation that I did for these figures (done winter as dec and jan):

35 (sales) x 310 (stores) x 2 (months) = 21,700

5 (sales) x 310 (stores) x 10 (months) = 15, 500

Total Sales: 37,200

I would estimate that homebase is about 20% of the market share in UK, so this means that 186,000 gas fires sold in UK annually

The percentage % of UK households that buy gas fires annually are:

186,000 / 22,800,000 x 100 = 0.81%

New Homes

There is to be 3 million new homes to be built in the UK by 2020. A basic calculation of this is 12 years (till 2020) divided into 3,000,000 homes:

12/3,000,000 = 250,000

That gives us 250,000 new homes per year.

We have to bear in mind that the majority of the gas fires fitted into new homes will be power flue, the reason for this is that homebuilders need to keep costs down and they are not going to spend an extra £600 to put a gas fire in when a power flue gas fire would cost £60.

I have estimated that if 75% of all new homes are fitted with a gas fire that will make 187,500 new gas fires being installed each year in new homes alone.

There are currently 22.8 million households in UK.

Markets and Market Segments Aimed at

Our product is mainly aimed at people who already have a power flue gas fire or people who are thinking about getting a new flueless gas fire in place of their power flue gas fire. You can buy a 100% efficient flueless gas fire, but they are 6-10 times more expensive than power flue gas fires. So part of our strategy will be to target the people are considering upgrading their gas fire to a flueless system. We shall point out to these people that our product will increase the efficiency of their gas fire at much less cost than simply getting a new gas fire.

Sales Strategies

One option for bringing our new product to the market will be to contact several DIY stores like Homebase and B&Q, these stores could sell our product in their stores. These stores could use our new product as an extra that goes with existing gas fires that sue power flues.

Another sales strategy that could be used is to use a leaflet that gas engineers could hand to existing gas fire customers. It is UK law that every gas fire in the country is serviced every 12 months. This is done to make sure the gas fire and flue are operating safely and that no danger of carbon monoxide leaks are possible. This will give us a vital sales opportunity for people who already have a gas fire.

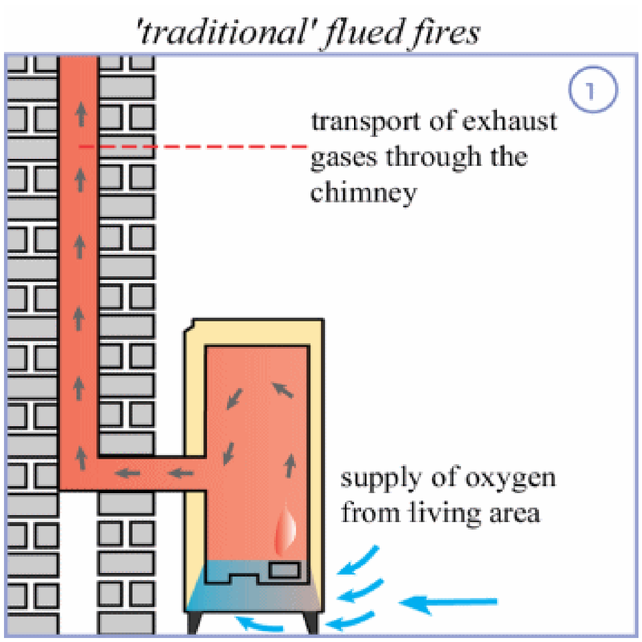
A web site could also be set up to advertise our product for sale. This web site could have multi media to show the potential customers how our product works, and if they have the right gas fire (power flue) to use our product. The media could show them how the waste gas is pumped out through their flue and this will show them how much heat they are wasting. The web site address could be added to the leaflet that gas engineers could hand to existing gas fire customers. This would allow the potential customer a better understanding of what our product does and how it works.

Below is an example of a leaflet that could be used by gas engineers to hand to potential customers:

Want to heat another room from your gas fire?

Did you know that your gas fire wastes 60% of the heat it uses?

The exhaust gases are simply pumped outside!



We know that to buy a new gas fire is very expensive, but there is a solution at hand.

Would you like to use this wasted gas that you pay for to heat another room?

All dangerous gasses from the fire would be made safe and the heat would be used to heat another part of the house that you desire.

This unique system simply re-uses the waste heat and out it back into your house and not pumped outside and wasted.

There is no need to buy a new expensive fire!

Cost £200

Tel: 0800 400 400

Sales Forecast

Sales Forecast on 186,000 gas fires sold per year

(% / 186,000)

0.5% Sales year 1 = 930

1.5% Sales year 2 = 2,790

2.5% Sales year 3 = 4,650

4% Sales year 4 = 7,440

5.5% Sales year 5 = 10,230

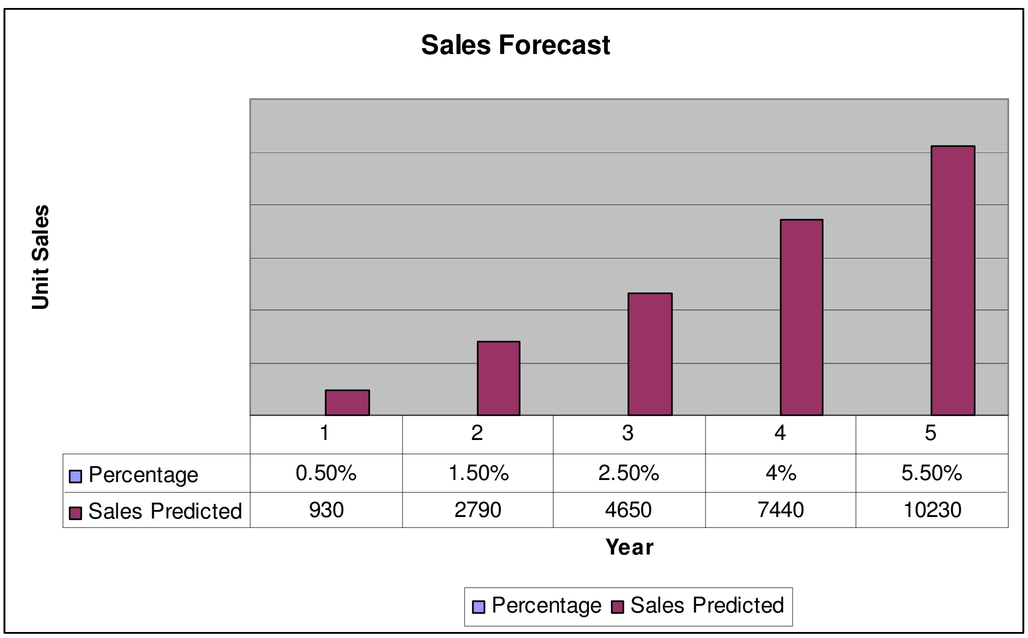


Fig 10

Here are the results again in a line chart format:

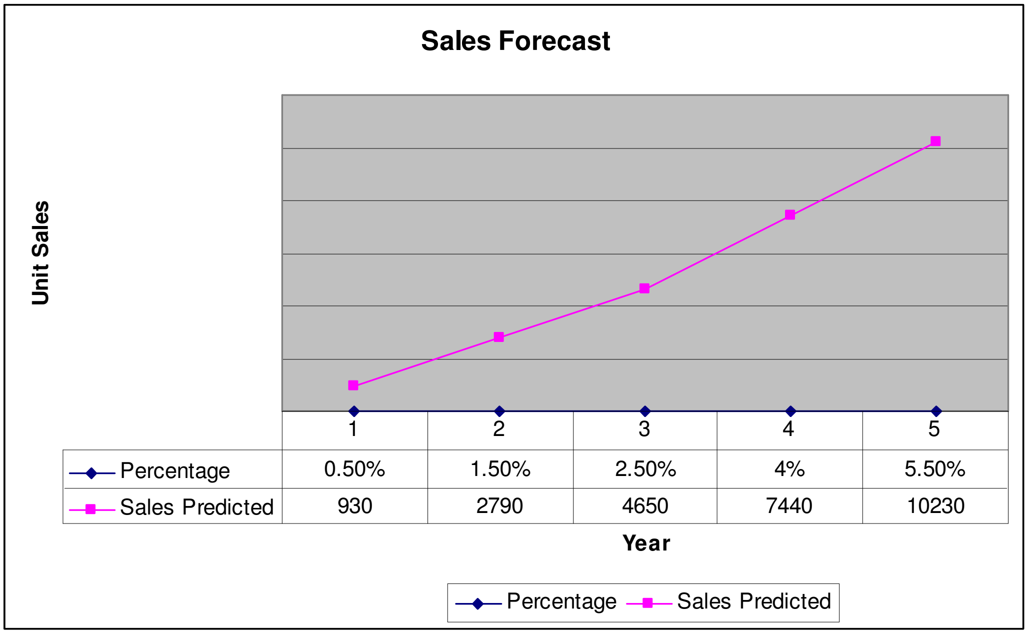


Fig 11

The sales forecast is a bit pessimistic to begin with as it is a new product and I do not wish to have unrealistic sales forecasts. I have done the forecasts to stagger upwards so that the sales percentages get higher with each year gradually. I have done this as I predict that word would spread amongst people and businesses alike. We have to bear in mind that engineers are visiting households to service their gas fires each year so with the leaflet and web site this will increase the sales upwards hopefully.

FINANCE CHAPTER

This section details the costs that must be met from development of the product to storage, distribution and finally selling it off. It also gives details on the assessment of whether or not Echo will perform well financially over a 5 years period, thus ultimately determining whether pursuing the opportunity further would be profitable or not. For the sake of clarity, this section has been divided into three sections namely, Development Cost (i.e., bills of materials and costing), Overheads, (i.e. fixed expenses), and sales and profits with a special emphasis on break-even point and then net present value considerations.

Development Cost:

Development costs are set up costs and as the term suggests, set up cost are costs required to start up a business. In terms of Echo, these are costs that will be incurred to produce the product. These may include cost of materials, and the cost of transforming those materials into an actual product. The Table below summarizes these costs.

See Apendix 1

Overheads:

These in a sense are fixed costs (when not billed on units basis) that a company meets over a fixed term period, e.g over a month or over a quarter of a year, whether it has made a profit or not. Overheads may include but not limited to the cost of salaries, rentals, and energy and water bills. They may also include communication charges and administration. In terms of Echo's personnel, there are 5 full-time employees associated with the product and Table 2 below shows their monthly income earnings.

