HDPD315 – Advanced Product Design

Greenfly Report

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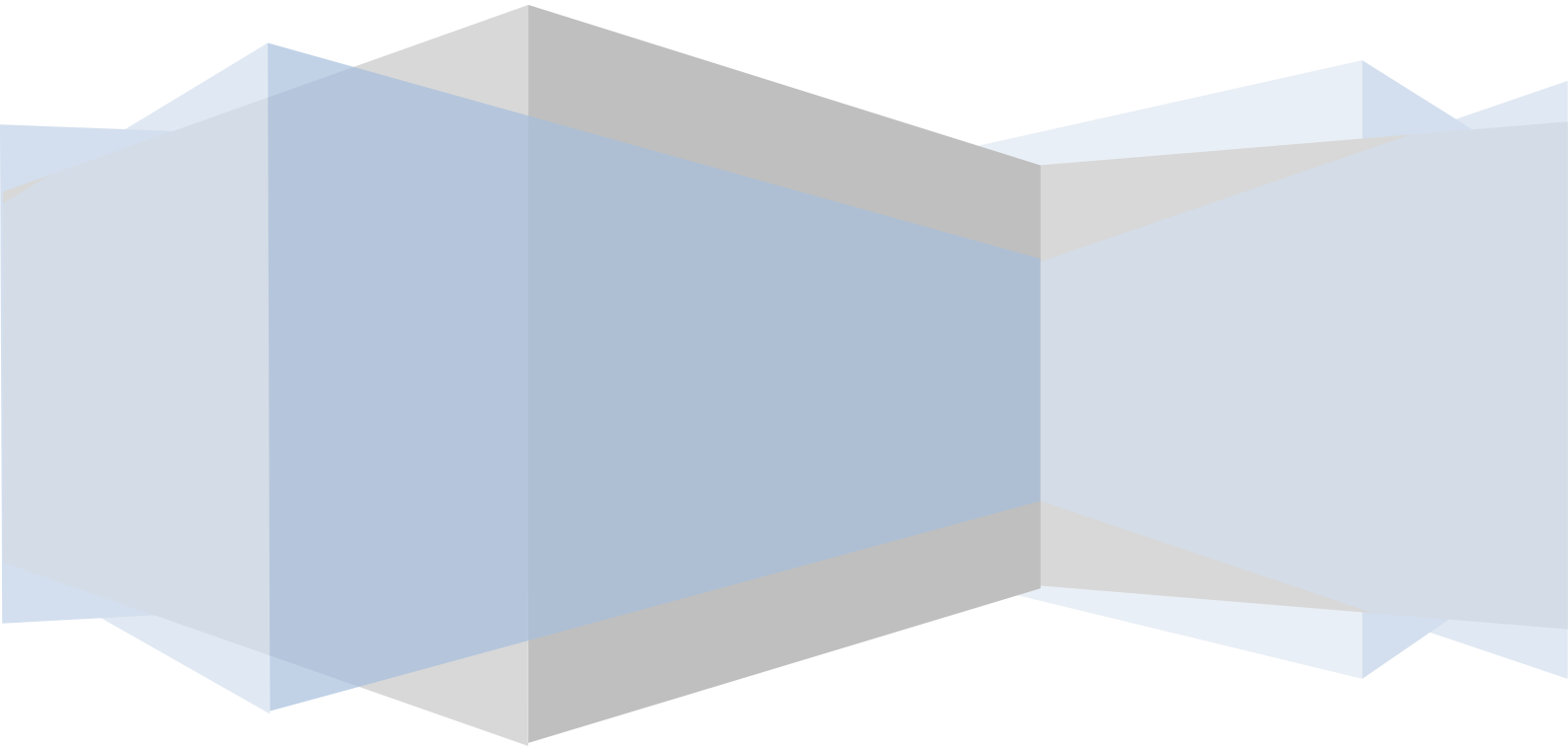

