Business Plan

PETexe, Exeter iGEM Team 2019
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II. Executive Summary

PETexe is a recently formed, student led, start-up company working to produce enzyme-based microplastic filters for washing machines which both capture and degrade plastic clothing fibres. The company plans to develop the product further over five years, optimising before the sale of the filters as a component in a washing machine.

Market research suggests the filter has unique advantages over other existing filters that are brought about by the use of enzymes to degrade the plastic, meaning that the filters need less user interaction and do not need the captured plastic to be disposed of by the user into general waste. Its presence in a rapidly expanding market is examined with both SWOT (Strengths, Weaknesses, Opportunities, Threats) and PEST (Political, Economic, Social, Technological) analysis, these highlight a significant opportunity for rapid growth due to current social movements and pressures whilst also stressing the potential for an increase in competition over the coming years.

PETexe would currently be aiming to sell to premium washing machine manufacturers, with the expectation that as the company develops and costs are reduced the filter would then be more accessible to a wider audience. There is further potential for growth in other markets including fashion mills and water treatment centres in which there is a need for microplastic filters and relevant parties have expressed interest in pursuing this.

A full operational plan presents the details relevant to production of the filters including product development, personnel, quality control, location and suppliers. Additionally, customer service, inventory control and the legal environment are outlined for the sale of the filters.

The finances for the first year, including costs, cash flow, balance sheet and profit and loss statements are included and analysed. The forecasted finances show a net profit in the first year before tax with a net profit margin of 7.6%. After tax there is an expected loss, however this is forecasted to improve in subsequent years as production becomes continuous throughout the year.

III. Company Description

PETexe is a newly formed bio-filter company that provides expertise and products for companies looking to reduce their microplastic waste. We primarily cater to washing machine companies but also hold the possibility to provide services to water treatment plants in different industries. There will also be an opportunity for the general public to buy individual units to integrate into their existing household washing machines.

PETexe was formed in September 2019 and originated as the team representing the University of Exeter in the international iGEM synthetic biology competition. The team started as a 10-person bioengineering research group, conducting research into the possibility of creating an enzyme-based filter system to capture and degrade the microplastics released during washing of synthetic fabrics. Laundry accounts for 35% of all microplastic pollution, and the team founded the company as a direct response to this.

The business is currently based at the University of Exeter and has access to support and facilities there. However, it may become necessary to move locations to a new headquarters if the company expands. The business currently consists of ten STEM undergraduate researchers: Jonathan Bailey, Jessica Billington, Dragoș Dumitrescu, Jonathan Elliott, Adriano Matousek, Chloe Matthews, John Felipe Murphy, Lydia Pike, Rachael Quintin-Baxendale and Ceilidh Welsh who founded the company.

While PETexe is currently in the design process for a microplastic filter that will be integrated into new washing machines before the general public buy them, we have ambitious short and long-term goals:

- After one year we aim to have a patent pending for the design of the filter that has been optimised for the most effective removal of microplastics at specific washing machine flow rates.
- After three years we aim to have optimised the enzymes, improving their stability for use within the filter. We also aim to have IP on specific ancestors of MHETase and PETase that we have developed for the degradation system. We will be looking for collaboration and funding from enzyme companies, who would provide the lyophilized enzyme powders used to make the solution released into the filter system.
- After five years we are aiming to have a fully integrated filter system in a test washing machine, running tests to determine its reliability within the machine. Once this has happened, we can begin to pitch and sell the integrated filter to widespread washing machine companies, producing larger quantities of the filter.

While other microplastic-capturing devices do exist, this product is unique as it has the capability to break down the captured microplastic fibres, whereas other available filter systems require them to be disposed of in general waste bins. Removal into waste bins is not always practical as it requires the consumer to change it regularly and it can also lead to the release of airborne microplastics, which is speculated to be damaging to human health. This filter design provides a huge environmental advantage over other filter designs, as the plastic fibres are not only removed from the water system but are also degraded into substances safe to be released, which prevents the plastic from going to landfills, and also from indirectly reaching the water system. This design also provides an easier user experience, as the filter will require less maintenance than other concepts due to less blockages.

The PETexe vision is to revolutionise the washing machine industry, creating a future in which laundry is no longer the largest contributor to microplastic pollution.

IV. The Product

PETexe are developing a microplastic filter which captures and degrades the microplastic fibres using bioengineered enzymes. The PETexe filter will attach to the outlet of (or housed within the structure of) washing machines, preventing the fibres from entering the water systems. The fibres will be broken down by a combination of enzymes, releasing the environmentally-benign chemicals terephthalic acid and ethylene glycol.

In 2016, the bacterium Idonella Sakaiensis was discovered in a plastic recycling centre in Japan. It was found to produce the plastic degrading enzyme PETase. The DNA that codes for this enzyme was sequenced and with bioengineering techniques, labs are able to produce the recombinant enzyme in *E.Coli* or yeast. The Exeter-based team have produced this enzyme along with MHETase which when combined will completely degrade polyester fibres in the integrated filter design. The team are currently taking strides to improve the efficiency and stability of the enzymes to increase commercial viability.

The filter will operate by taking the water outlet of the washing machine into the filter unit pictured in Figure 1. The water will pass through a 40-micron nylon filter after each wash. A solenoid valve system is attached to the filtration unit, which will control the release of the enzyme solution into the filter. Once a threshold point is reached (i.e. 10 washes) solenoid values on the entry and exit points to the water unit are closed and a valve to the enzyme holding unit is opened. This will allow the enzyme solution to fully submerge and degrade the PET microfibres. Once the required time for degradation has passed, the valves will return to their normal states to allow the next wash to wash out the soluble products from the microplastic breakdown.