Table 2

Position	Amount Payable (GBP) per Annum
Project Manager	29,000.00
Commercial and Production Manager	28,000.00
Finance Manager	28,000.00
Technical Manager	28,000.00
Marketing Manager	28,000.00
TOTAL	**141,000.00**
Other Cost	
Office Rentals	**3,000.00**

Source: Salary scales surveyed from EMR Specialist Recruitment (www.utalkmarketing.com).

Source of Rental costs: http://www.servicedofficeadvisor.com/serviced-office-space/postcode-HU.aspx

Thus, a total of **GBP141, 000** must be paid out to staff annually.

Other overheads costs such as energy and electricity are included in the rental offer and as such have not been considered separately.

Net Present Value.

According to Accaglobal.com (2008) NPV is used in capital budgeting to analyze the profitability of an investment or project. NPV analysis is sensitive to the reliability of future cash inflows that an investment or project will yield and as such, it is very useful in appraising investment opportunities.

NPV is the sum of all terms $\frac{R_t}{(1+i)^t}$, where;

t - the time of the cash flow

i - the discount rate (the rate of return) that could be earned on an investment in the financial markets with similar risk.

R_t - the net cash flow (the amount of cash, inflow minus outflow) at time *t.*

In the Echo ltd case, discount rate was put at 5%, as this is rate of return many other limited companies of equivalent risk normally use.

Table 3: NPV Tabulation

Year -Time T	**Cash Flow** (i.e. Inflow – outflow)	**Time T Value**	**Net Present Value**
0	144,863.86 - 0	1.0	-144,863.86
1	186,000 – 301,942.95	1.05	-110,421.85
2	558,000 – 352,470.60	1.1025	186,421.22
3	930,000 – 664,236.50	1.157625	229,576.50
4	1488,000 – 975,602.40	1.21550625	421,550.77
5	2,046,000 – 1,391,223.60	1.2762815625	513,034.44
Total NPV			**1,095,297.22**

Adopted from www.cimaglobal.com, www.Wikipedia.com

Investment Appraisal Decision Rule based on NPV can be considered in terms of the following aspects:

Table 4

If…	**It means…**	**Then…**
NPV > 0	The investment would add value to the firm	The project may be accepted
NPV < 0	The investment would de value the firm	The project should be rejected
NPV = 0	The investment would neither gain nor lose value for the firm	Should be indifferent in the decision whether to accept or reject the project. The project adds no monetary value. Decision should be based on other criteria, e.g. strategic positioning or other factors not explicitly included in the calculation.

However, NPV = 0 does not mean that a project is only expected to break even, in the sense of undiscounted profit or loss (earnings). It may show net total positive cash flow and earnings over its life.

NPV compares the value of an investment today to the value of that same investment in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative (www.accaglobal.com)

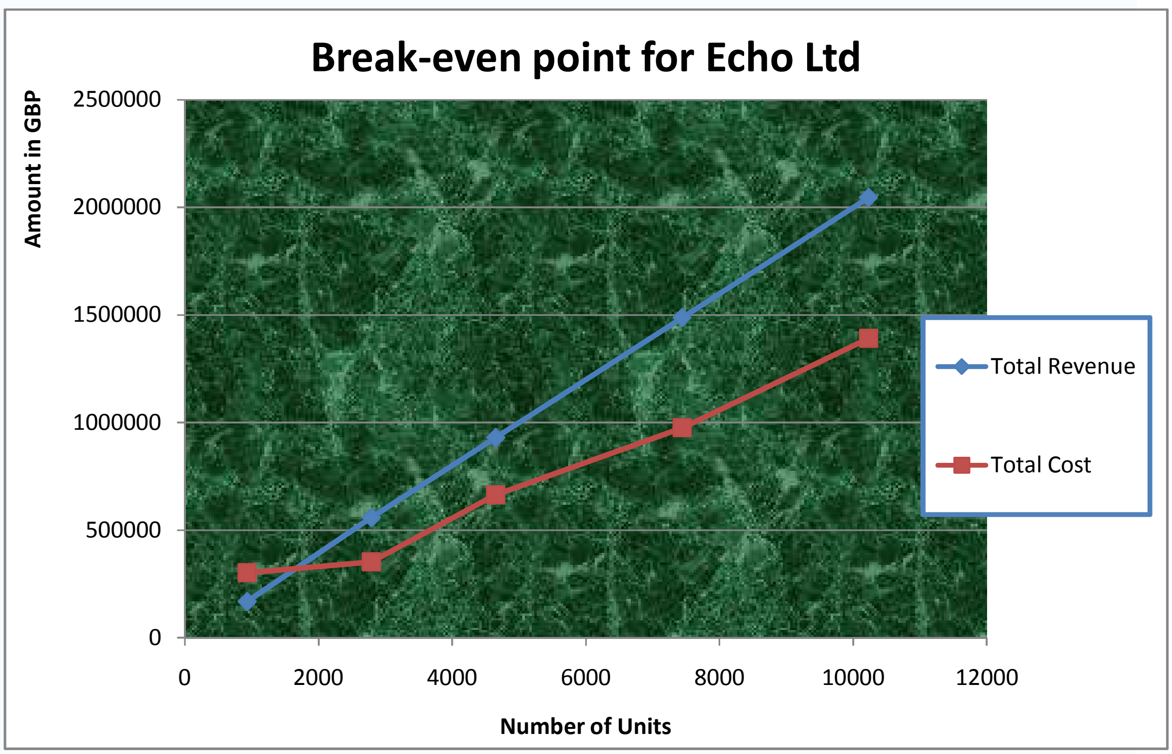
In our case at Echo Ltd, the conclusion is clear: we can pursue the concept further.

Break-Even Point

While the break-even point is one of the simplest yet least used analytical tools in management. It helps to provide a dynamic view of the relationships between sales, costs and profits. A better understanding of break-even—for example, expressing break-even sales as a percentage of actual sales—can give managers a chance to understand when to expect to break even (by linking the percent to when in the week/month this percent of sales might occur).

The break-even point is a special case of Target Income Sales, where Target Income is 0 (breaking even). In Business Economics specifically cost accounting, the break-even point (BEP) is the point at which cost or expenses and revenue are equal: there is no net loss or gain, and thus "broken even". Therefore no profit or a loss is made at this point (Wikipedia, 2008).

Figure 12.

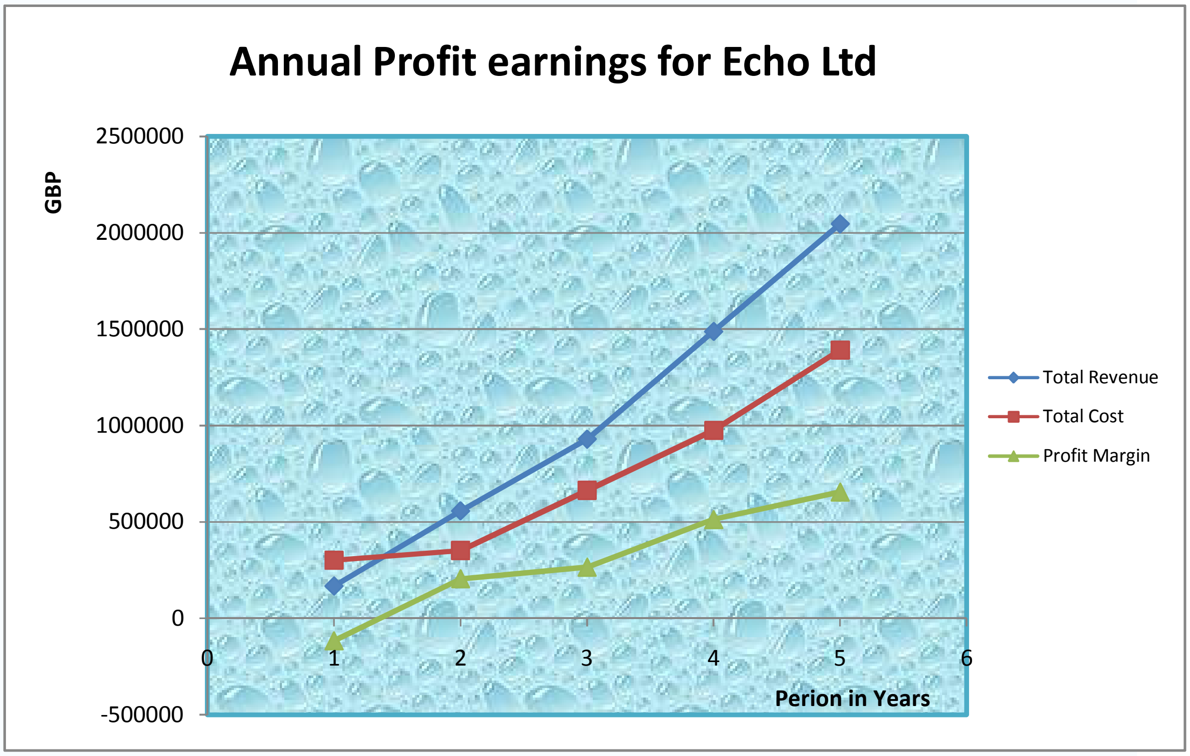


Echo Ltd's break-even point is around 1800 units (i.e. somewhere around the end of the first quarter of the second year)

Profit

The expected total profit for this investment is GBP1, 522,523.95 over a 5 year period. The graph in Figure 2 below shows the profit broken down to annual accruals, in which case, the first year is "red" value -115, 942.92. In the second year the profit is about GBP 205,529.40.

Figure 13:



After assessing the financial appraisals based on the financial modeling procedures highlighted in this Chapter, it is safe to conclude that the business investment in the flue gas fire product can be profitable and therefore worth pursuing further.

Technical Research

Heat Exchanger

A heat exchanger is a device built for efficient heat transfer from one medium to another, whether the media are separated by a solid wall so that they never mix, or the media are in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing.

How heat exchanger work:

A system for treating a flue gas includes a first condensing heat exchanger located in the housing for removing heat from flue gas as the flue gas is downwardly passed there through. A first collection tank is located in the housing below the first heat exchanger for collecting liquid and particulate. A second heat exchanger is located in the housing for
condensable removing pollutants from the flue gas as the flue gas is
upwardly passed through the second heat exchanger. A second collection tank is located in the housing below the second heat exchanger for collecting liquid and particulate.