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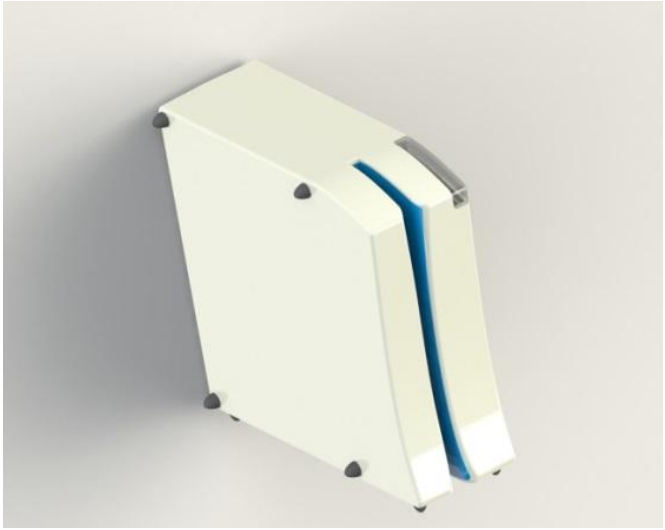
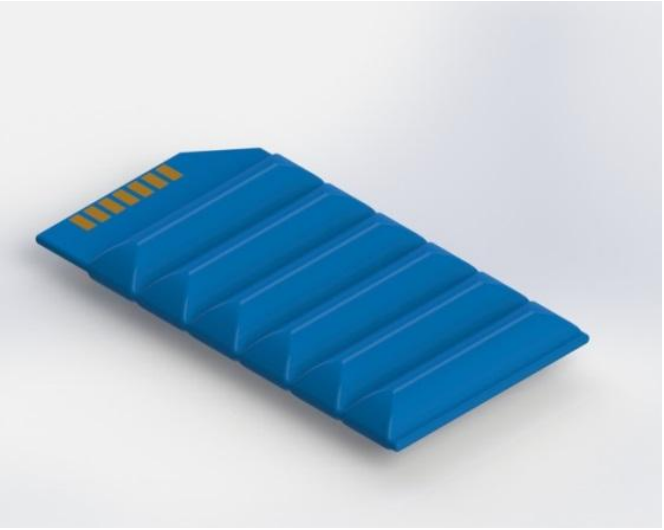
Introduction

This Greenfly report was generated to analyse the Life Cycle of our portable heat therapy application system, consisting of our products; the Heat pack and the Battery pack which incorporate Microheat technology.
Through this we aim to provide a general overview of the impact that the products will have on the environment, and thus we will highlight the basic LCA based on the research conducted by our group.
Both the Battery and Heat packs were analysed separately for Manufacturing, Use, and End of Life, and therefore have been listed in that order. Transportation and Guidelines have been generalised, referring to the combination both products as a system, as we have planned to sell the products as a package consisting of the Battery pack and three different sizes of Heat packs.



Battery Pack



Heat Pack

Product Objectives

These were the goals for us to consider when designing our products. With these considerations we were able to keep our environmental impact to a minimum and thus making our system of products sustainable:

- Use easily recyclable materials where possible.
- Appropriate amount of material use.
- Low global carbon footprint of distribution.
- More energy efficient than competitor products.
- Long lasting, upgradable and easily repaired.
- Recyclable and/or reusable components.

Scenario 1 - Battery Pack

Product Breakdown and EOL destination*					
Part	**Material**	**Process**	**Amount (KG)**	**Recycled Content**	**EOL Destination**
Casing (all external casing)	ABS	Injection Moulding	0.25	Can be 40-60% recycled. This will affect the structural integrity slightly.	ABS recycling, to be used in other products.
Plug port casing	ABS	Injection Moulding	0.02	Can be 40-60% recycled.	
Batteries	Li-Po (lithium polymer)	Delivery (truck or train)	0.94	0%	Non-recyclable however can be refilled. Does reduce performance
Fan	PVC (rigid)	Delivery (truck or train)	0.07	Depending on supplier or manufacturer, 50-60%	PVC recycling, to be used in other products.
Transformer	Misc.	Delivery (truck or train)	0.11	0%	Made from various materials, which can be separated and recycled.
Magnet board	Misc.	Delivery (truck or train)	0.07	0%	Magnets are high impact and can be reused in other products.
LED circuit board	Misc.	Delivery (truck or train)	0.01	0%	Small percentage to landfill. High impact metals and toxic chemicals can be extracted and recycled.
Power and analysis circuit board	Misc.	Delivery (truck or train)	0.02	0%	
Contact circuit board	Misc.	Delivery (truck or train)	0.02	0%	

(these values and processes are higly inconsistent, as the references are vague and give a general overview of the recycling processes. Due to time restrictions we have made the most logical assumptions possible)*

Overall, the Battery pack is fairly environmentally friendly and sustainable. The high ABS content makes it sufficiently recyclable. Nevertheless it consists of a high number of current generation electrical components; these do have a small amount of high impact metals and chemical which reduce the sustainability of the product. However, if the product was redesigned in 5-10 years, and considering advancements of manufacturing and recycling processes, the outcome would be much better.

