UNIVERSITY OF GLASGOW

ENG2016: Bike Project

GROUP 23

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Abstract

The purpose of this project is to design an electric bicycle for 55+-year-old men. The goal is to provide insight on the thought process and decision making behind the final design, and how it will be implemented into the current market. This has been done by examining the growing market of electric bikes, and applying sufficient research, in order to construct a realistic bicycle. After analysing multiple different concepts, it was concluded that a men's Dutch style bike was the ideal design as it allowed a stylish, and comfortable means of commute, in comparison to alternatives.

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1 Introduction

With a growing interest in battery powered transportation devices, the electric bicycle has experienced a worldwide, rapid growth in popularity since 1998 (Weinert, Burke, & Wei, 2007). However, many companies try to sell their product as an athletic alternative, this caters towards young to middle-aged adults (20-40 years old), and neglects the older population.

The aim is to design an e-bike that accommodates an older audience by reducing effort, emphasising ergonomics, and improving the quality of their commute. The final product is targeted towards a male market, above the age of 55, and will provide these characteristics in an exceptional manner.

This report will convey the emulation of a typical design process, the means used to conduct decisions for the final design, and its implementation into the current market.

2 Project Planning

In order to remain organised, a Gantt chart was formulated. The Gantt chart allowed a visualisation of work allocations, for the various topics that were required to complete the project.

2.1 Initial Work Allocations

Table 1: Initial Gantt chart

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11
Research			ALL								
PDS			ALL	ALL							
Concept Generation				ALL	ALL						
CAD					EW-ED-IV	EW-ED-IV	EW-ED-IV				
Market Analysis					QIYU	QIYU					
House of Quality						WILLIAM	WILLIAM				
Report								ALL	ALL	ALL	ALL
Presentation								ALL	ALL	ALL	ALL
Group Meetings		ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL

In terms of initial work distribution, each topic was allocated between the group members based on: background (course), experience from previous projects, and abilities. Therefore, Ewan, Eduard, and Ivan were assigned the CAD work, as William and Qiyu had little to no experience with SolidWorks. As a result, William and Qiyu were left to work on the Market Analysis and House of Quality.

The distribution of the CAD work was amongst 3 people, as it was speculated to take longer. Furthermore, in the initial stages group work (labelled 'ALL') was emphasised to integrate individual concepts, and weekly meetings were scheduled in order to remain on the same page.

2.2 Final Work Allocations

As progress was made with the project, initial roles couldn't be maintained due to different individual schedules. Additionally, by further expanding on the generalised topics in the previous chart, the work had to be allocated differently. This resulted in the following work distribution in order to complete the project on time.

Table 2: Final Gantt chart

<table>
<tr><th>Task</th><th>W1</th><th>W2</th><th>W3</th><th>W4</th><th>W5</th><th>W6</th><th>W7</th><th>W8</th><th>W9</th><th>W10</th><th>W11</th></tr>
<tr><td>PDS</td><td></td><td></td><td colspan="3">ALL</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Concept Designs</td><td></td><td></td><td colspan="2">ALL</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Biomechanics</td><td></td><td></td><td></td><td></td><td colspan="5">QIYU</td><td></td><td></td></tr>
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</table>

In the Final Gantt chart, the person to whom the Task is credited towards, is the one who contributed the most in that discipline. For example, in the process of producing the CAD, Ivan and Eduard made individual parts which included: wheels, electrical drivetrain, battery, pedals, and mechanical disc brakes. However, Ewan completed the remaining components, created drafts, and assembled the components into a bicycle. Therefore, Ewan is credited in the chart, as he devoted the most time to the CAD.

Conversely, tasks completed by 'ALL,' were completed by the entire group. This was achieved by either congregating in the form of a weekly group meeting, and contributing to a task together, or creating an online document in which the group was able to gather and present their ideas.

In terms of milestones, initial research was concluded in week 4. Development into particular categories of the report were concluded in week 9. From the interim to final presentation, a clear structure was formulated for the presentation together, as well as practice rehearsals were held every week. Finally, from week 10 onwards, progress was fully committed towards the report in order to finish the project on time.