What is claimed:

1. A segmented heat exchanger system for treating a flue gas, the system comprising: a housing having an inlet and an outlet, the flue gas entering the housing through the inlet and exiting the housing through the outlet; first tubular heat exchanger means in the housing below the inlet for removing heat from the flue gas, the first tubular heat exchanger means having heat exchanger tubes with a corrosion resistant covering and being constructed and arranged such that the flue gas downwardly in the housing through the first tubular heat exchanger means, the first tubular heat exchanger means operating in a condensing mode for removing both sensible and latent heat from the flue gas liquid spray means located in an exit of the first tubular heat exchanger means for assisting in removal of particulate and pollutants from the flue gas passing there through, the liquid spray means saturating the flue gas with water first collection means in the housing below the first tubular heat exchanger means for assisting in removal of particulate and pollutants from the flue gas passing there through, the liquid spray means saturating the flue gas with water first collection means in the housing below the first tubular heat exchanger means for collecting liquid and particulate from the flue gas; first mist elimination means situated in the housing in an exit of the first collection means for removing mist from the flue gas; reagent slurry spray means positioned in the housing prior to an inlet of a second tubular heat exchanger means for further washing and removing pollutants from the flue gas with an alkali slurry; second tubular heat exchanger means positioned in the housing prior to the outlet of the housing for condensable removing pollutants from and being constructed and arranged such that the flue gas, the flue gas passes upwardly in the housing through the second tubular heat exchanger means after passing through the first tubular heat exchanger means, the second tubular heat exchanger means having heat exchanger tubes with a corrosion resistant covering; and second collection means in the housing below the second tubular heat exchanger means and adjacent the first mist eliminations means for collecting liquid reacted slurry, alkali slurry and particulate.

2. The system according to claim 1, including a tray in the housing near the reagen slurry spray, means.

3. The system according to claim 1, further comprising first wash means located above the first tubular heat exchanger means for spraying water thereon.

4. The system according to claim 3, further comprising second wash means located above the second tubular heat exchanger means for spraying water thereon.

5. The system according to claim 1, including second mist elimination means situated in the outlet of the housing for removing mist from the flue gas.

Different types of Heat Exchangers:

Plate heat exchanger

One type of heat exchanger is the plate heat exchanger. One is composed of multiple, thin, slightly-separated plates that have very large surface areas and fluid flow passages for heat transfer. This stacked-plate arrangement can be more effective, in a given space, than the shell and tube heat exchanger. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical. In HVAC applications, large heat exchangers of this type are called *plate-and-frame*; when used in open loops, these heat exchangers are normally of the gasket type to allow periodic disassembly, cleaning, and inspection. There are many types of permanently-bonded plate heat exchangers, such as dip-brazed and vacuum-brazed plate varieties, and they are often specified for closed-loop applications such as refrigeration. Plate heat exchangers also differ in the types of plates that are used, and in the configurations of those plates. Some plates may be stamped with "chevron" or other patterns, where others may have machined fins and/or grooves.

Regenerative heat exchanger

An other type of heat exchanger is the regenerative heat exchanger. In this, the heat from a process is used to warm the fluids to be used in the process, and the same type of fluid is used either side of the heat exchanger (these heat exchangers can be either plate-and-frame or shell-and-tube construction). These exchangers are used only for gases and not for liquids. The major factor for this is the heat capacity of the heat transfer matrix.

_Plate Fin heat exchanger

This type heat exchanger uses "sandwiched" passages containing fins to increase the effectivity of the unit. The designs include crossflow and counterflow coupled with various fin configurations such as straight fins, offset fins and wavy fins.

Fluid heat exchangers

This is a heat exchanger with a gas passing upwards through a shower of fluid (often water), and the fluid is then taken elsewhere before being cooled. This is commonly used for cooling gases whilst also removing certain impurities, thus solving two problems at once. It is widely used in espresso machines as an energy-saving method of cooling super-heated water to be used in the extraction of espresso.

Phase-change heat exchangers

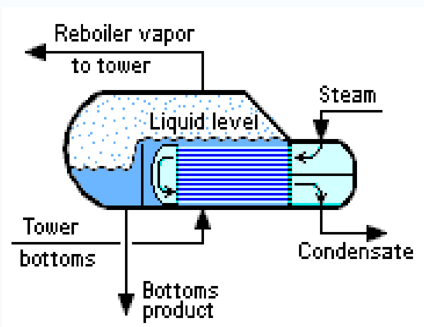


Fig 14

Typical kettle reboiler used for industrial distillation towers

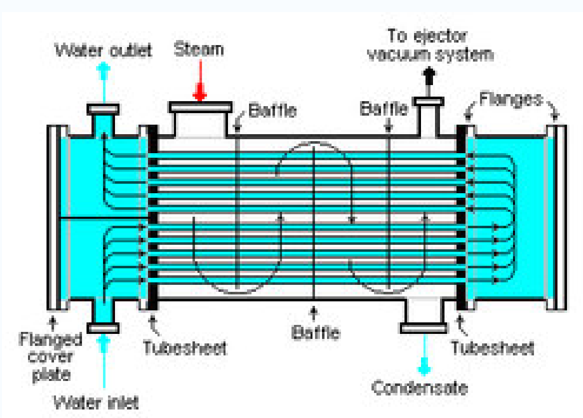


Fig 15

Typical water-cooled surface condenser

In addition to heating up or cooling down fluids in just a single phase, heat exchangers can be used either to heat a liquid to evaporate (or boil) it or used as condensers to cool a vapor and condense it to a liquid. In chemical plants and refineries, reboilers used to heat incoming feed for distillation towers are often heat exchangers. Distillation set-ups typically use condensers to condense distillate vapors back into liquid. Power plant which have steam-driven turbines commonly use heat exchangers to boil water into steam. Heat exchangers or similar units for producing steam from water are often called boilers or steam generators. In the nuclear power plants called pressurized water reactors, special large heat exchangers which pass heat from the primary (reactor plant) system to the secondary (steam plant) system, producing steam from water in the process, are called steam generators. All fossil-fueled and nuclear power plants using steam-driven turbines have surface condensers to convert the exhaust steam from the turbines into condensate (water) for re-use.

In order to conserve energy and cooling capacity in chemical and other plants, regenerative heat exchangers can be used to transfer heat from one stream that needs to be cooled to another stream that needs to be heated, such as distillate cooling and reboiler feed pre-heating.

This term can also refer to heat exchangers that contain a material within their structure that has a change of phase. This is usually a solid to liquid phase due to the small volume difference between these states. This change of phase effectively acts as a buffer because it occurs at a constant temperature but still allows for the heat exchanger to accept additional heat. One example where this has been investigated is for use in high power aircraft electronics.

HVAC air coils

One of the widest uses of heat exchangers is for air conditioning of buildings and vehicles. This class of heat exchangers is commonly called *air coils*, or just *coils* due to their often-serpentine internal tubing. Liquid-to-air, or air-to-liquid HVAC coils are typically of modified crossflow arrangement. In vehicles, heat coils are often called heater cores. On the liquid side of these heat exchangers, the common fluids are water, a water-glycol solution, steam, or a refrigerant. For *heating coils*, hot water and steam are the most common, and this heated fluid is supplied by boilers, for example. For *cooling coils*, chilled water and refrigerant are most common. Chilled water is supplied from a chiller that is potentially located very far away, but refrigerant must come from a nearby condensing unit. When a refrigerant is used, the cooling coil is the evaporator in the vapor-compression refrigeration cycle. HVAC coils that use this direct-expansion of refrigerants are commonly called *DX coils*.

On the air side of HVAC coils a significant difference exists between those used for heating, and those for cooling. Due psychometrics, air that is cooled often has moisture condensing out of it, except with extremely dry air flows. Heating some air increases that airflow's capacity to hold water. So heating coils need not consider moisture condensation on their air-side, but cooling coils *must* be adequately designed and selected to handle their particular *latent* (moisture) as well as the *sensible* (cooling) loads. The water that is removed is called *condensate*.

For many climates, water or steam HVAC coils can be exposed to freezing conditions. Because water expands upon freezing, these somewhat expensive and difficult to replace thin-walled heat exchangers can easily be damaged or destroyed by just one freeze. As such, freeze protection of coils is a major concern of HVAC designers, installers, and operators.

The best sort of heat exchanger for our product is a **simple spiral heat exchanger (SHE)**, may refer to a hedical(coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. A pair of fluid ports are connected tangentially to the outer arms of the spiral, and axial ports are common, but optional. The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an over-sized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

- The body of heat exchange is made by aluminium 2300&2500 (ISO:AlSi1MgMn)
- The pipes inside is made by Cast Iron (ISO:R185Gr20)
- The thread inside the pipes where becomes the treatment is made by Carbon Steel (ISO:AlSiMgMn)