Design Considerations for the Battery Pack:

Plastics	
Have materials containing toxic substances been avoided?	Yes. Materials containing toxic substances have been avoided.
Have you used plastics with recycled content where possible?	Yes. We have used plastics with recycled content wherever possible.
Have surface coatings been avoided? How?	Yes. Surface finishes were part of the moulding processes, thus no coatings were used.
Have all plastic used been clearly labelled?	Appropriated labels and symbols have been used for identifying, recycling and manufacturing.
Has the minimal amount of material required to do the job been used (light weighting)?	Yes. Minimal amount of material has been used to construct the product; this was done so once the FEA analysis was conducted.
Have the number of different plastic types been avoided?	Yes. Minimal amount of different plastics have been used. The entire casing is constructed from ABS.
Concluding Statement	The plastic components are recyclable and contain a percentage of recycled material. Minimal material used to lower environmental impact and be durable. No external surface coatings or treatments have been used, since ABS comes in various colors and we didn't require fancy surface finishes. All raw materials will be sourced from certified vendors.

Electronics	
Have halogenated-free fire retardants been specified for PCBs?	The required PCBs are available 'off the shelf' but would have to be custom made to fit inside the casing. To use halogenated-free fire retardants, they would have to be manufactured by certified producers.
Have low impact batteries been specified?	Li-Po batteries are high-impact if improperly discarded, however with proper labeling and treatment they can have a minimal impact.
Are the electronic components located in an area where they are easy to access?	Yes. When repairing the product, all electrical components are designed to be easily accessible. Also no glues or solvents have been incorporated as a part of the manufacturing processes. All joining and connecting is through the use of simple clip joins for the battery pack, and heat welding for plastics.
Have lead-free solders been specified?	No. The Sourced components that we found did not state whether they used lead-free solders. However given more time, we could conduct more thorough research.
Conclusion	A lot of the electrical components that were sourced only provided general specifications. From this we search for manufacturing and recycling processes which we used to make educated guesses.

Material	*Pros*	*Cons*	*Comments*
ABS	• Good low temperature application • Good electrical properties • Good chemical resistance e.g. resistant to conc. hydrochloric and phosphoric acid	• Derived from a non-renewable source (crude oil) • Poor solvent and fatigue resistance • poor bearing qualities as it has high friction and ware • Poor UV resistance	Using plastics is generally not an environmentally friendly option. This, however, can be offset by proper labeling, handling, discarding and end of life processing. If everything is managed properly then there can be lower footprints.
PVC Rigid	• Good low temperature application • Good electrical properties	• Derived from a non-renewable source (crude oil) • Although it can be recycled, it is not widespread	
Battery - LiPo	• Rechargeable • Good energy-to-weight ratio • Good charging efficiency • Small variation in terminal voltage during discharge • Low internal resistance • Slow loss of charge when not in use.	• Cadmium contained within battery, being a heavy metal, can cause substantial pollution when landfilled or incinerated. Because of this, many countries now operate recycling programs to capture and reprocess old LiPo batteries.	
Printed Circuit Boards		• Resource intensive production process • Toxic materials commonly used as retardants - halogenated compounds	A recycling process is available for PCBs, however a small amount does reach landfill and this does contribute to the negative impact.

Total Impact:

Total	*Solid Waste*	*Water Use*	*Global Warming*	*Energy Demand*
Manufacturing	13.87 kg	2.12 kL	54.89 kg CO2 eq	924.23 MJ LHV
Use	0 kg	0 kL	0.42 kg CO2 eq	6.25 MJ LHV
End of Life	2.15 kg	1 kL	1 kg CO2 eq	1.06 MJ LHV

Manufacturing:

The solid waste generated consists of the ABS casing offcuts and quality control rejects; these will be put back at the start of the process to be recycled. The water use during this stage is unavoidable as it is crucial in the construction process. The amount of CO2 generated and energy demand is fairly low which is due to the injection moulding process. This can be further reduced by creating a large quantity of casings at once.

Use:

No solid waste is generated since no component is discarded. There is no water use in the battery pack because it is used to heat the water in heat packs. The amount of CO2 generated and energy demands are fairly low, however these still have a negative impact since Victorian energy supply is from coal. If renewable energy supplies are utilised then the impact will be significantly lower.

End of life:

A small amount of solid waste is generated in this phase, which is form the PCBs and some of the electrical components. The water used is during the recycling process. As with the use phase, if renewable sources are utilised then the CO2 production and energy demand can be lowered.