This product is unique in the way that it has the capability of breaking down the captured microplastic fibres, compared to the usual method of disposal for most other microplastic washing machine filters, which is to put the fibres in general waste bins. This gives both a major environmental advantage, as the plastic fibres are not only removed from the water system but also degraded into substances safe to be released; and the advantage of a simpler experience for the end user, as the filter requires less maintenance due to reduced blockages.

PETexe is the only company currently publicised producing an enzyme-based microplastic filter.

A CAD image of current filter prototype can be seen below:

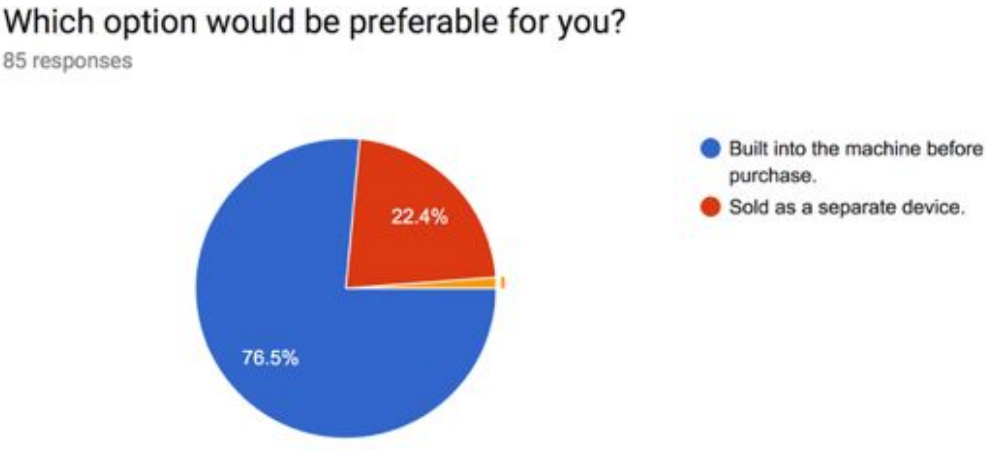
Figure 1: Schematic of the enzyme-based filter system, showing the water inlet and outlet, the inlet for the enzyme solution and the nylon filter support structure.

V. Marketing Plan

Primary Market Research

To gain feedback from the general public, we conducted primary market research whereby a group of 85 people from different countries and age demographics were asked a set of questions about our product. Our research showed that 96.5% of people asked were keen to have a microplastic filter installed into their washing machines.

We also asked whether it would be preferable for the filter to be sold as a separate item or be integrated into the machine before purchase. In total, 76.5% of people agreed that the best option would be to have it build into the machine before purchase, and so we based our design around this concept.



The design of our filter initially was completed as a proof of concept as an additional external unit to the washing machine. The design was then discussed further as its application in a washing machine was preferred by over 75% of people in our market research. This was an important process for the development of the filtration unit.

Moreover, the integration of the filtration system would mean that the cost of the filter is absorbed into the cost of the washing machines as opposed to an additional cost for the user. This idea is reflected in the original market analysis, where consumers of this product would rather have the filter integrated into the machine.

SWOT Analysis

We carried out a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis on our product, to identify the company's competitive position and overcome any challenges we predict that we would face. This analysis can be shown in the table below
SWOT analysis demonstrated that our design is unique, different and there is a gap in the market for this type of filtration system. Moreover, there is potential for this design to be used on a large scale especially within industries who are looking to be more environmentally minded. It also showed that the integration of the filtration system would make the product more accessible to a wider range of people and societal groups. Moreover, there are many opportunities available to a company with an innovative idea that aims to fill a gap in the market. For example, there is potential to collaborate with a variety of international companies that use any kind of filtration system that could stop microplastics. This technology could also be adapted to tackle other areas of plastic pollution.

However, the SWOT analysis brought to light some of the things we may need to consider when bringing this product to market. For example, the filtration system is dependent on companies being willing to purchase the filters and front the cost of installing them into their washing machines at their manufacturing stage. There would need to be extensive field testing before manufacturers of household appliances would consider integrating this product into their systems. On a more critical level, there are no sources of funding immediately apparent, however there are sources of funding that are more widespread for environmental business start-ups that could be pursued.

Our SWOT analysis table can be seen below:

INTERNAL FACTORS	
STRENGTHS (+)	**WEAKNESSES (–)**
• Offers a unique design which can be easily fitted and integrated into common household washing machines. • Have the potential to upscale this model to industry level. • Very current issue and so there is lots of interest and incentives to apply this product. • Currently very little similar products on the market. • Easily accessible to a wide range of people, as it can be pre-installed and requires no live bacteria. • We have working relationships with key partners on an international level, who are keen to help us continue to develop this product. • Support from, and use of University facilities.	• Current model depends on being pre-installed by manufacturers, and would have to be adapted to be sold as a separate component. • Our current prototype needs further development and testing to reach commercial level. • We would need to perform field testing with our finalized prototype to ensure success. • Dependent on manufacturers being willing / able to invest in reducing microplastic pollution levels by integrating our filter. • Lack of secure funding beyond the prototyping phase.
EXTERNAL FACTORS	
OPPORTUNITIES (+)	**THREATS (–)**
• Viable to easily adapt model to different markets. • Possibility of upscaling this model to larger water treatment facilities and fashion mills. • Potential of applying this technology to other areas of plastic pollution. • Potential to collaborate with developed companies in the industry to make use of their facilities. • Current pressure on the government and industry to address plastic pollution. • Potential to integrate other plastic degrading enzymes into the solution.	• Competitors currently researching similar areas. • Exposed to the variable costs of manufacturing the filter system and producing the enzymes. • Dependant on large partners. • Fast growing industry and so competition in the market could intensify rapidly.