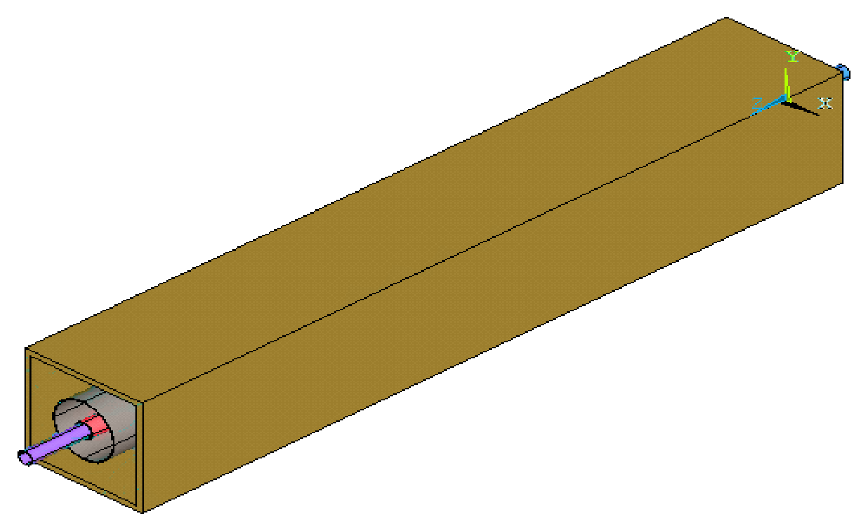


Fig 16

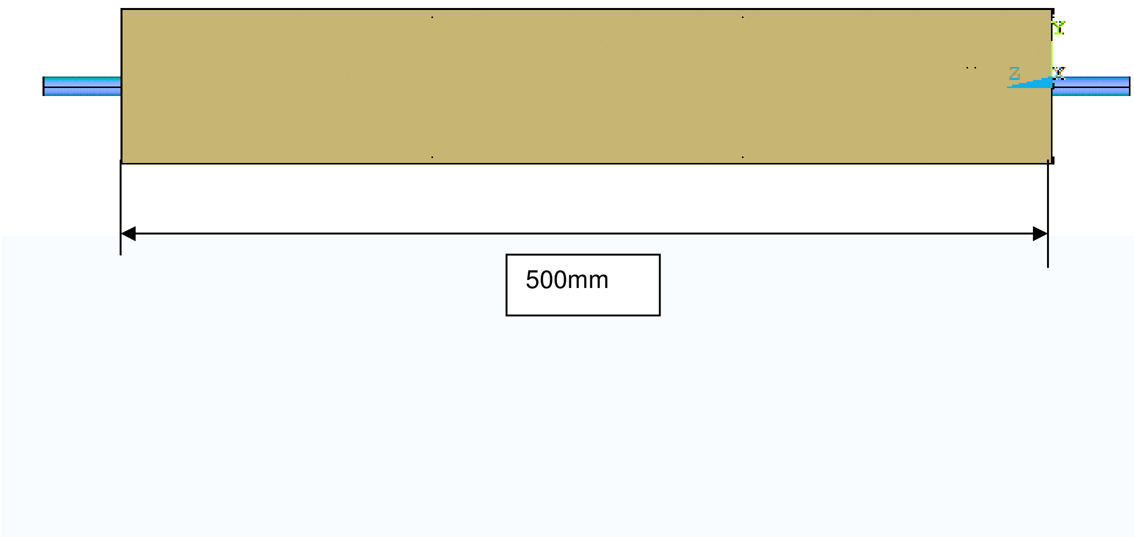


Fig 17

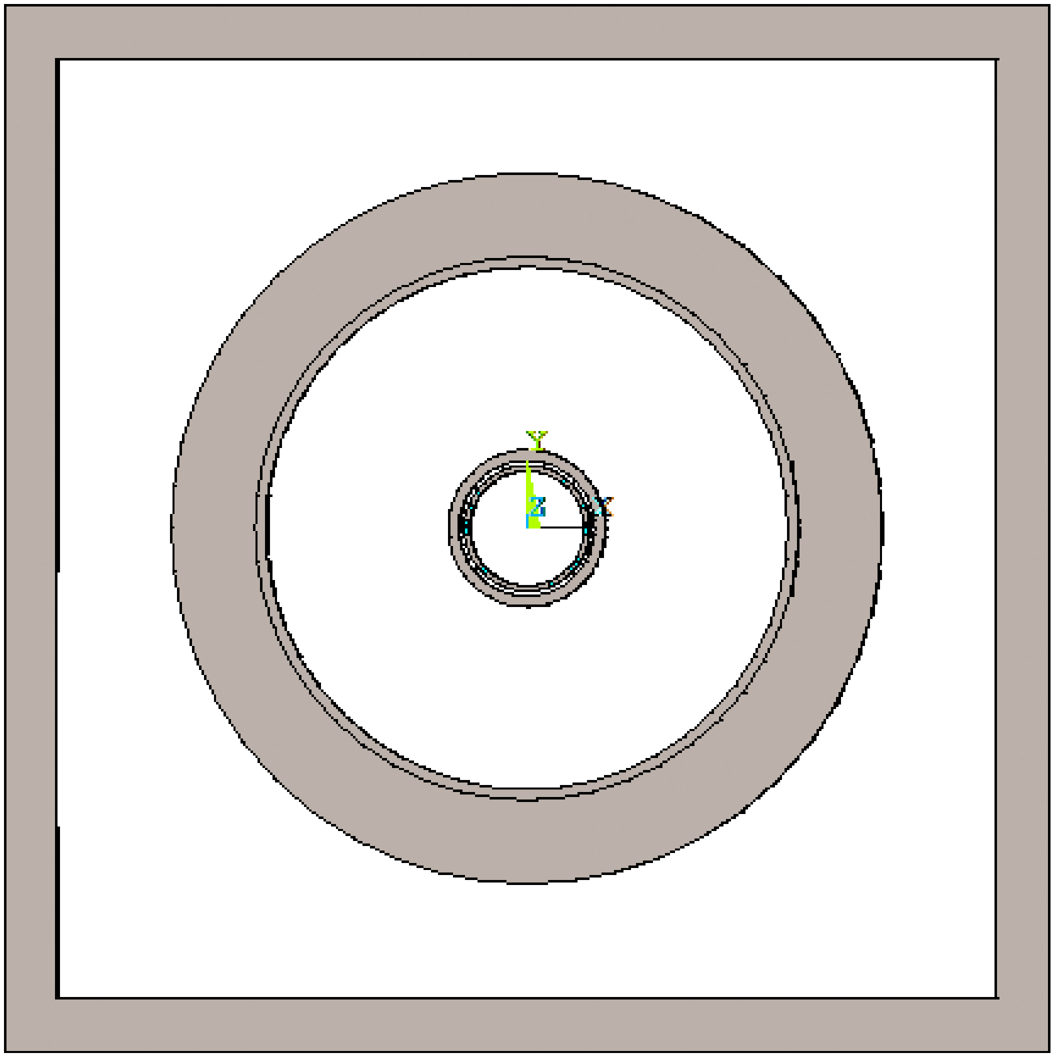
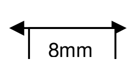


Fig 18

Here is a model of our simple heat exchanger:



A simple heat exchanger might be thought of as two straight pipes with fluid flow, which are thermally connected. Let the pipes be of equal length *L*, carrying fluids with heat capacity C_i (energy per unit mass per unit change in temperature) and let the mass flow rate of the fluids through the pipes be j_i (mass per unit time), where the subscript *i* applies to pipe 1 or pipe 2.

The temperature profiles for the pipes are $T_1(x)$ and $T_2(x)$ where *x* is the distance along the pipe. Assume a steady state, so that the temperature profiles are not functions of time. Assume also that the only transfer of heat from a small volume of fluid in one pipe is to the fluid element in the other pipe at the same position. There will be no transfer of heat along a pipe due to temperature differences in that pipe. By Newton's law of cooling the rate of change in energy of a small volume of fluid is proportional to the difference in temperatures between it and the corresponding element in the other pipe:

$$\frac{du_1}{dt} = \gamma(T_2 - T_1)$$

$$\frac{du_2}{dt} = \gamma(T_1 - T_2)$$

where $u_i(x)$ is the thermal energy per unit length and γ is the thermal connection constant per unit length between the two pipes. This change in internal energy results in a change in the temperature of the fluid element. The time rate of change for the fluid element being carried along by the flow is:

$$\frac{du_1}{dt} = J_1\frac{dT_1}{dx}$$

$$\frac{du_2}{dt} = J_2\frac{dT_2}{dx}$$

where $J_i = C_i j_i$ is the "thermal mass flow rate". The differential equations governing the heat exchanger may now be written as:

$$J_1\frac{\partial T_1}{\partial x} = \gamma(T_2 - T_1)$$

$$J_2\frac{\partial T_2}{\partial x} = \gamma(T_1 - T_2)$$

Note that, since the system is in a steady state, there are no partial derivatives of temperature with respect to time, and since there is no heat transfer along the pipe, there are no second derivatives in *x* as is found in the heat equation. These two coupled first-order differential equations may be solved to yield:

$$T_1 = A - \frac{Bk_1}{k}\,e^{-kx}$$

$$T_2 = A + \frac{Bk_2}{k}\,e^{-kx}$$

where $k_1 = \gamma / J_1$, $k_2 = \gamma / J_2$, $k = k_1 + k_2$ and A and B are two as yet undetermined constants of integration. Let T_{10} and T_{20} be the temperatures at x=0 and let T_{1L} and T_{2L} be the temperatures at the end of the pipe at x=L. Define the average temperatures in each pipe as:

$$\overline{T}_1 = \frac{1}{L}\int_0^L T_1(x)dx$$

$$\overline{T}_2 = \frac{1}{L}\int_0^L T_2(x)dx$$

Using the solutions above, these temperatures are:

$$T_{10} = A - \frac{Bk_1}{k} \qquad T_{20} = A + \frac{Bk_2}{k}$$
$$T_{1L} = A - \frac{Bk_1}{k}e^{-kL} \quad T_{2L} = A + \frac{Bk_2}{k}e^{-kL}$$
$$\overline{T}_1 = A - \frac{Bk_1}{k^2 L}(1 - e^{-kL}) \qquad \overline{T}_2 = A + \frac{Bk_2}{k^2 L}(1 - e^{-kL})$$

Choosing any two of the above temperatures will allow the constants of integration to be eliminated, and that will allow the other four temperatures to be found. The total energy transferred is found by integrating the expressions for the time rate of change of internal energy per unit length:

$$\frac{dU_1}{dt} = \int_0^L \frac{du_1}{dt}\,dx = J_1(T_{1L} - T_{10}) = \gamma L(\overline{T}_2 - \overline{T}_1)$$

$$\frac{dU_2}{dt} = \int_0^L \frac{du_2}{dt}\,dx = J_2(T_{2L} - T_{20}) = \gamma L(\overline{T}_1 - \overline{T}_2)$$

By the conservation of energy, the sum of the two energies is zero. The quantity $\overline{T}_2 - \overline{T}_1$ is known as the log mean temperature difference and is a measure of the effectiveness of the heat exchanger in transferring heat energy.

Our basic plan

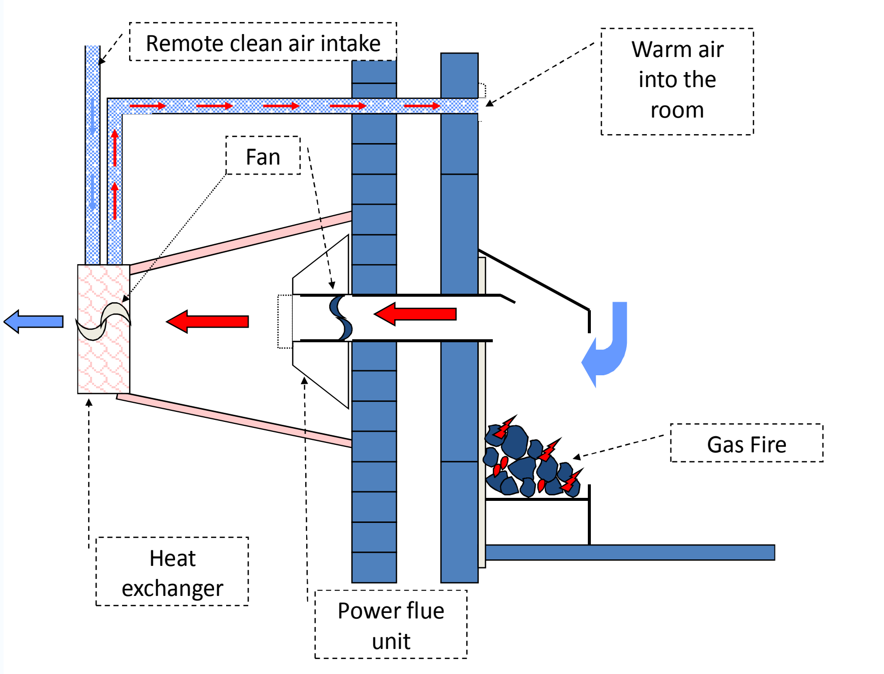


Fig 19

We have got a gas fire. Behind the fire there is a pipe with length 1.5m:

There are lot of types of materials that we can use for the pipes, like:

- Metal
- Superalloy
- Iron Base

Actually, we want our pipes be made for iron base because the temperature of gas fire is 60^{o}C and for this reason this material tolerate the the heat. Iron content as remainder. Inflection point 220^{o}C. A nickel-iron low-expansion alloy containing 36% nickel. It maintains nearly constant dimensions over the range of normal atmospheric temperatures and has a low coefficient of expansion from cryogenic temperatures to about 500^{o}F (260^{o}C). The alloy also retains good strength and toughness at cryogenic temperatures. Used for standars of length, measuring devises, laser components, bi-metal thermostat strip, thermostat rods and tanks and piping for storing and transporting liquefied gas.