3 User Requirements

3.1 Identifying the Target Market

- Designed for a 55+ year old man who is commuting to work in the city
- Design should be comfortable and accommodate non-conventional riding gear such as a full suit
- Expected to be transporting at least one piece of luggage, e.g. briefcase
- Wants to arrive to work without being sweaty
- Relatively fit, travelling a maximum of 50km per day (to and from work)
- Tenured employee with sufficient funds

3.2 Product Design Specification

Table 3: PDS and Importance scale

Category	Specification	Importance (1-5)
Technical Requirements	Despite being electrically assisted, operation for the user should resemble that of a normal push bike	3
	According to EU regulations, the motor will assist up to maximum speeds of 25 km/h	5
	The bike's structural integrity should withstand worst case loading scenarios without permanent deformations	5
	Mechanical components should withstand at least 20,000 operational hours	4
	The frame should withstand the weight of a 55-year-old man up to the 95^{th} percentile $\approx$ 113kg	4
	Wheels, rims, gearing, and turning angles should be optimised for a city environment	3
	According to EU regulations, maximum motor power of 250W.	5
	Components should not be compromised structurally and accommodate for thermal expansion between -30 to 60°C	2
	Design should accommodate a solution for comfortably transporting at least one suitcase.	4
	Full-cycle recharging of the battery should be within 4 hours	3
	Battery should offer a minimum range of 70km	4
Ergonomics	Design should offer a comfortable riding position	4
	Emphasis on comfort should be placed on points of contact such as the handlebars and the seat.	3

	Bike geometry should not stress common points of injury such as lower/upper back, neck, and knees.	3
	A non-trained person could assemble/disassemble the bike within 60 minutes.	2
	Feet should not slide off the pedals during normal operation.	3
	Battery should be rechargeable from a conventional outlet, such as the ones found at home or work.	5
	Bike should offer different driving modes such as disengaging the motor and economy mode.	3
Maintenance	Battery should not require changing or maintenance for at least 1,000 charging cycles.	3
	Mechanical components which are non-specific for the bike design should be readily available	4
	Motor should be reliable, and in case of failure it should be serviced by an expert mechanic	4
	Sensors and tools available on-board of bicycle, should offer the user information about possible system failures	3
	Battery should be easily accessible whilst being shielded from the environment	3
	To avoid mechanical component degradation, mild corrosion resistance should be provided for water, salt, dust, wind, ice, rocks, oil, and gasoline.	3
	Suspension should not only provide comfort for the user, but also protect the electrical hardware.	4
Safety	A full stop from 25 km/h should be achieved within a braking distance of 8 m.	4
	Chain should be protected from the driver's attire and environment	3
	Street accessories as per law, such as alights, reflectors, and brakes.	5
	Battery should be compatible with different outlets and standards to avoid failure during charging.	5
	Control system should include a feedback loop to avoid exposing components to voltages and currents outside operational ranges.	5
	The explosion from a punctured tyre should be minimised.	4

Cost	Final product price should be a bit higher than the market average, within the range of £1,500 - £2,200	4
	Self-maintenance cost should be similar to that of a conventional push bike.	3
	Battery replacement should be within the range of £200 - £300.	3
	Average market price (disregarding economies of scale) should be taken for individual components and materials for the cost report	3
	The bike should be a long-term investment with an ensured ROI when compared to conventional transport methods offered within the city (incentive for potential customers)	5

The PDS has every point rated from 1 to 5 in terms of its importance to the final design, with 5 being most important. The majority of the most important points are to do with the standards that must be complied with when designing and selling a bike in Britain.

The standards that need to be complied with are one which outlines the motor and battery performance of an e-bike (DIN EN 15194, 2017), and another which adheres to general bicycle safety (DIN EN 14764, 2006). The next most important points were generally to do with ease of use for the user, and the rider safety. After that came points that should be adhered to naturally as part of designing a bike and should not require to much thought or work. The least important aspects were points that are desirable but not required.

4 Biomechanics

The most attractive part in regards to an e-bike is that it is able to provide assistance in proportion to how much the rider pedals. This allows the rider to conserve energy and reduce their effort while commuting.

For both e-bikes and ordinary bikes, there are two same basic riding mechanics. Firstly, the hip flexion which is the extension of hip and knee in positions between 70° and 140° between the quadriceps and calf muscles. Secondly, the knee flexion which is the extension of muscles in the leg at the bottom and top of the pedal stroke. However, the big difference for an e-bike in comparison to an ordinary one, is that the quadriceps and gluteus muscles will require less force to bring one pedal to the top position. Additionally, less downward force will be required by the hamstring and calf muscles to the opposite pedal.