Scenarios 2 - Heat Pack

Product Breakdown and EOL destination*					
Part	*Material*	*Process*	*Amount (KG)*	*Recycled Content*	*EOL Destination*
External Skin	Nylon coated PVC	Plastic Blow Moulding	0.16	0%. These can be recycled which affects the structural and thermal properties.	Nylon and PVC recycling, to be used in other products.
Water Pouch Skins	PVC Flexible	Plastic Blow Moulding	0.13		PVC recycling, to be used in other products.
Straps	PP (film grade)	Plastic Injection Moulding	0.02	40-60%	PP recycling, to be used in other products.
Separators	ABS	Moulding	0.01		ABS recycling, to be used in other products.
Electrodes	Stainless steel	Metal Extrusion	0.22	60-70%	Stainless Steel recycling, to be used in other products.
Wires	Copper	Metal Drawing	0.06	0%	Small percentage to landfill. High impact metals and toxic chemicals can be extracted and recycled.
Contact Plate	Misc.	Delivery (truck or train)	0.02		
Temperature Sensor	Misc.	Delivery (truck or train)	0.05		
Pressure Sensor	Misc.	Delivery (truck or train)	0.03		

(these values and processes are higly inconsistent, as the references are vague and give a general overview of the recycling processes. Due to time restrictions we have made the most logical assumptions possible)*

As with the battery pack, the heat pack is fairly environmentally friendly and sustainable.
For the analysis of our heat pack, we used the medium size heat pack (500ml) as our base study.
A lot of the parts are custom made and can be recycled. Temperature and Pressure sensors, the only two off the shelf components, have a minimal contribution to the overall impact of the heat pack. Again these can be eliminated if the product is redesigned in 5-10 years' time.

Design Considerations for the Heat Pack:

Plastics	
Have materials containing toxic substances been avoided?	Yes. Materials containing toxic substances have been avoided.
Have you used plastics with recycled content where possible?	Yes. We have used plastics with recycled content wherever possible.
Have surface coatings been avoided? How?	No finishing surface coats have been applied. only in-mold finishes used
Have all plastic used been clearly labelled?	Yes. All PVC, ABS, and nylon parts are clearly labeled conforming to standards.
Have recycled plastics been used?	Yes. ABS, PVC, and PP.
Has the minimal amount of material required to do the job been used (light weighting)?	All the layers of plastics used in the product are 1mm thick; this gives sufficient strength as well as keeps the product lightweight.
Have the number of different plastic types been avoided?	ABS, PVC, and Nylon are the predominant materials used and account for most of the product.
Concluding Statement	Using innovative design to keep the product simple as well as make it durable. Utilizing recycled polymers and metals. Also limiting the number of components. Also no glues or solvents have been used; instead the whole pack is heat or laser welded to seal.

Electronics	
Have halogenated-free fire retardants been specified for PCBs?	The required PCBs are available off the shelf but would have to be custom made to fit inside the casing. To use halogenated-free fire retardants, they would have to be manufactured by certified producers.
Have low impact batteries been specified?	No batteries in Heat pack.
Are the electronic components located in an area where they are easy to access?	Yes. When repairing the Heat pack, all electrical components are to one side and are easily accessible.
Have lead-free solders been specified?	No. The Sourced components that we found did not state whether they used lead-free solders.
Concluding Statement	Because the electronics contain metals and toxins they are slightly less sustainable. However we have used clear labeling and reputable manufacturers to produce them.

Metals	
Have you used materials with recycled content?	Yes the Steel electrodes have a recycled percentage.
Have you minimized the amount of processes?	Yes. Only require metal extrusion or sheet forming.
Have surface coatings been avoided? How?	Some coatings have been used, which are from Microheat.
Have you designed the product so that the metals can be easily removed for recycling?	Yes. No welding or screwing. Only simple clipped in plastic components.
Has the minimal amount of material required to do the job been used (light weighting)?	Yes. We calculated the area of electrodes we will need to heat the water.
Concluding Statement	The metal components contribute the least negative impact of all. They are easy to produce and process with minimal machining. They don't have harmful coating, and are recyclable to a degree.

Material	*Pros*	*Cons*	*Comments*
Nylon coated PVC	• Good electrical insulator. • Good thermal conductor.	• Derived from a non-renewable source (crude oil). • Although it can be recycled, it is not widespread. • Hygroscopic - requires drying.	Using plastics is generally not an environmentally friendly option. This, however, can be offset by proper labeling, handling, discarding and end of life processing. If everything is managed properly then there can be lower footprints.
PVC Flexible		• Derived partly from a non-renewable source (crude oil) • Although it can be recycled, it is not widespread • Contains additives to make it flexible which if leached out are toxic.	
PP (film grade)	• Good chemical resistance.	• Derived from a non-renewable source (crude oil).	
ABS	• Good low temperature application. • Good electrical properties. • Good chemical resistance.	• Derived from a non-renewable source (crude oil) • Poor solvent and fatigue resistance	
Stainless Steel	• Contains up to 50% scrap steel • High demand for scrap metal	• Resource intensive production process • High Eco-Indicator Impact Score • Mining of base material environmentally harmful	Even though they use relatively high resources, they can be recycled. Managing the end of life processing will be a key to reducing their impact.
Copper	• High demand for scrap metal	• High Eco-Indicator Impact Score • Mining of base material environmentally harmful	
Printed Circuit Boards		• Resource intensive production process • Toxic materials commonly used as retardants - halogenated compounds	A recycling process is available for PCBs, however a small amount does reach landfill and this does contribute to the negative impact.