PEST Analysis

PEST analysis is a management method whereby an organisation can assess major external factors (Political, Economic, Social and Technological) that influence its operation in order to become more competitive in the market. We conducted this in the table shown below to review in detail any possible threats we would encounter when taking our product to market.
PEST analysis demonstrated that there are barriers in all sectors of society that we will need to consider when bringing our filtration system to market. Politically, legislation would need to be brought into place to encourage large scale companies to meet environmental targets and install a filtration system such as our own. From communication with a Senior Policy Advisor at DEFRA, we know that the UK "government does not have any specific plans for enforcing the self-regulation of washing machine manufacturers to include microplastic filters within their machines". Thérèse Coffey, (formerly) Minister of State at DEFRA, has told us that they are "working with industry to encourage improved environmental outcomes and reduce water pollution on a voluntary basis". From our communication with senior

government officials it is clear that there are hurdles to pass when it comes to encouraging government intervention.

Economically, the variable cost of manufacturing and producing the enzymes would need to be absorbed by either our own company or the manufacturers installing the filtration system. The economics of the resources needed for the production of our filter would also depend on the political landscape.

The social aspect is positive as public opinion surrounding climate change, environmental sustainability and protection is increasingly active and progressive. However, it has to be an accessible product for consumers to either purchase individually or be a no-hassle part of their existing system.

Technologically, this product will have competition from research that also looks to filter microplastics.

Our PEST analysis table can be seen below:

POLITICAL	ECONOMIC
• No regulation on washing machine companies to install microplastic-capturing filter. • No tax incentive for washing machine companies to install microplastic-capturing filter • Government currently focusing on regulating other types of microplastic pollution (microbeads, etc.).	• Emerging industry. It is growing fast at the moment but is not established so uncertain future. • Exposed to the variable costs of manufacturing the filter system and producing the enzymes. • Staff costs.
SOCIAL	**TECHNOLOGICAL**
• Lifestyle choices and public opinions have shifted to be more environmentally-minded, so market is likely to become more competitive. • Concern about sustainability within the fashion industry currently, but public opinion could once again change. • Dependent on social trends.	• Competitors currently researching similar areas of technology. • Dependant on large partners.

Market need:

The market need for our product would be driven by the societal drive to prevent the effects of pollution, specifically microplastic waste. The filter is not required to make the washing machine work, so a washing machine is no worse off without it. However, with the increased cultural awareness of the effects of microplastic pollution and the growing statistics about the

damage it is doing to our health and our planet, pressure will be placed on companies in the future to make more ecological choices. This is the first key driver of the market.

Moreover, larger companies care about their image and what their brand is representing which is the second driver in this market. For example, the introduction of ecological washing cycles was due to widespread awareness of fossil fuel use and the need for its reduction. Companies have introduced this cycle to prove to consumers that they are doing something about the fossil fuel problem as well as to make the consumer feel better about their energy usage. Therefore, companies may want to encourage the use of microplastic filters into their machine to prove that they are acting in an ecological way.

Size of Market:

Our product would be sold nationally to washing machine manufacturers to be installed at the manufacturing stage. There would be a large market, due to the advancement of technology within washing machines, and the development of smart washing machines, as well as the current trend of increased sustainability. The current UK market value for microplastic filters for washing machines is estimated to be $454million within the UK, calculated using bottom up methodology. This value is based off the 2.27million washing machine units sold in 2018, and the product value estimated at $200 based on other filter designs.

The growth of the market is dependent on economic cost and profit, as well as demand. Washing machine manufacturing sites in the UK are likely to be tied to international companies and therefore an international market. Furthermore, if washing machines with integrated washing machines filters are fractionally more expensive but are bought more frequently by the consumer the cost will be driven down, leaving washing machines with integrated filters no more expensive than the original washing machines over a relatively short time period.

If the demand for washing machines with integrated filter is placed on business by the consumer, industry is likely to respond. If there are increased sales for these integrated washing machines, and therefore increased profit, international business may sell washing machines not only nationally within the UK but further afield. This would open the market for the business up to more countries.

Customer:

We are targeting manufacturers of premium washing machine appliances including AEG, Beko, Bosch, Hoover, Hotpoint, Indesit, Miele, Samsung, Zanussi. Higher end brands with more expensive washing machines would be easier to target initially as the manufacturing costs of integrating the picture would be absorbed by them. Lower - middle range market

washing machines, which are more affordable and used by a larger portion of civil society would need subsidies for the manufacturing costs.

The target market for this product would initially be high-end washing machine manufacturers who are more able to front the initial investment costs of integration. Once there is a more widespread use of the filter and lower production costs with time, the target market would increase to cover all washing machine manufacturers. As the business develops, the aim is to produce different models of this filter, with the hope of targeting industry scale processing plants. Top selling washing manufacturers currently include Miele, Hotpoint, Samsung and Bosch. We also aim to encourage the government to provide subsidies to the manufacturers to help tackle the investment costs of integrating this system, and if this is successful the target market will cover all washing machine manufacturers. The end user would be the owner of a domestic household washing machine.

Barriers to Entry:

Barriers to entry highlight all possible obstacles or costs that a start-up could encounter which usually slow-down or stop the entry of new competitors into a market. We have investigated the major barriers to entry which we could face below:

Investment: The filter will need to be bought on a large scale by washing machine companies, who will then need to invest money into integrating the filter into the machines at manufacturing. The companies will therefore need to be able to afford the cost of the filter as well as the integration into the machine before they can go on to sell any products.