Then the energy that we lose is directed to a fan. A fan heater is a heater that works by using a fan to pass air over a heating element. The maximum heat output of 1000w - 2000w.

Inside of fan there are:

1) A specially designed turbine ensures the uniform distribution of hot air stream
2) 2 power settings which work to push the air
3) Air intake is through the top of the heater, preventing dust accumulation

The material of turbine is made by iron and the body of fan is made by aluminium.

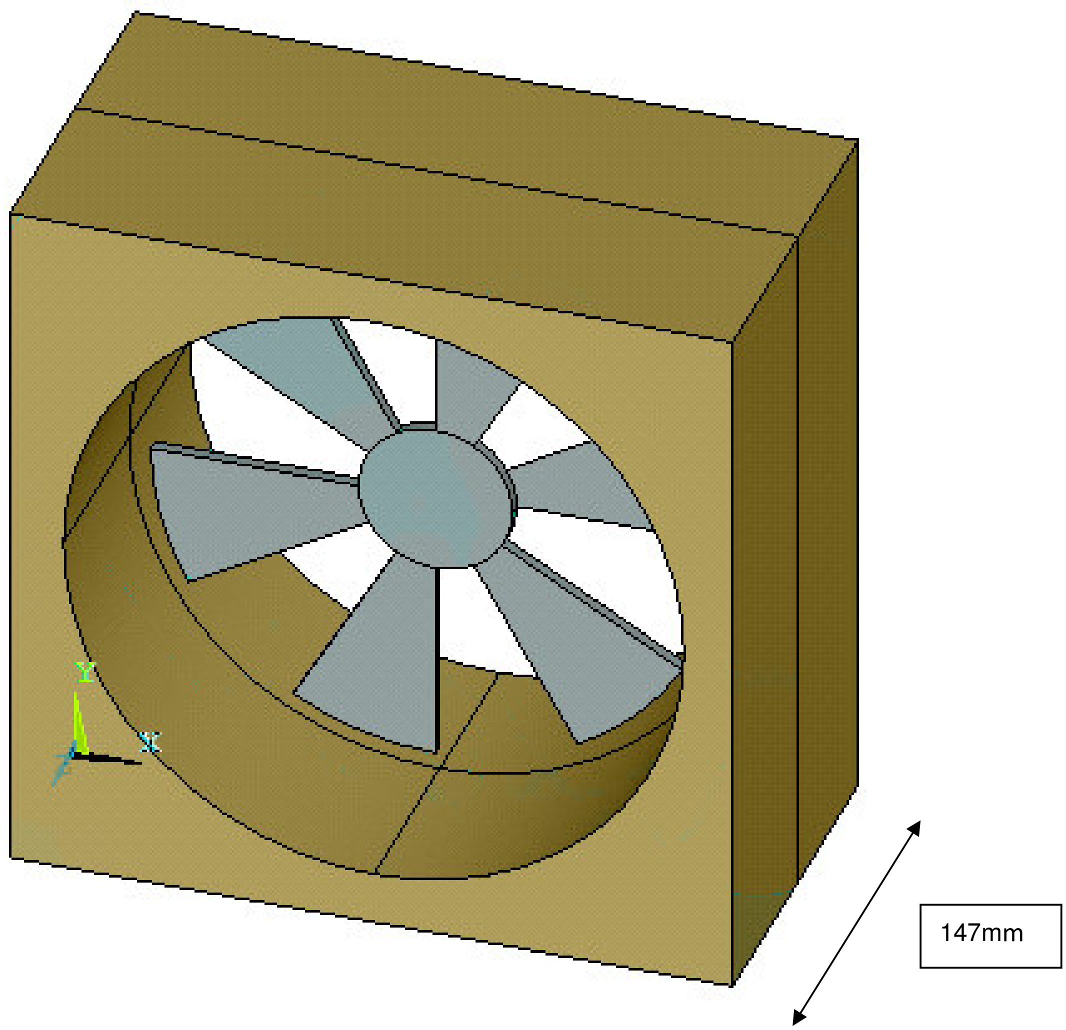
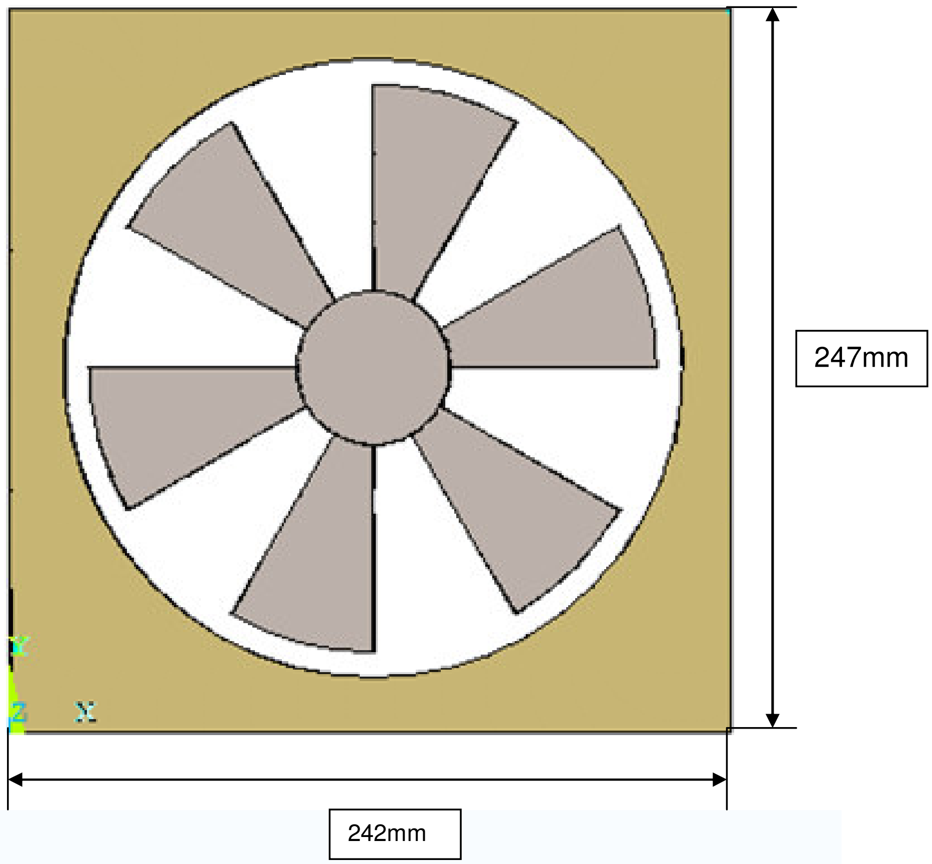


Fig 20

FAN



The energy that we lose is going to the heat exchanger and finally we have got the result that we want. From a pipe 5m, the new heat returns at our house to use it at the central heating.

Fig 21

Central Heating

The concept of central heating can provide the warmth and hot water on demand. The most popular central heating systems involve the combustion of a fossil fuel-oil, gas or LPG (Liquified Petroleum Gas) in a boiler and the subsequent distribution of heat around the home by water or steam circulating through pipes.

A typical domestic central heating system comprises a hot water system feed tank and storage cylinder, along with a heating system feed tank. The storage cylinder holds a large quantity of hot water-available immediately or as quickly as the feed tank allow but once the supply is exhausted the cylinder and its contents needs to be reheated.

Central heating has evolved significantly in recent years. Many older boilers installed prior to 1990 were the boilers can be installed almost anywhere in themodern home. A condensing boiler utilises much of the heat that would otherwise be wasted in the flue of a standard boiler and may convert more than 90% of its fuel into useful heat.Thera are lot of ways to use the heat in our house like:

PLUMBING

In central heating systems with thermostatic valve temperature control it is a well known fact that room temperature ascillations may occur when the heat demand becomes lowdue to the nonlinear behavior of the control loop.This is not only discomforting but it also increases the energy cost of heating the room.Using the pump speed as an active part in control is it shown that the room temperature may be stabilized in a wider interval of heat demand.The idea is to control the pump speed in a way that keeps the thermostatic valve within a suitable operating area using an estimate of the valve position.

OIL RADIATOR

The radiators are filled with oil that warms up whenever heat is required. The great thing about oil filled radiators is that when they have reached the desired temperature they stop consuming electricity but stay warm for a considerable time. They only start to consume power again when the temperature drops. Unlike fan heaters they do not make any noise and do not create dust. Oil filled radiators are the perfect solution when radiators attached to a central heating system are either not available or not provide enough warmth.

WATER RADIATOR (GRAVITY HOT WATER PUMBED HEATING)

Gravity hot water is just that, when the clock is in the position the boiler’s burner lights and a large volume of water is heated up. Because hot water is lighter than cold water, the hot water from boiler rises up to the cylinder and the couler water drops back to the boiler. If the room thermostat is calling for heat this simply switches the pumb on, circulating the heat to the radiators. It is not possible to have heating without hot water. This system can be used with a Primatic cylinder or an indirect cylinder (often fitted with back boiler fires).Usually no cylinder thermostat is fitted so the only temperature control for the hot water is the boiler thermostat. This type of system can be expensive to run but extremely reliable.