Total Impact:

Total	*Solid Waste*	*Water Use*	*Global Warming*	*Energy Demand*
Manufacturing	10.98 kg	1.66 kL	56.41 kg CO2 eq	949.85 MJ LHV
Use	0 kg	0 kL	0.42 kg CO2 eq	6.25 MJ LHV
End of Life	1.25 kg	0.45 kL	1 kg CO2 eq	1.06 MJ LHV

Manufacturing:

The solid waste generated consists of the Nylon and PVC skin offcuts and quality control rejects; these will be put back at the start of the process to be recycled. The water use during this stage is unavoidable as it is crucial in the construction process. The amount of CO2 generated and energy demand is fairly low which is due to the blow moulding process. This can be further reduced by creating a large quantity of skins at once.
Also if the manufacturing plant uses renewable sources and carbon footprint offsetting methods, they can be neglected entirely.

Use:

During use no components are discarded and therefore do not produce solid waste. The 0 kL is for EXTRA water use, however there is a maximum of 0.75 liters which is inside the Heat pack and cannot be refilled.
The amount of CO2 generated and energy demands are fairly low, however these still have a negative impact since Victorian energy supply is from coal. If renewable energy supplies are utilised then the impact will be significantly lower.

End of Life:

The solid waste generated from the Heat pack, during this phase, is a combination of the plastic skins and components which can be recycled, along with the electrical components, wherein some of it will go to land fill while the rest is recycled. The water use, again, is for the recycling process.
As with the use phase, if renewable sources are utilised then the CO2 production and energy demand can be lowered.

Scenario 3 - The Heat Pack and Battery Pack as a Package:

Total Impact:

Total	*Solid Waste*	*Water Use*	*Global Warming*	*Energy Demand*
Manufacturing	25 kg	4 kL	111.300 kg CO2 eq	1874 MJ LHV
Transport	0 kg	0 kL	0.09 kg CO2 eq	1.31 MJ LHV
Use	0 kg	0 kL	0.84 kg CO2 eq	12.5 MJ LHV
End of Life	3.4 kg	1.45 kL	2 kg CO2 eq	2.12 MJ LHV

Manufacturing:

The solid waste generated consists of all the off-cuts and quality control rejects form Battery and Heat packs, as well as from the Packaging, all of which is placed back at the start of the manufacturing process and reused.
Same for water usage, CO2 production and energy demand, and is necessary for the production of paper mulch packaging.

Use:

Description	*Consumable*	*Amount Consumed*	*Unit*
Power	Victorian Energy Supply	5.48	KWh
Water	Water	0	L

Again the amount of water consumed during the use phase accounts for any extra water.
Nevertheless the maximum used is 0.75 L inside the heat pack. The daily consumption of power is based on the assumption that the user is going to charge the medium heat pack six times.
All the CO2 production and energy demand can be reduced through the use of renewable energy sources.

Transport:

Description	*Transport Mode*	*Distance*	*Unit*
International	Container Ship	4.34	tkm
National	Train	3.92	tkm

This extremely low CO2 production and energy requirement is because of the highly efficient transport capabilities of container ships and trains. They can carry heavier loads further in less time, eliminating the need for multiple deliveries. The distance for container shipping is based on the fact that an average ship will travel three quarters of the distance to moon in a year; from this the daily distance was calculated. The tkm was then produced from this. As for train, a distance between Melbourne and Sydney was used to calculate the tkm.

End of Life:

Again all the factors are a combination of the Battery pack, the Heat pack and the packaging.

Design Guidelines

Dematerialisation

Aim for rigidity through construction techniques such as reinforcement ribs rather than 'over dimensioning' the product.	Over dimensioning has been avoided because all wall thicknesses are 1mm or less. However structural integrity has been reinforced through the use of ribs and bosses in the battery pack. For the heat pack two layers were used, to provide the appropriate heat dissipation performance but still protecting from avoidable cuts, punctures, and abrasions.
Consider material substitutions that reduce the weight of the product but still meet the functional requirements.	Originally the intention was to use aluminum for battery pack casing. However with further discussion and research we found that we would have to use the same of thicker wall size in order to avoid plastic deformation and for aesthetic purposes.
Can the functionality of the product result in the elimination for the need of ancillary products?	No. All products are crucial to the system and its performance. No ancillary products have been considered to avoid excess material use.
Attempt to minimize the number of different types of materials specified.	Only four different materials have been used. These have been selected for their mechanical and thermal properties.
Attempt to minimize the amount of packaging for the product.	All packaging will be done with recycled, paper mulch molds. This will reduce, weight, cost and material usage, while being environmentally friendly.