Technology: The technology needs to be advanced enough so that the filter does not get blocked after the first wash. The filter cannot be replaced or cleaned regularly so it cannot get clogged easily. The filter needs rigorous testing before it can be sold.

Brand: the filter is reasonably unique and quite specialist. The companies would need to be able to afford the filter as well as have the assurance that it will work.

Access to resources: Enzyme production will need to be reliable and consistent as this is essential for degrading the plastics fibres. The enzymes will also need to be produced for the consumer to buy to refill the filter.

Whilst developing our business model and designing our product we took these potential obstacles into consideration and adjusted accordingly.

Industry Interest

Throughout the research project and development of the filtration system, the team engaged with industry and business to receive direct feedback and also to assess the industry interest. This was crucial as industry will play a large role in the integration of the filters into household appliances. Industry must be willing to pay for the cost of the filter and then absorbed the cost of both the purchase of the filter and adaptations to the manufacturing process.

Washing Machine Manufacturers:
Premium domestic appliance manufacturer Miele, was in contact with our team from the beginning of the process. They were influential to the design of the filtration system. It was also important to see what technology they already used in their household appliances, so that we could integrate technology that washing machine manufacturers are already using into our design, reducing their manufacturing costs in the long-term.

Fashion Companies:
Fashion companies were crucial to talk to as they would inform whether it would be possible to scale up the filtration system to a larger industry scale. They are able to provide flow rates for mathematical scaling and give industry an idea of whether our filtration ideas could be integrated in the future of the manufacture of synthetic clothing. We had keen industry interest from various stakeholders including The Microfibre Consortium, Ralph Lauren and Stella McCartney and many of them were keen to see our filter could be integrated into the Circular Economy of Fashion in the near future.

Filter Companies:
Filters companies were essential to be in communication with as they provided insight into what products were already on the market. Xeros Technology Group were particularly helpful towards the engineering and testing of the filter design, as they provided us with a sample prototype of their filter, XFiltra, and giving us advice.

Competition:

Currently, there are not many similar products available on the market, and none which have the capability of breaking down the captured fibres. We have analysed several other competitors who produce microplastics filters to capture microplastics during a standard washing cycle. The distinct difference between our filter and these competitors we have investigated is that our filter will degrade the plastics that are caught, not just catch them to then dispose of them.

This will inevitably increase the cost of our filter in comparison with the alternative options, however degrading the plastics should reduce the number of replacement filters that are needed. We aim to price our filter at a similar level to competitors, but understand that costs could potentially be slightly higher due to our more sophisticated solution

Current competitors include:
Filtrol 160 [1]**:** Filtrol 160 is an external microplastic filter which can be attached to the back of washing machines through their drainage hose. It is installed by the user and must be cleaned every 3 weeks, disposing of collected microfibres into the general waste. The Filtrol 160 is produced by WEXCO Environmental, a wastewater treatment company.

Lint LUV-r [2]**:** Lint LUV-r is an external microplastic filter made out of stainless steel, which can be attached to the back of washing machines through their drainage hose.

Guppy Friend [3]**:** Guppy Friend is a filter bag for the washing machine which can hold all synthetic clothing being washed. It reduces fibre breakage and filters out microplastic waste, to prevent it from entering the water system. Once the wash is over the clothes are removed from the bag and the collected microplastic fibres are gathered from the lining of the bag and disposed of into general waste by the user. Guppy friend is produced by a non-profit organisation, 'Stop! Microplastic Waste' who are looking at producing other alternatives as well, including filters.

Comparison of Competitors				
	GuppyFriend Bag [3]	**Filtrol 160** [1]	**Lint LUV-r** [2]	**PETexe Filter**
Cost	€30.00	Initial Filter with bag = $140.00 Replacement filter = $13.00	$155 for unit with wall mount	Still in prototype phase
Efficiency	Reduces 86% of fibre breakage	89% of microfibres removed	N/A	Still in prototype phase
User friendly?	Cleaned after every wash	Filter must be cleaned monthly	Filter cleaned every 3 weeks	Still in prototype phase
Replacement duration	> 50 washes	Replace filter bag every 1-2 years	N/A	Still in prototype phase

Disposal Method	General Waste	General Waste	General Waste	Degraded

Our competitive advantage is dependent on our niche and our unique selling point in the market. After analysing the competitive market, we have realised that we hold a unique selling point in the market as we break down microplastic fibres not just catch them. We also have a unique selling point as we are aiming to sell these filters that break down plastics to large industrial companies that sell their household washing machines widespread across the country. The disadvantage of company proposal currently is the requirement for further research into the enzymes being used, to ensure that they are capable for consumer use.

Our advertising and marketing would be targeted at larger companies, including household appliance companies and larger fashion industries. We would be targeting them directly as from our market research we have determined that the end user would prefer the filter to be integrated before purchase, and so our target customer would be industry companies.

VI. Operational Plan

The operational plan highlights key points relating to how the company would function in the long term.

Production

We would use metal tubing with nylon filter sieves for our final design, due to simplicity, ease of manufacture, cost and durability. This can be manufactured using welding equipment, a band saw, a milling machine and lathe, along with soldering equipment for the mechatronic filter design. All the costs of production, along with equipment and materials can be found in Appendix 1.

Quality Control

To ensure constant high quality, initially all filters will be hand inspected within the first 6 months of production, and then after this point, random inspection of filters will be completed.

Customer Service

A warranty of 2 years' service will be guaranteed to all customers, along with reduced maintenance costs. An integrated filter will be protected by the warranty of the washing machines company's overall household appliance warranty.