AIR RADIATOR

When there is no inhibitor in a system, the slightly acidic water causes galvanic corrosion to occur between the copper pipes, brass fittings and the steel radiators. Without getting too technical, there is an elecrical cell generated which causes hytrogen gas to be formed, this gathers at some point, and you have to let this "air" out. The result of this corrosion is eaten away radiators, black water formed, and expensive replacement of rads.

BENEFITS OF CENTRAL HEATING

1. You will be warm and comfotable throught your home
2. Allow full use of all rooms in the home
    - Children can do homework in their own room
    - Your home is warm when you wake up
3. It is fully controllable with the use of a timer, room thermostat, and TRVs (thermostatic radiator valves)
4. Reduces condensation and mould growth
    - Protects your belongings
    - Protects the building
5. Can help prevent various health problems
    - Asthma, bronchitics, hypothermia, heart, attacks and stokes
    - It can also help prevent falls
6. Can reduce fuel bills by replacing expensive to run or inadequate heating and hot water systems.
   Modern central heating systems when used effectively can reduce fuel bills
7. It is more cost-effective method of providing heating and hot water
8. It can lower carbon dioxide emissions and therefore help you to help the environment.

DON'T WANT

- High fuel bills
- Boiler damage
- Boiler breakdown
- High breakdown call out charges
- Invalid boiler warranty

First law of thermodynamics

In thermodynamics, the first law of thermodynamics is an expression of the more universal physical law of the conservation of energy. The first law of thermodynamics states:

> ‘The increase in the internal energy of a system is equal to the amount of energy added by heating the system, minus the amount lost as a result of the work done by the system on its surroundings’.

The first law of thermodynamics basically states that a thermodynamic system can store or hold energy and that this internal energy is conserved. Heat is a process by which energy is added to a system from a high-temperature source, or lost to a low-temperature sink. In addition, energy may be lost by the system when it does mechanical works on its surroundings, or conversely, it may gain energy as a result of work done on it by its surroundings. The first law states that this energy is conserved: The change in the internal energy is equal to the amount added by heating minus the amount lost by doing work on the environment. The first law can be stated mathematically as:

$$dU = \delta Q - \delta W$$

where dU is a small increase in the internal energy of the system, δQ is a small amount of heat added to the system, and δW is a small amount of work done by the system.

Our project is very efficient. At our home return up to 70% of the lost heat.

Consideration of our competitors

Fan heaters are usually operated by being plugged into the mains electricity supply. Because fan heaters have (albeit encased in plastic) metal where electric current is passed through, it is important not to get them wet or use them in humid conditions due to the risk of electricution. Many modern fan heaters have a dial on them that represents "heat", or the level that you want the heat to get. The fan heater will have a device in it that senses the air temperature or the temperature inside the heater itself. When the temperature of the air being taken into the back of the fan heater reaches this point it will automatically turn off until it senses the temperature is cool enough to turn back on again. This feature helps the fan heaters to not overheat, as the combination of electricity, heat and plastic (which is what fan heaters are normally made from) could lead to a fire if left unchecked.

Convector heater is a heater which operates by air convection currents circulating through the body of the appliance, and across its heating element. This heats up the air, causing it to rise and being replaced by colder air, and thereby creating a natural ventilation, warming the surrounding area. A convection heater may have either an electrical heater element, hot water coil, or steam coil. Because of the natural ventilation, they are quieter in operation than fan heaters.

Radiators and convectors are types of heat exchangers designed to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobiles, buildings and electronics.

One might expect the term "radiator" to apply to devices which transfer heat primarily by thermal radiation, while a device which relied primarily on natural or forced convection would be called a "convector". In practice, the term "radiator" refers to any of a number of devices in which a liquid circulates through exposed pipes (often with fins or other means of increasing surface area), notwithstanding that such devices tend to transfer heat mainly by convection and might logically be called convectors. The term "convector" refers to a class of devices in which the source of heat is not directly exposed.

Embodiment of echoes project.

Echo envisages a prototype to consist of :

A typical Power Flue gas fire is the Magiglo Duo Power

Magiglo Duo Power NG Input / Output	
Max Input (kW)	6.90
Max Output (kW)	3.10

As can be seen this unit is only 45% efficient.

The aim of this project is to recover as much as possible of this lost heat.

The heat recovery unit consists of:

- A cross flow plate heat exchanger (Hazardous gas to air, stainless model)*
- A fan assembly to circulate the warmed air
- Flexible ducting to connect via magnetic ring to rear of power flue unit (65mm dia)
- Connecting duct with gravity louvers to vent the system in case of blockage in heat exchanger / flue outlet
- Ducting for fresh air transport to heat exchanger with angle ducts, flexible duct and fittings as appropriate (50mm)
- Air intake filter
- Ducting for transporting warm air to room with angle ducts, flexible duct and appropriate fittings
- Wall cowl for ducting entering room
- Lightweight fabricated steel; powder coated casing with air vents and appropriate wall fixings
- Wire mesh safety shield to encase whole unit.
- Fixing brackets, wit appropriate fixings (4)
- Cable 3m for power to the fan

*during more detailed product prototyping , a decision will be made about the most appropriate heat exchanger to be deployed within Echo's product.

In principal the system involves capturing the exhausted flu gases, are ejected from the fire by a powerful fan unit, and using the heat contained in the gases to warm fresh air that is then pumped to where required. (The power flue fan is designed for use for flue lengths up to 8.2m, which allows for sufficient pressure to pass through a low-pressure heat exchanger.)

The proposed component parts are shown in the diagram below:

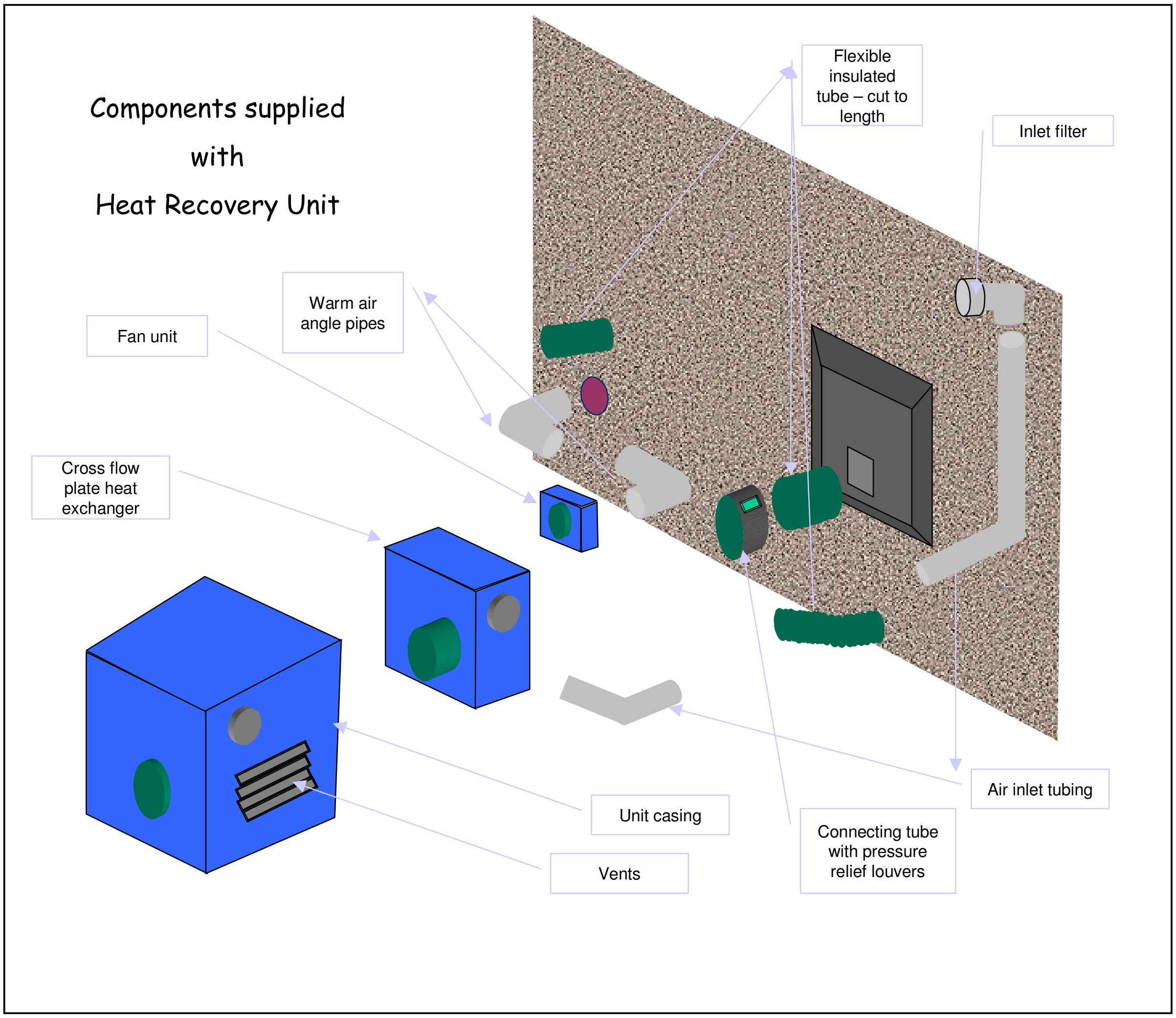


Fig 22

Below are shown a side and elevation plan of Echo's initial proposal for a prototype version of our product.