The main cause for the big difference comes from the propulsion provided by the pedal motor, applied in the rear part of the e-bike which is also the main motivation of the bike. There is the comparison of different amount of force provided by human muscles to the pedal during riding e-bikes and ordinary bikes which are able to demonstrate the big difference for e-bikes, and is shown by figure X.

Figure 1: Force applied comparison

In terms of the upper part of the human body, the same muscles are engaged regardless of type of bike. This comprises of the abdominal muscle, which is responsible for the cycler's spine, and ensuring the balance for the pelvis and spine. Moreover the muscles in the back and front of arms allow people to hold the handle bar. However, the difference for the e-bike designed by us is the up ride riding position frame with a cruiser handle bar which enable cycler's spine to be straight rather than at an angle. In this up-right riding position, the abdominal muscle and the arm muscles will put less force in order to hold the posture which may avoid some possible physical problems in the back, spine, and neck of the rider (Schwellnus & Derman, 2005).

5 Current Market Analysis

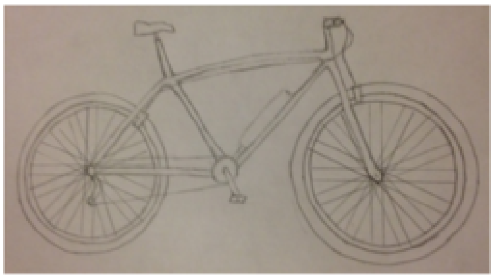
6 Conceptual Design

6.1 Concepts Sketches

The following are concept sketches (Figure 2) which correspond to ideas 1-5, in order, in the subsequent morphological analysis. The second sketch has been rendered by hand to show the colour scheme that has been approved by the group. The chosen black/grey colour scheme is utilised as it gives a classy and mature look, and would best appeal to the specified target market of more classy and mature men. The sketches, morphological analysis, in conjunction with the most popular choices from it, conceptualised the final design choice (Figure 3).

The sketches allowed for a better understanding of how the design might be implemented and how to make it visually appealing, as that is a major part of any design in terms of getting it to sell well. Whilst the morphological analysis allowed the decision on certain specifics of the design based on their function and what would make the design optimal for its function, as a design which looks good but does not work will not sell either.

1



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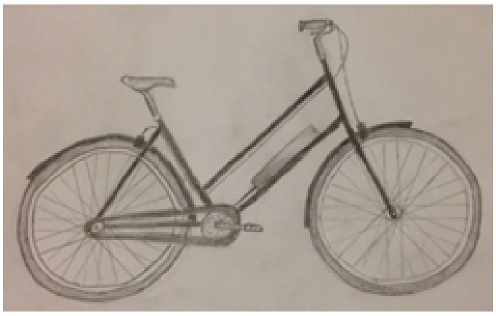

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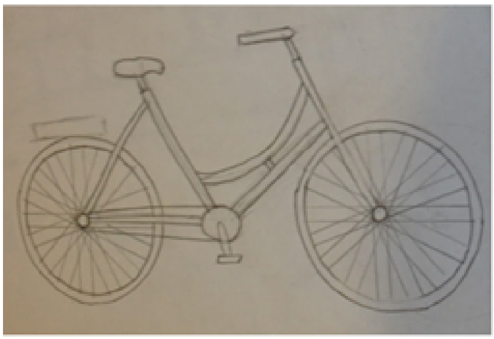
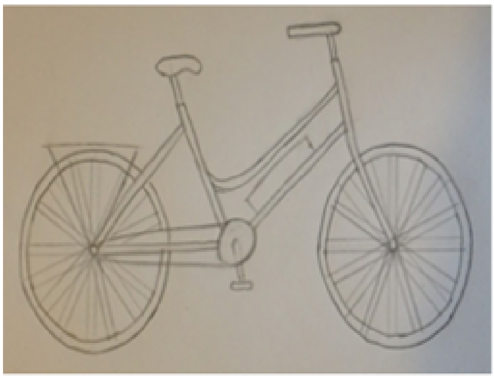