Inventory Control

A constantly updated record of inventory will be kept, and new stock will eventually be ordered using Materials Requirement Planning (MRP) technique. This is when stock is only ordered once the sales forecast has been studied, and so the correct amount of stock should be available for the market demand. The inventory held will include one month's supply of finished product, alongside 40% of a month's supply of raw materials. This is to ensure that deliveries will not be delayed if a problem is encountered within the factory.

Product Development

The product will constantly be going through design iterations and improvements to release newer models with time.

Suppliers

Local suppliers for the materials needed to produce the filter will be used where possible, to improve the sustainability of production. The enzymes will be supplied by a large enzyme production company, to maximise the yield able to be produced.

Location

The factory required will initially need to be 1000^2 ft, with 37.7 kW [4] of power needed per hour. This will allow us to produce the required quantity of filter systems for the predicted sales. Once the company progresses and grows these numbers will need to be re-evaluated and increased as necessary.

Legal Environment

Regulations will be required for the use of the PETase and MHETase enzymes within washing machines. Compliance with these regulations will be investigated before the release of a filter onto the market. There will also be regulations for the release of TPA and EG. Compliance with these regulations will be required in prior testing before selling to ensure the amounts of EG released are within guidelines.

Personnel

We will initially have 10 members of staff employed on a full-time basis, with 5 working on machinery and production, and 5 admin staff. All staff will be paid equally, at 8 pounds per hour, expected to work 8 hours per day. As the company develops and grows, the number of employees will need to be increased, and the pay will also be raised with experience.

VII. Financial Analysis

Funding Plan

This start-up would be funded by a number of various sources. Existing capital from personal investment equates to £50,000, including competition prizes and own money. A medium-term bank loan was decided to be the best way to gain capital, as it can be secured with a relatively low interest rate. For this report an interest rate of 5% was assumed, with a payback period of 4 years, and the loan, of value £50,000, will be paid back in fixed monthly instalments. Additionally, an equity sale of 10% of the company for £100,000 will be negotiated to further increase starting capital. This value will be confirmed by our partners prior to the start-up. The purchase of materials will be bought using trade credit with a one-month delay, to ensure there is constant liquidity. Due to the company not making a profit in the first year, corporation taxes do not need to be paid, and these will be delayed until the company starts to turn over a profit.

As the company develops, more methods can be used to increase funds. Business grants, especially in the sector of R&D and innovation, are a good option. They are either supplied by the government, non-profit organisations, or by larger firms who have the intention of investing in entrepreneurship. Crowdfunding could also be used, as this has grown in recent years as a way to raise capital for start-ups. It could be possible to generate funds from persons with a desire to reduce microplastic pollution and wash synthetic fibres in a more environmentally friendly way. However, neither of these options allow for certain inflows of capital, and so they will be done to further raise funds but are not crucial to the start-up immediately.

Costs

The machines will be purchased outright, as there is capital available and not many machines are required, and this will save money in the long term compared to renting. The costs for each machine, along with their power usage and staff required can be found in appendix 1. These power usage values, along with power usage for the running of the factory were used to estimate the total power usage of the warehouse. 10 staff will be required to start the company: 5 manual workers, and 5 administrative staff, all with a wage of £8 per hour. The factory will be running for 8 hours a day, 253 days a year (excludes weekends and public holidays). The total years wages equate to an estimated £161,920 per year.

The material costs per filter come to £104.00, and the cost breakdown of all individual components can be found in appendix 1. It is feasible to estimate the production to be 5000

filters per year, and so the total material costs of the first year (with staggered production levels initially) come to £320,700.

Utility and rent costs can be found in appendix 1 and these include estimated Wi-Fi, electricity and water usage values, estimated from average quotes for companies of a similar size. This table also include miscellaneous costs which includes computers, desks and chairs for administrative staff.

All these assumptions lead to an estimated total cost of £539,000 in the first year.

Cash Flow Statement

The company's cash flow statement forecast for the first year of trade can be found in appendix 2. The target is to produce 5,000 filters per year (417 filters per month), and to have these filters sold to one washing company producing washing machines. The company aim to supply 13% of the number of new washing machines produced by one premium manufacturer per year in the UK. This value was estimated due to 776,000 washing machine users owning this brand of machines in 2018 [5]. Each of these washing machine is designed to have a long lifespan of 20 years [6], and so it can be estimated that in 2018, 38,000 of these machines were bought in the UK. The proposed contract with such a company would commence in May with a reduced delivery of 25% of full capacity. This would stay constant in June and increase to 50% of full capacity in July. In August, full capacity deliveries of 417 filters per month will be delivered. Payment for the filters would be in monthly instalments, and they would be sold at £180, based on own production costs and the costs of other filters on the market. Production will be staggered initially and eventually increase to full capacity by October.

The costs of the machines are staggered over the year, which will be agreed with the machine suppliers. This means that there are 12 equal monthly instalments to pay, to ensure constant liquidity throughout the first year. Alongside this, the other costs of production, such as materials costs are also paid monthly. The deposit interest has been calculated as 1% of the total in bank the month before. The wages are paid every month at the start of the next month, along with pensions (rate of 3% as standard [7]. Utilities are paid at the beginning of every month, along with the rent. All miscellaneous items, company registration and IP application will be paid as a one-off cost at the beginning of the first year.

The bank loan of £50,000 has an agreed interest rate of 5%, and a payback time of 4 years. To maintain a constant payback in monthly instalments, the loan will be paid at a rate of £2297.90 per month [8].