Selecting Low Impact Materials

Source materials that do not contain toxic or hazardous substances. Click here for more information.	Minimal materials such as the circuits and Li-Po batteries do contain chemicals. However through the proper use, discard and/or treatment can limit the harm caused by them.
Source materials from environmentally and ethically appropriate sources.	Since the circuits are custom made, they will be sourced from highly regarded and certified manufacturers.
Source materials which are renewable in origin.	Victorian energy supply is through coal. However if in future with the use of renewable energies such as solar and wind.
Source materials that do not contain toxic or hazardous substances. Click here for more information. Avoid non-ferrous metals such as copper, zinc, brass, chromium and nickel due to harmful emissions that occur during production.	The circuit boards will contain a small percentage of these materials; however through the utilization of high quality production methods the emissions can be reduced.
Avoid energy-intensive materials such as aluminum in products with a short lifetime.	No Aluminum was used.
Specify materials with recycled content whenever possible.	All components with recycled content have been clearly labeled and identified.
Use recycled plastics for parts that do not require high mechanical, hygienic, tolerance or aesthetic requirements.	All plastic components used in this product can be recycled. Therefore by extension, the product can be built from recycled materials and still provide similar performances.

Cleaner Production Processes

Attempt to limit the number of production processes as much as possible.	Processes such as injection moulding, blow moulding, metal extruding and drawing have been utilized. This way a large quantity of components can be made at once while using minimal amounts of energy and other resources.
For off-cuts and production waste that have established recycling markets ensure that the processor has a recycling program in place.	Any wasted material, along with offcuts and quality control rejects, can be sent back to the start of the production line to be recycled rather than discarded.
Avoid the use of solvents, glues and other compounds that release volatile organic compounds (VOCs) or specify compounds with low or zero VOC emissions.	No glues or solvents have been incorporated as a part of the manufacturing processes. All joining and connecting is through the use of simple clip joins for the battery pack, and heat welding for plastics.

Optimisation of Distribution System

Attempt to source components and materials from local suppliers thus reducing transportation distances.	All materials can be sourced from local distributors. However the custom made circuits maybe constructed overseas (i.e., china) to keep end costs lower.
Attempt to reduce the weight of the product and packaging in order to minimize transportation impacts.	The total weight of the packaged system is 5.5kg including the packaging itself. This is a minimum amount.
Attempt to reduce the amount of space required for transport and storage by decreasing the product's size and volume.	The battery pack has been designed to accommodate all internal components, while allowing safe operating conditions so as not to damage them.
Design the product to be foldable and/or suitable for nesting when applicable.	
Consider transporting the product in loose components that can be nested, leaving final assembly up to a third party or end user.	For local transports all assembly is done at the manufacturing plant. However for overseas distributions, the final assemblies can be completed by the manufacturing plants (if there are any)
For transportation and bulk packaging consider reusable packaging and a return system where ever possible.	For local distributions, each system is packaged in recyclable packaging which can be discarded in recycle bins. For international distributions, individual components can be packaged into large shipping containers which can later be reused for a return journey on-board the container ship.
Transport by container ship or train is preferable to road transport.	Yes. A high percentage of transportation within Australia is done through rail. Container ships are utilized for overseas delivery.

Design for Durability

Extend the product life by ensuring that it is durable and all weak points are eliminated.	We have extended the product life by applying durable materials where necessary.
Design the product's appearance so that it does not quickly become dated, thus ensuring that the product's aesthetic life is not shorter than its technical life.	We have designed the products so that they have a modern, simplistic yet appealing aesthetic to ensure that the system does not become outdated aesthetically before its technical life ends.
Can the product be upgraded?	The battery pack can be upgradable
Ensure all parts that need upgrading are easily accessible.	The casing of the battery pack has been designed for disassembly to ensure that replacing and upgrading components can be done easily.
Provide clear instructions for how to upgrade the product.	On our packaging boxers and in a user's hand book that comes with the system, instructions for upgrading would be covered.
Is it designed to be compatible with existing products?	The system is not designed to be compatible with other products, as our heat pack and battery pack together is all that is needed to apply heat therapy efficiently and effectively.
Is the product easy to maintain?	Both products are easily maintained. Cleaning with cold water is advised when necessary.
Ensure the maintenance of the product is a pleasure rather than a duty.	User would not need to maintain the product often. It would simply be a useful product that does not require much maintenance, besides occasional cleaning when necessary.