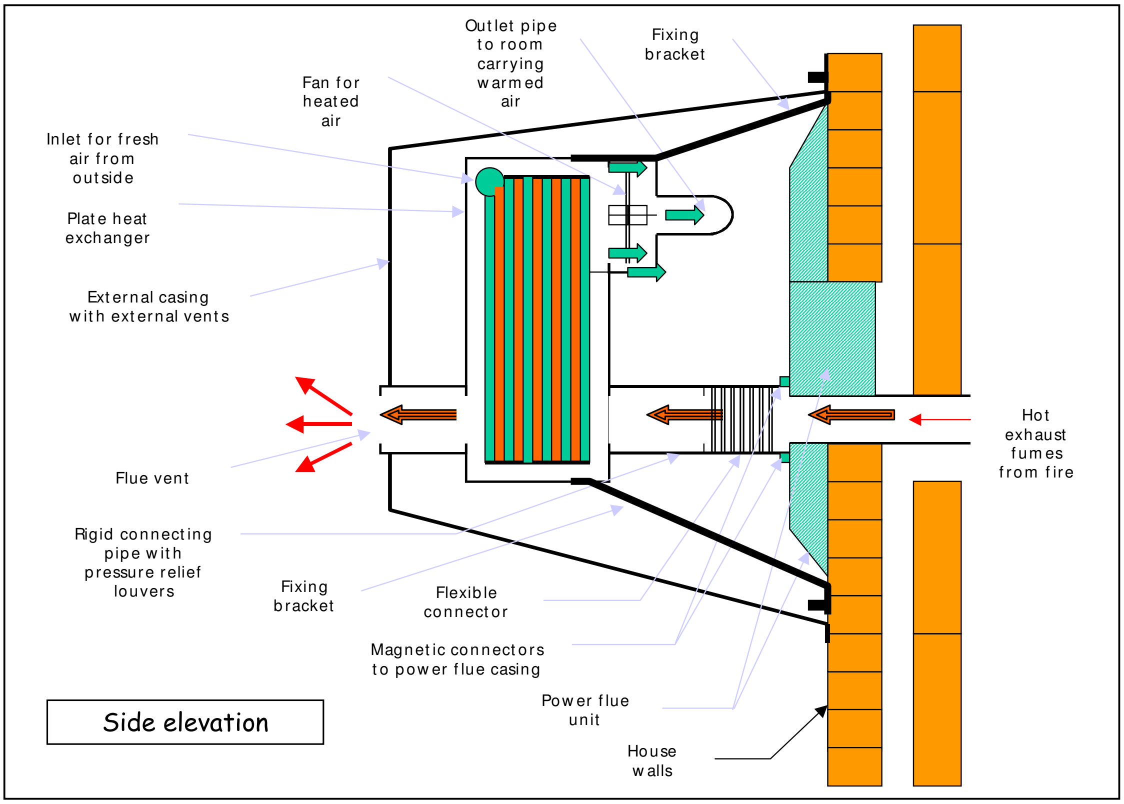
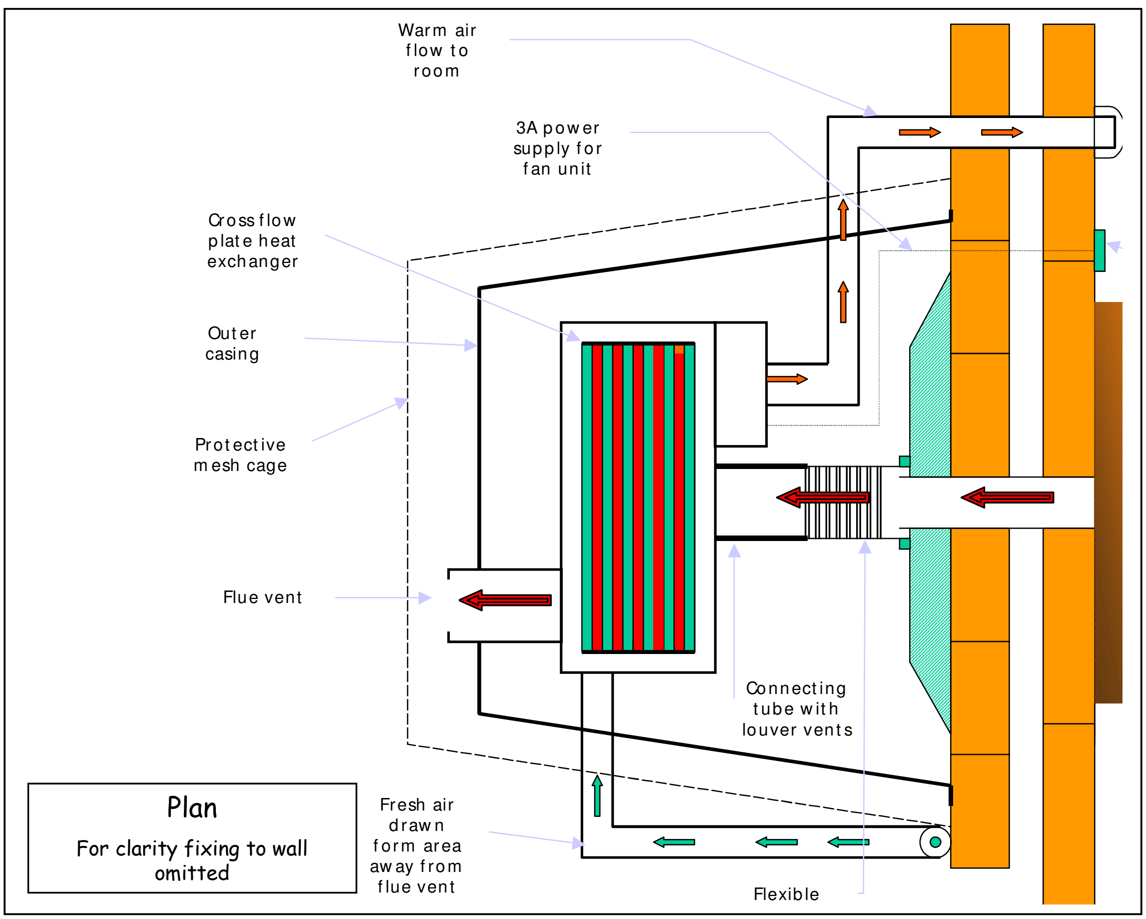

Outlet pipe to room carrying warmed air
Fixing bracket
Fan for heated air
Inlet for fresh air from outside
Plate heat exchanger
External casing with external vents
Hot exhaust fumes from fire
Flue vent
Rigid connecting pipe with pressure relief louvers
Fixing bracket
Flexible connector
Magnetic connectors to power flue casing
Power flue unit
House walls
Side elevation

Fig 23

Fig 24


Warm air flow to room
3A power supply for fan unit
Cross flow plate heat exchanger
Outer casing
Protective mesh cage
Flue vent
Connecting tube with louver vents
Plan
For clarity fixing to wall omitted
Fresh air drawn form area away from flue vent
Flexible

Consideration of the main product components (Heat exchanger & fan).

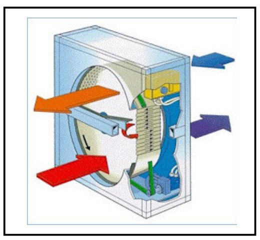
In feasibility test a fin radiator placed 400mm from the exhaust vent of a Power Flue Duo raised the temperature of 15lt of water from 12ºC to 74ºC in one hour indicating that approximately 1kW[2] of energy was being captured, or approximately 15% of the energy supplied to the gas fire.[3]

A number of heat exchangers were considered including:

Thermal Wheels,

This employs a rotating wheel to transfer heat between two air/gas streams.

These were rejected because of possible problems with leakage between the flue gases and warmed air that would have dangerous consequences, and they require energy input.



Thermal Wheel

Fig 25

Then time for a new

Plate Heat Exchangers

A plate heat exchanger uses metal plates to transfer heat between two fluids. This has a major advantage over a conventional heat exchanger in that the fluids are exposed to a much larger surface area.

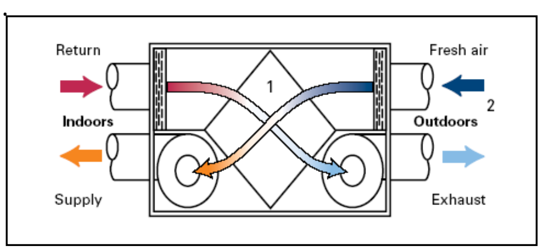
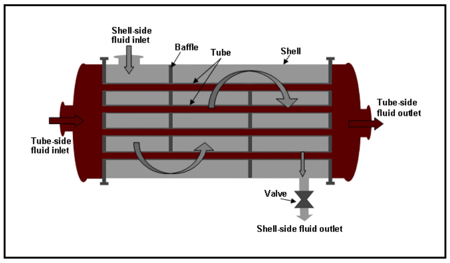


Plate Heat Exchanger

[2] KW = (litres/second) x temperature difference x Specific heat
kW = (15/3600) x 62 x 4.18 = 1.08kW
[3] Input to fire 6.9kW/h

Tube Heat Exchangers



Tube Heat Exchangers

Fig 27

Tube exchangers are easy to source but do not offer the efficiency of plate exchangers. Standard fin pass-through exchangers were considered a possibility, as they are easy to source and had worked well in the feasibility trial. But overall the plate exchanger seems to offer the best possibility for recovering the most heat.

The type of exchanger indicated in the diagrams is shown below.

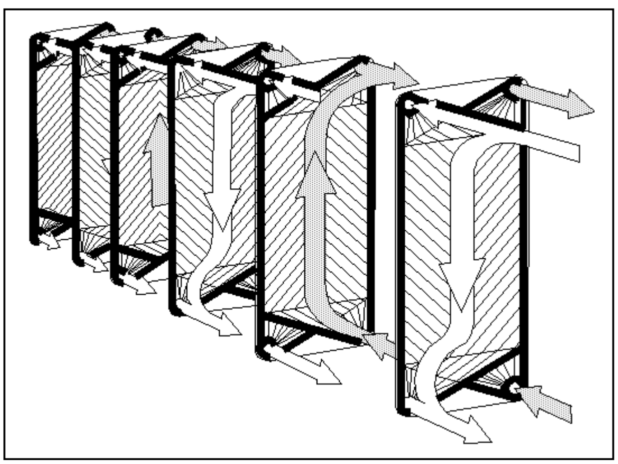
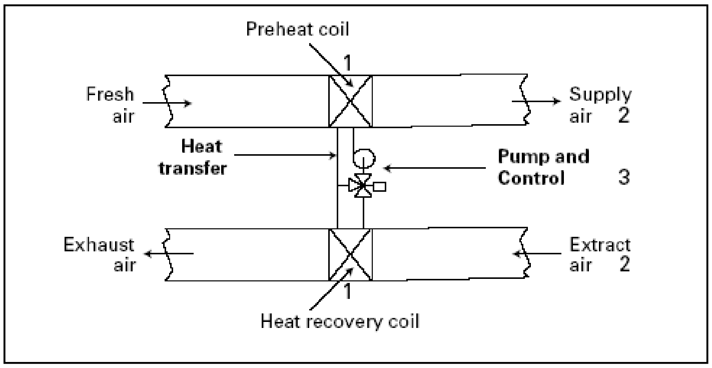


Fig 28

There possible problems associated with the long-term integrity of plate exchangers causing contamination of the air stream that would require a carbon monoxide detector and shut of system to be installed if this was a real danger.

A possible solution would be either to consider changing to a wet system or employing a Run-around coil exchanger but these are not every efficient and require an external power input.