Profit and Loss

The profit and loss statement can be found in appendix 4. It shows all the sales and costs of the first year of trading. The value of sales for the first year totals to £450,000, based on sales commencing at a lower capacity in May, and gradually increasing to full capacity. There is no opening stock as this is the first year of trade, and the closing stock amounts to 40% of a month's supply of raw materials, plus one month's supply of manufactured product. The value of purchases comes to £320,700. The total cost of goods sold then comes to £236400, with a gross profit of £213,600. Therefore, the Gross Profit Margin comes to 47.5%. This indicates that there are low overhead costs for the production, and that the overall efficiency of production is high, as a normal gross profit margin is around 40% [9]. All machinery and furniture are estimated to depreciate 15% per year, assuming both can be used for a minimum of 7 years. The net profit margin for the first year is 7.6%. This value for the net profit margin indicates long-term profitability, as it is well positioned between 5-10%. Retained profit for the first year is negative, at a value of -£8700, however a loss is expected for the first year due to it being a start-up and incurring many additional costs in the first year, including the entire costing of all machinery. If all other costs remain constant, the start-up should turn over a profit in the second year, showing that the company has profitability commencing in the second year.

Balance Sheet

The balance sheet can be found in appendix 3, which shows the first day of trade for the second year. The initial capital is still valued at £250,000 as this represents the value at the end of the first year of trading.

Whilst the net assets of the company decrease in the first year of operations, it is expected that this will rise subsequently as in the first year the production only starts at a reduced capacity in February, with sales not full sale of stock not commencing until July. As operations are continuous from then it is anticipated that the company's net assets will rise over subsequent years.

VIII. Prospects

Future Vision Statement:

One Year

- Patent pending for the design of the filter that has been optimised for the most effective removal of microplastics at specific washing machine flow rates. This way other companies may indeed copy the filter design but could not copy the optimised design. Therefore, if other filters appeared on the market with similar designs they would not be the most optimised for washing machine use.
- IP on specific ancestors of MHETase and PETase that have been developed using the ancestral construction software
- An optimised filter design, with further testing and funding from external funders and partners to provide more rigorous protocols for testing to ensure its suitability and reliability for within a washing machine.
- Further involvement with washing machine manufacturers as to their current filter and electronic valve technology, to make sure the technology is accessible at the manufacturing stage for all companies involved.