Reduced Impacts during Life Use

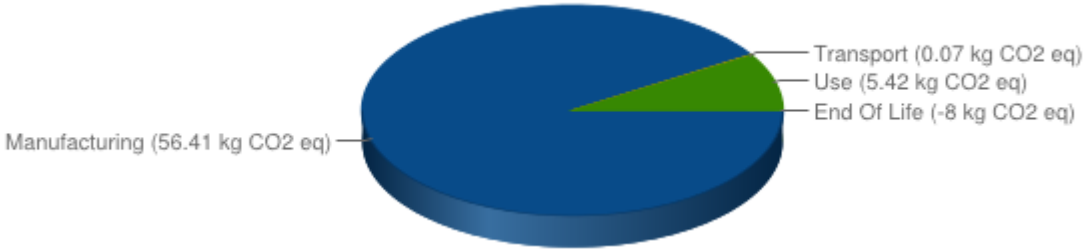
Understand user habits and design interfaces that encourage sustainable use.	Our system is extremely simple to use, as it does not have any buttons or screens, simple led indicators that communicate to the user. Hence the user interface is simple and encourages sustainable use.
Specify resource efficient components/technologies.	Microheat technology is the primary element in which our system was designed around, which alone encourages sustainable use.
Avoid the standby function in electrical products instead ensure that the user is able to switch off the product.	Our product has an on/off switch at the back of the battery case to avoid standby functions and eliminate energy wasting.
Wherever possible, replace disposable consumables with reusable alternatives.	We do not use disposable consumables
Use a default mechanism, which automatically re-sets the product to the most efficient setting.	We have utilized a default mechanism that automatically re-sets the battery pack to the most efficient setting.

Design for Waste Avoidance and Resource Recovery

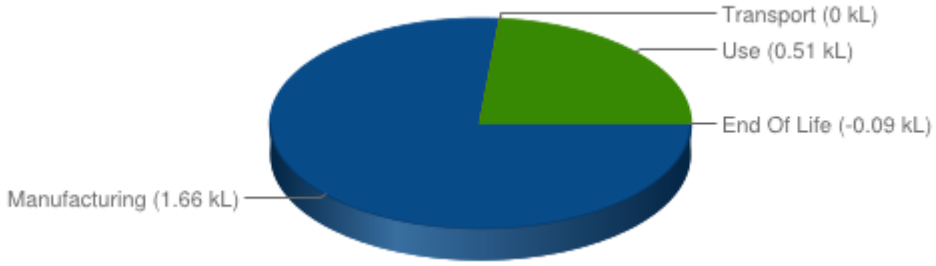
Less is more; by using less materials and components in the first place results in fewer materials entering the waste stream.	We have designed our products to be made using an appropriate amount of material. No excess material is incorporated into the design, as by using a lower amount of material results in fewer materials entering the waste stream.
Ensure the separation of different material types and components is as efficient as possible to aid in reuse or recycling	Materials of individual components shall be listed in the user hand book as well as on the components and the packaging, which would effectively allow for separation of different material types and components to aid in making the reuse and recycling of components as efficient as possible.
Minimize the use of surface coatings and finishes on materials, as this can contaminant the recycling process.	We have avoided the use of surface coatings and finishes on the materials to ensure that the recycling process does not become contaminated.
Avoid the use of glues, metal clamps and screws in favor of 'push, hook and click' assembly methods.	We have avoided using glues, metal clamps and screws, and have incorporated interference joins as well as hook and click assembly methods to allow for disassembly.
If glues are to be used, specify recycling compatible glues.	glues are not to be used
If using fasteners, make them easily accessible, no longer than needed, use one type of head per product, use ferromagnetic metals for magnetic separation.	Fasteners were kept to a minimum and instead clips were used.
Do the materials specified have an established recycling market?	The materials that we have allocated to our components have an established recycling market currently.

Pie Graphs

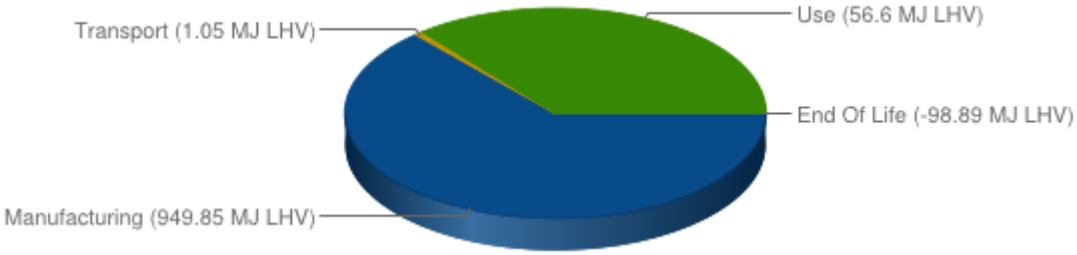
Global Warming:



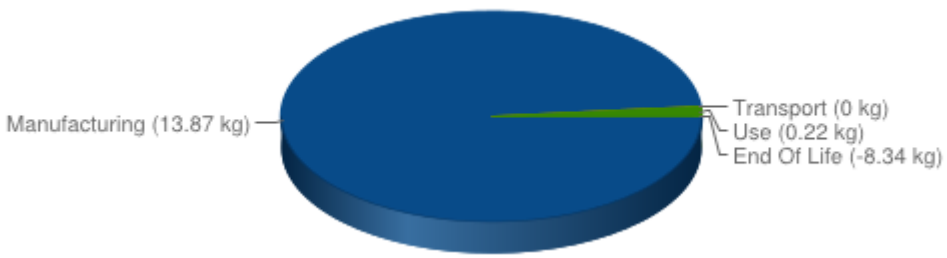
Water Use:



Energy Demand:

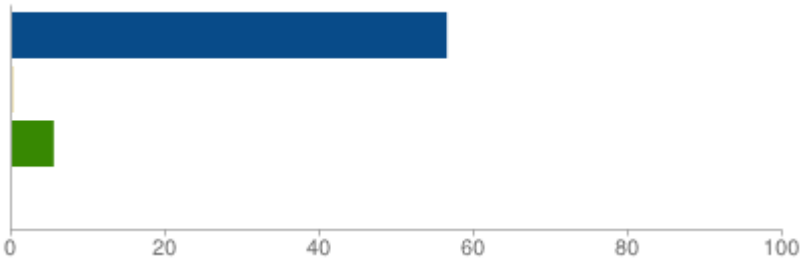


Solid Waste:



Bar Charts

Global Warming:



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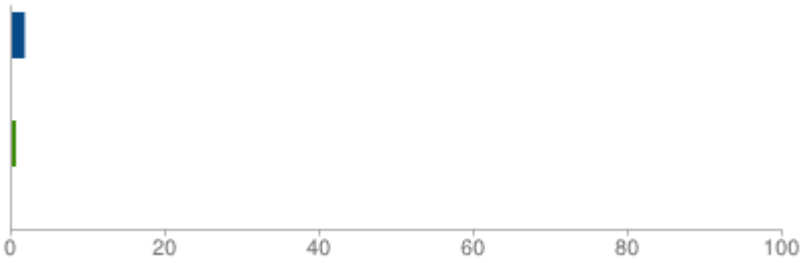

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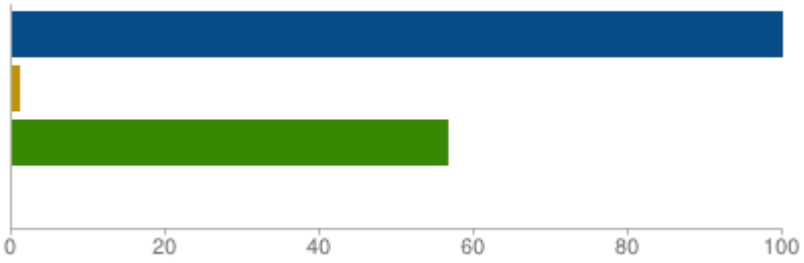

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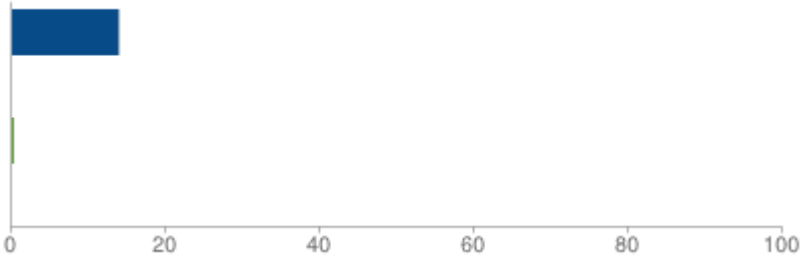

Reflection

After analysing the results that greenfly displayed as tables, graphs, and pie charts, it was made clear that the manufacturing stage has the highest impact on the environment, while that later phases are significantly lower. However, these results from the greenfly analysis show that both products have a relatively low environmental footprint. Almost all the waste generated during manufacturing and EOL stages, can be recycled or reused, while only a small amount would be sent to landfill.
This small amount is far less toxic or harmful when compared to existing products, which use toxic gels, chemicals and metals in a much larger quantity. We recommend that the product be redesigned in 5-10 years' time, as this will give the Victorian energy time to transfer over to renewable supply. Also more efficient and user/environmentally friendly electrical components will have been developed, along with more resourceful manufacturing processes. To conclude, we are pleased with our products and believe that the system we designed has potential to be manufactured and marketed, as our system beats existing competitor products, and the way in which they are heated, not only from a more user friendly view, but importantly from an environmentally friendly and sustainable perspective.