Run-around coil exchanger

Fig 29

Run-around coils use two physically separated heat exchangers (coils) in the air supply and exhaust ducts to recover and transfer heat between them. The heat is transferred from the exhaust to supply air using an intermediate heat transfer fluid, such as water. The main advantage of this system is that the supply and extract ducts can be physically separated, as well as no possibility of cross contamination between air streams. The main disadvantage of this system is that, because an intermediate fluid is used as a heat transfer medium, the system's efficiency is reduced and electricity is required for pumping fluid.

The fan assembly

A centrifugal in-line fan cable of moving up to 80 litres a second was thought adequate but trials would be needed to adjust the flow rate to achieve an acceptable air-flow temperature.

Conclusion of Echo project.

Echo have identified power flue gas fires to be an inefficient form of heating with the potential to be made more efficient with supplemental technologies.

Echo have identified this area to be one which is underexploited by the current market.

Exploration of the existing market has been undertaken by Echo and identified a clear opportunity for this form of technology.

A price limit was also identified by Echo through conducting market research. This strongly limited the project due to imposing cost constraints upon the technology required. The final retail price could not realistically be above £200. Although some leeway is envisaged due to increasing costs of domestic energy.

Echo propose to market our products based upon the savings that will be made by the consumer on their fuel bills. This strategy could potentially enable us to increase the price of our product, although further market research would be necessary.

Echo has struggled with the actual technical feasibility of the project, Echo lack the technical skills and knowledge required to realise this project, within the time allowed. However further time would allow Echo to source and negotiate with component suppliers who could enable us to overcome these issues.

Echo's project idea is a good one, and has the potential to make money as shown by our financial model (see appendices).

Echo has successfully identified a market niche which Echo believes has the potential to be exploited.

The strength of the product is in its relative simplicity and ease of installation.

Echo would recommend that this project be taken forward and the product further developed. The problems experienced by Echo are a result of lack of technical knowledge. These issues could be very easily overcome with more time to develop the separate components and take the project forward with prototyping and development.

The environmental aspect of Echo product ,means that in the current environment of concern about energy efficiency and green issues, open it to a further avenue through which Echo can market its products.

Appendices

Appendix 1

Failure Modes and Effects Analysis

Part Name	Process Operation Ref.	Potential Failure Mode	Potential Cause of Failure	Potential Effects of Failure	Currently existing Conditions Manufacturer's Controls	Occ.	Sev.	Det.	RPN	Echo's Recommended Action on part.
Fan	Venting	Rotating Motor stalling	Mechanical Design	entire system failure	Endurance test	2	7	4	56	Must have Warranty
Pipes/Ducting	Connects with Exchanger	leaks from bends/joints	Joint integrity	loss of boost	Endurance Test	3	5	6	90	Must have Warranty
Heat Exchanger	Recirculates heat	pipes burst Exchanger Assembly	Overheating Weakening joints	loss of boost	Temperature test Endurance test	11	77	36	2142	Must have Warranty

Occ. >Possibility of Occurrence

Sev. > Severity of Effects

Det. >Possibility of Detection

RPN. >Risk Priority Number

Appendix 2

Direction of Improvement			↑	↑	↑	↑	↓	↑	↑
Customer Requirements (What)	Design Requirements (How)	Customer Rating Value	Performance & Efficiency	Environmental Friendliness	Energy Efficiency	Ease of Installation	Sophistication	Safety	Durability
Aesthetics	Range of Color	1	1	1	1	1	1	1	1
	Appearance	1	1	1	1	1	1	1	1
	Weight	3	1	1	1	1	1	3	1
Reduce	Energy cost	9	9	9	9	1	1	3	1
	Defects	9	3	1	3	1	3	9	9
	Product Cost	3	9	3	9	3	3	3	9
Organizational difficulty			O	△	●	O	●	●	●
Target									
	Absolute importance		7	6	9	1	2	7	6
	Relative importance		18%	16%	24%	3%	5%	18%	16%

●	= 9 High
O	= 3 Medium
△	= 1 Low

Appendix 3

Echo Budget

		Components	Cost per Component	Total Unit Cost	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Development Costs										
	Heat Exchanger	1	£ 50.00	£ 50.00	£ 75,000.00	£ 100,000.00	£ 250,000.00	£ 400,000.00	£ 600,000.00	£ 1,425,000.00
	Fan	1	£ 16.56	£ 16.56	£ 24,840.00	£ 33,120.00	£ 82,800.00	£ 132,480.00	£ 198,720.00	£ 471,960.00
	Insulated Ducting (10m)	1	£ 28.76	£ 28.76	£ 43,140.00	£ 57,520.00	£ 143,800.00	£ 230,080.00	£ 345,120.00	£ 819,660.00
	Vents	2	£ 3.40	£ 6.80	£ 10,200.00	£ 6,800.00	£ 17,000.00	£ 54,400.00	£ 81,600.00	£ 170,000.00
Packaging (redeemable)										
	Labour	4/hr	£ 1.50	£ 1.50	£ 2,250.00	£ 3,000.00	£ 7,500.00	£ 12,000.00	£ 18,000.00	£ 42,750.00
	Boxes	1	£ 0.07	£ 0.07	£ 105.00	£ 140.00	£ 350.00	£ 560.00	£ 840.00	£ 1,995.00
	Stickers	1	£ 0.16	£ 0.16	£ 239.25	£ 319.00	£ 797.50	£ 1,276.00	£ 1,914.00	£ 4,545.75
	Tape	0.04	£ 0.15	£ 0.01	£ 8.70	£ 11.60	£ 29.00	£ 46.40	£ 69.60	£ 165.30
Total Production					1,500	2,000	5,000	8,000	12,000	28,500
Total Cost				£ 103.86	£ 155,782.95	£ 207,710.60	£ 519,276.50	£ 830,842.40	£ 1,246,263.60	£ 2,959,876.05
Ramp-up										
	Patents (IPR)		£ 200.00		£ 200.00	£ 0.00	£ 200.00	£ 0.00	£ 200.00	£ 600.00
	Product Testing		£ 1,200.00		£ 1,200.00	£ 0.00	£ 0.00	£ 0.00	£ 0.00	£ 1,200.00
Operations (Annual)										
	Promotion (leaflets)	20000	£ 0.04	£ 760.00	£ 760.00	£ 760.00	£ 760.00	£ 760.00	£ 760.00	£ 3,800.00
Admin										
	Office Rental	1	£ 3,000.00	£ 3,000.00	£ 3,000.00	£ 3,000.00	£ 3,000.00	£ 3,000.00	£ 3,000.00	£ 15,000.00
	Electricity									
	Insurance									
	Transport/Product Distribution			£ 34.99	£ 32,540.70	£ 97,622.10	£ 162,703.50	£ 260,325.60	£ 357,947.70	£ 911,139.60
Total					£ 36,300.70	£ 101,382.10	£ 166,463.50	£ 264,085.60	£ 361,707.70	£ 929,939.60
Salaries										
	Project Manager	1	£ 29,000.00		£ 29,000.00	£ 29,000.00	£ 29,000.00	£ 29,000.00	£ 29,000.00	£ 145,000.00
	Marketing Manager	1	£ 28,000.00		£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 140,000.00
	Production/Commercial Manager	1	£ 28,000.00		£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 140,000.00
	Technical Manager	1	£ 28,000.00		£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 140,000.00
	Financial Manager	1	£ 28,000.00		£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 28,000.00	£ 140,000.00

Total				£ 141,000.00	£ 141,000.00	£ 141,000.00	£ 141,000.00	£ 141,000.00	£ 705,000.00
Expenditure									
	Total		£ 3,863.86	£ 334,483.65	£ 450,092.70	£ 826,940.00	£ 1,235,928.00	£ 1,749,171.30	£ 4,596,615.65
Taxes									
	Coperate Tax (from annual revenue)	21%		£ 0.00	£ 37,308.03	£ 46,055.10	£ 91,995.12	£ 116,041.53	£ 265,100.71
	VAT (per Product sold) redeemable	15%		£ 27,900.00	£ 83,700.00	£ 139,500.00	£ 223,200.00	£ 306,900.00	£ 781,200.00
Total Tax				£ 27,900.00	£ 121,008.03	£ 185,555.10	£ 315,195.12	£ 422,941.53	£ 1,046,300.71
Income	Price per unit	£ 225							
	Turnover			**£ 209,250**	**£ 627,750**	**£ 1,046,250**	**£ 1,674,000**	**£ 2,301,750**	£ 5,859,000
	Gross Profit			-£ 125,233.65	£ 177,657.30	£ 219,310.00	£ 438,072.00	£ 552,578.70	£ 1,262,384.35
	Total unit sales			930	2,790	4,650	7,440	10,230	26,040
Net Profit				-£ 153,133.65	£ 56,649.27	£ 33,754.90	£ 122,876.88	£ 129,637.17	£ 216,083.64
Redeemable Costs	Postage + Packaging	£ 39.99	£ 36.73	£ 37,190.70	£ 111,572.10	£ 185,953.50	£ 297,525.60	£ 409,097.70	£ 1,041,339.60
	Vat		£ 30.00	£ 27,900.00	£ 83,700.00	£ 139,500.00	£ 223,200.00	£ 306,900.00	£ 781,200.00
	Gross Profit + Redeemables			-£ 60,142.95	£ 372,929.40	£ 544,763.50	£ 958,797.60	£ 1,268,576.40	£ 3,084,923.95
Net Profit (Gross Profit + redeemables) less Corporate Tax				-£ 60,142.95	£ 335,621.37	£ 498,708.40	£ 866,802.48	£ 1,152,534.87	£ 2,793,524.17

Appendix 4

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Weeks 7	Week 8	Week 9	Week 10	Week 11	Week 12	Christmas break	Week 13
Choose team name	1	1												
Assigned roles	1	1												
Generate product ideas		1	1	1	1									
Select a general product idea				1	1	1								
Concept generation				1	1	1	1							
Legal issues				1	1	1	1							

Concept screening				1	1	1							
Market research	1	1	1	1	1	1	1	1	1	1	1		
Research into competitors					1	1	1	1					
Research into market segment			1	1	1	1	1	1	1	1			
Research into possible sales outlet							1	1	1	1	1		
Technical research		1	1	1	1	1	1	1	1	1	1		
Patenting issues		1	1	1									
Supply chain								1	1	1	1	1	
Preliminary design						1	1	1	1	1	1		
Develop possible marketing plan					1	1	1	1	1	1	1	1	
Production strategy					1	1	1	1	1	1	1	1	
Product failure analysis										1	1	1	
product embodiment								1	1	1	1	1	
Financial Planning and costs			1	1	1	1	1	1	1	1	1	1	
Final design									1	1	1	1	
Report consolidation											1	1	
Oral presentation													1
Project closure													1