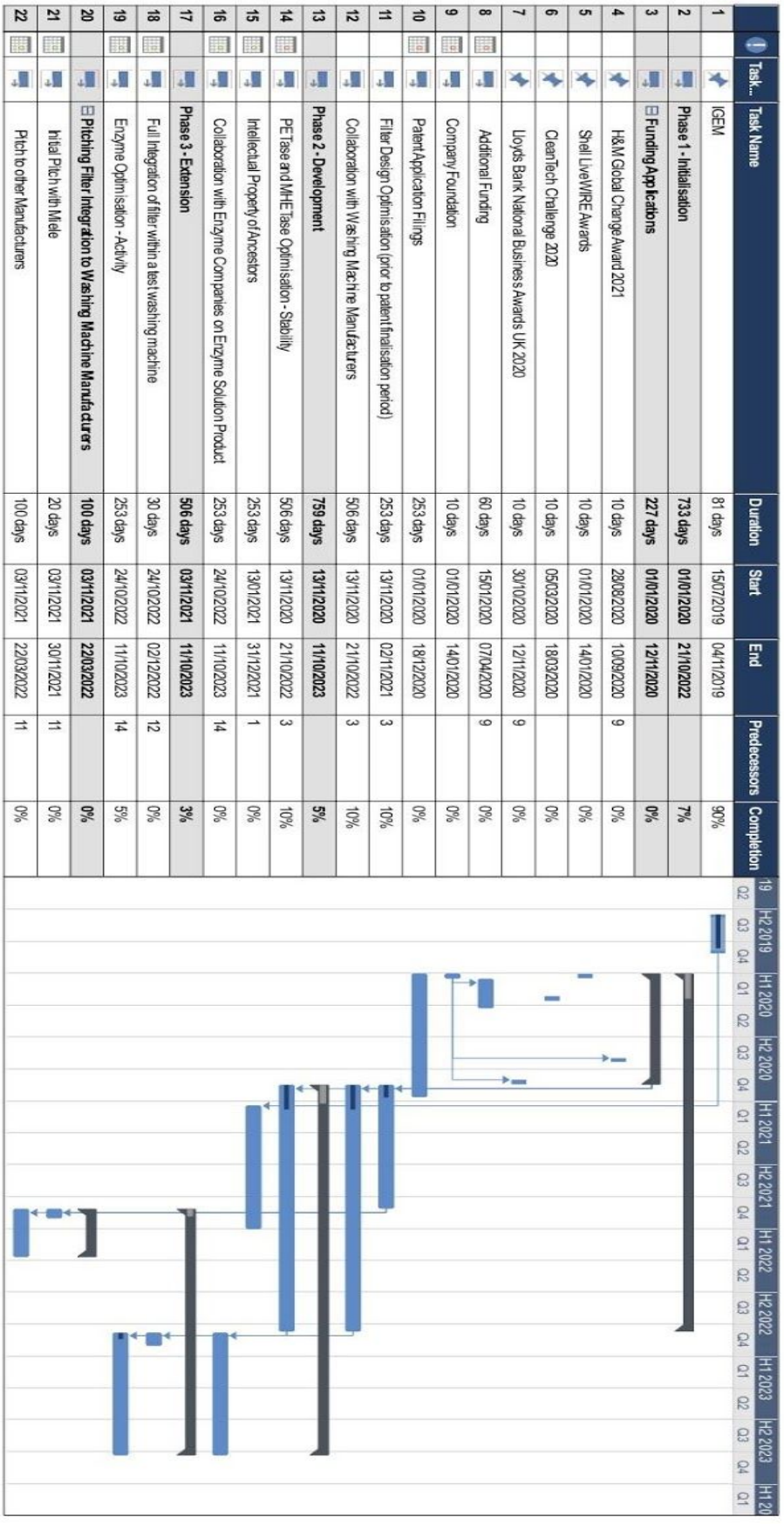
Three Years

- Optimisation of the PETase and MHETase enzymes, improving their stability for use within the filter, using further exploration of the most stable ancestors
- Collaboration and funding from enzyme companies, who would provide the enzyme powders. These powders would then be converted into a solution, which would be tested on PET plastics to ensure that a solution with enzymes sent by a larger enzyme company are as effective as the ones developed and tested within the lab environment

Five Years

- Integration of the filter system into the inside of a test washing machine, running tests to determine its reliability within the machine. For example, determining how long the filter would before it needed changing, how often enzyme solution needs replacing and the best ways for the user to do this if the filter is integrated in the washing machine.
- The optimisation of the enzymes to reduce the number of times the consumer would need to input the enzyme solution into the washing machine.
- Begin to pitch and sell the integrated filter to widespread washing machine companies, producing larger quantities of the filter.

Future Timeline:



	Task...	Task Name	Duration	Start	End	Predecessors	Completion
1		IGEM	81 days	15/07/2019	04/11/2019		90%
2		**Phase 1 - Initialisation**	**733 days**	**01/01/2020**	**21/10/2022**		**7%**
3		**Funding Applications**	**227 days**	**01/01/2020**	**12/11/2020**		**0%**
4		H&M Global Change Award 2021	10 days	28/08/2020	10/09/2020	9	0%
5		Shell LiveWIRE Awards	10 days	01/01/2020	14/01/2020		0%
6		CleanTech Challenge 2020	10 days	05/03/2020	18/03/2020		0%
7		Lloyds Bank National Business Awards UK 2020	10 days	30/10/2020	12/11/2020	9	0%
8		Additional Funding	60 days	15/01/2020	07/04/2020	9	0%
9		Company Foundation	10 days	01/01/2020	14/01/2020		0%
10		Patent Application Filings	253 days	01/01/2020	18/12/2020		0%
11		Filter Design Optimisation (prior to patent finalisation period)	253 days	13/11/2020	02/11/2021	3	10%
12		Collaboration with Washing Machine Manufacturers	506 days	13/11/2020	21/10/2022	3	10%
13		**Phase 2 - Development**	**759 days**	**13/11/2020**	**11/10/2023**		**5%**
14		PETase and MHETase Optimisation - Stability	506 days	13/11/2020	21/10/2022	3	10%
15		Intellectual Property of Ancestors	253 days	13/01/2021	31/12/2021	1	0%
16		Collaboration with Enzyme Companies on Enzyme Solution Product	253 days	24/10/2022	11/10/2023	14	0%
17		**Phase 3 - Extension**	**506 days**	**03/11/2021**	**11/10/2023**		**3%**
18		Full Integration of filter within a test washing machine	30 days	24/10/2022	02/12/2022	12	0%
19		Enzyme Optimisation - Activity	253 days	24/10/2022	11/10/2023	14	5%
20		**Pitching Filter Integration to Washing Machine Manufacturers**	**100 days**	**03/11/2021**	**22/03/2022**		**0%**
21		Initial Pitch with Miele	20 days	03/11/2021	30/11/2021	11	0%
22		Pitch to other Manufacturers	100 days	03/11/2021	22/03/2022	11	0%

IX. References

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X. Appendix

Appendix 1: Cost Sheet

Machinery	Upfront Cost (£)	Power Usage (kW)	Staff Required		Utilities	Cost (£/month)		Cost (£/year)	
Welding Equipment	199	7.5	1	https://www.am	Wi-Fi	20		240	
Band Saw	800	2	1	https://www.alibaba.com/prod	Consumption per Employee (l/day)		Rate (£/l)	Cost (£/year)	
Milling Machine	2000	2.2	1	https://www.al	Water	50	0.0033605	425.10325	
Lathe	4000	11	1	https://www.alibaba.com/prod	Rate (£/kWh)		Requirement (kW)	Cost (£/year)	
Soldering Equipment	83.45	0	1	https://uk.rs-onlin	Power				
					Machines	0.16	22.7	7351.168	:)
					Misc	0.16	15	4857.6	
						Cost (£/year*ft^2)	Footprint (ft^2)	Cost (£/year)	12873.87125
					Rent	10	1000	10000	
					TOTAL			22873.87125	
TOTAL	**7082.45**	22.7	5						
						Misc	Cost Each (£)	Number Required	Total Cost (£)
Staff	**Wage (£/h)**	**Hours (h/year)**	**Number of People**	**Cost (£/year)**		Office desks	30	5	150
Machinists	8	2024	5	80960		Chairs	10	5	50
Admin	8	2024	5	80960		Computers	450	6	2700
TOTAL			10	**161920**		**TOTAL**			**2900**
Material	**Cost (£/unit)**	**Product/unit**	**Cost (£/product)**			**Hours of Operation (h/year)**			
Copper Pipes	5.90	2.00	2.95	https://uk.rs-online.com/web/p/sold		Working Days (day/year)	253		
YF-S201 1-30L/min Water Flow	3.29	0.50	6.58			Hours per Day (h/day)	8		
Freenove Starter Kit V2.0 with A-UNO	26.44	1.00	26.44			**TOTAL**	**2024**		
Solenoid Valve, 12V DC G3/4inch N/O	18.99	1.00	18.99						
Washers	0.02	0.05	0.34	https://uk.rs-online.com/web		**Start-up Costs (£)**			
Screws	0.05	0.05	1.02	https://uk.rs-online.com/web		Machines	7082.45		
PCB	0.40	1.00	0.40			Misc	2900		
1/2"DC12V Electric Solenoid Valve N/C	19.99	0.5	39.98			**TOTAL**	9982.45		
Relay Module 4 Channel DC 5V	5.49	1.00	5.49						
Aluminium Pipe https://www.aluminiumwar	50.76	28	1.81						
						Ongoing Costs (£/year)			
TOTAL			104.00			Wages	161920		
						Utilities	22873.87		
Filters produced per year	5,000					Materials	520014.29		
Cost per filter	104.00					**TOTAL**	704808.16		
TOTAL (£/year)	520014.29								
	*US dollar conversion rate		ton to kg0						
	0.76		907					-	

Appendix 2: Cash Flow

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Incomings														
Sales income		0.00	0.00	0.00	0.00	18750.00	18750.00	37500.00	75000.00	75000.00	75000.00	75000.00	75000.00	**£450,000.00**
Deposit interest		1500.00	2387.91	2116.53	1842.44	1500.60	1299.52	1053.09	948.36	1174.26	1359.08	1502.41	1647.18	**£18,331.37**
Bank Loan		100000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£100,000.00**
Equity (investors)	100000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£0.00**
Personal Investment	50000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£0.00**
Sub - total		101500.00	2387.91	2116.53	1842.44	20250.60	20049.52	38553.09	75948.36	76174.26	76359.08	76502.41	76647.18	**£568,331.37**
Outgoings														
Wages		0.00	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	13493.33	**£148,426.67**
Pensions (3%)		0.00	404.80	404.80	404.80	404.80	404.80	404.80	404.80	404.80	404.80	404.80	404.80	**£4,452.80**
Machines Cost		590.20	590.20	590.20	590.20	590.20	590.20	590.20	590.20	590.20	590.20	590.20	590.20	**£7,082.45**
Materials Cost		0.00	10833.33	10833.33	17333.33	21666.67	26000.00	30333.33	34666.67	39000.00	43333.33	43333.33	43333.33	**£320,666.67**
Bank Loan payment		2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	2297.90	**£41,362.20**
Rent		833.33	833.33	833.33	833.33	833.33	833.33	833.33	833.33	833.33	833.33	833.33	833.33	**£10,000.00**
Utilities		1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	1,072.82	**£12,873.87**
Misc Costs		2900.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£2,900.00**
Patent		5000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£5,000.00**
Registry of company		15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**£15.00**
Sub - total		12709.26	29525.73	29525.73	36025.73	40359.06	44692.39	49025.73	53359.06	57692.39	62025.73	62025.73	62025.73	**£538,992.25**
Total Movement		88790.74	-27137.82	-27409.20	-34183.29	-20108.46	-24642.87	-10472.64	22589.30	18481.86	14333.35	14476.68	14621.45	**£29,339.12**
Total in bank	150000.00	238790.74	211652.92	184243.72	150060.43	129951.98	105309.10	94836.47	117425.77	135907.64	150240.99	164717.67	179339.12	**£179,339.12**

Appendix 3: Balance Sheet

	Total Current Liabilities	Total Calculated Current assets - Current liabilities	
Fixed Assets			
Machinery (15% depreciation after 1 year)			£6,020.08
Furniture (15% depreciation after 1 year)			£2,465.00
			£8,485.08
Current Assets (the end of december)			
Cash in hand		£179,339.12	
Stock-in-trade (1 month raw materials)		£54,162.50	
Stock-in-trade (167 filters, fully manufactured)		£30,060.00	
Trade debtors (filter trade credit from December sales)		£75,000.00	
		£338,561.62	
Current Liabilities (at the beginning of second year)			
Rent (monthly, January)	£833.33		
Wages (work from December)	£13,493.33		
Utilities (January)	£1,072.82		
Trade Creditors (material for January)	£43,333.33		
Bank loan payment (January)	£2,297.90		
Pension Obligations (for December)	£470.58		
Dividend Payouts	£0.00		
		£61,501.30	
			£277,060.32
Total Assets less Current liabilities			£285,545.40
Less:			
Long-term Liabilities			
Long-term Loan			£76,900.61
Long-term Product Warranty			£5,200.00
Net Assets			**£203,444.79**
Capital			
Opening Balance			£250,000.00
Add:			
Profit			-£8,718.94
			£241,281.06
Less:			
Drawings for the year			£37,836.27
			£203,444.79

Appendix 4: Profit & Loss Statement

	Column 1 (£)	Column 2 (£)
Sales		*450000.00*
Opening Stock	0.00	
Purchases	*320666.67*	
Subtotal	320666.67	
Less: Closing Stock	*84222.50*	
Cost of Goods Sold		236444.17
Gross Profit (or Gross Loss)		213555.83
Fixed Costs/Exceptional Expenses		
Wages	148426.67	
Pensions	4452.80	
Utilities	12873.87	
Registry Costs	15.00	
Rent	10000.00	
Machinery depreciation	1062.37	
Bank Charges	2297.90	
Office Expenses Depreciation	435.00	
		179563.60
Net Profit (or Net Loss)		33992.23
Less: Tax, Dividends, Extraordinary Items		
VAT	42711.17	
		42711.17
Retained Profit (or Retained Loss)		-8718.94