4



5

Figure 2: First concepts

Figure 3: Final concept

6.2 Morphological Analysis

Table 4: Morphological analysis and 6 designs

Component	Method			
Battery placement	Over the back wheel[3]	On the down tube[1,2,4,6]	On the seat tube[5]	
Brakes	Mechanical disc[2,6]	Rim[1,3]	Drum	Hydraulic disc[4,5]
Shifter	Indexed[1,3]	Down tube	Trigger[2,4,6]	Integrated[5]
Suspension	None[1]	Seat[3]	Back[5]	Full[2,4,6]
Suspension method	Spring[2,3,4,6]	Air[5]	Elastomer	
Pedals	Platform[1,2,3,4,5,6]	Toe clip	Clipless	
Chain set	Chain[1,2,3,4,5,6]	Belt		
Tyres	Tubed[1,2,3,4,6]	Tubeless	Solid[5]	
Handlebars	Flat[1,4]	Cruiser	Dropout	Comfort[2,3,5,6]
Dropouts	Vertical[2,3,6]	Horizontal[1,4]	Track[5]	
Motor	DC[1,2,5,6]	AC[3]	BLDC[4]	
Motor placement	Frame mounted[1,3,5]	Hub motor[2,4,6]	Belt-Drive	
Battery	Lithium[1,2,4,5,6]	Ni-Cad[3]	SLA	
Frame	Recumbent[5]	Road[1,6]	Upright[2,4]	Step-through[3]
Material	Aluminium[1,2,4,6]	Steel[3]	Carbon fibre[5]	
Gears	7[2,3,5,6]	10[1,4]		
Wheel size	24”[5]	26”[2,3,4,6]	27.5”	29”[1]
Wheel	Knobbly[1]	Smooth	In-between[2,3,4,5,6]	

7 Quality Function Deployment

In order to meet customer demands, research and initial product specifications are combined to form the House of Quality. The aim is to produce a customer driven product which will fulfil key demands, by translating user requirements into engineering requirements. Then, by comparing the individual aspects, the importance can be visualised and securely compromised if deemed unimportant to the design (Franceschini, 2001).

7.1 Engineering Specifications

From the product design specifications, specifications from Table 3 were grouped together to form an umbrella statement, which a potential user might inquire about the bike. For example, “Mechanical components should withstand at least 20,000 operational hours,” and “Motor should be reliable, and in case of failure it should be serviced by an expert mechanic,” are translated into “Bike parts will last for a long time.”

Some statements from Table 3, were ruled out as they seemed inappropriate towards the objective of the House of Quality. For example, “The explosion from a punctured tyre should be minimised.” The entire category specifying “Cost,” was not included as it is essentially how the outcome of the House of Quality is quantified.

Table 5: Translation of user requirements

Category	User Requirements	Engineering Specifications
Performance	Bike parts will last for a long time	Fatigue Limit Cycles
	Adequate gearing for a city environment	Number of Gears
	Mobility at moderate speeds	Turning radius at 20km/h
	Temperature resistant	Melting point of Material
	Corrosion resistant	Based on material selection
	Luggage space	Amount of suitcases supported
	High acceleration from rest	Effort required for acceleration
	Low-effort for commute	Effort required for distance
	Supports the weight of the rider	Material yield strength
	Good braking	Braking distance from max speed
	Low centre of gravity	Height of C.o.G. above ground
Battery	High battery capacity/battery lifespan	Battery capacity
	Battery assists up to specified speed	Input choked at certain speed
	Battery recharges quickly	Recharge cycle time (full)
	Battery supports significant power	Work input
Suspension	No deformations due to vibrations	Material yield strength
	Remains steady at high speeds	Structural vibrations
	Smooth ride	Spring stiffness
Ergonomics	Comfortable riding position	Amount of satisfied people
	Height adjustable seat and handlebars	Range of adjustment
	Easy to assemble	Assembly time
	Easy to maintain	Amount of tools required
	Easy to carry	Overall weight of bicycle

When translating user requirements to engineering specifications, various methods of testing and measuring were considered in the process. In terms of performance, properties of the general structure of the bike, and its functionality are considered. Furthermore for the battery and the suspension, these characteristics were considered outside of the performance, as they are aspects that must be well defined for the end design of the bike. Lastly, requirements categorised as ergonomics, are quantified in terms of ease of use and comfort.

7.2 Analysis

To form the House of Quality, the following investigations were made to find relationships between the requirements:

- What vs. How? (User requirements vs. Engineering specifications)
- How vs. How? (Engineering specifications vs. Engineering specifications)
- Who vs. What? (Potential buyers vs. User requirements)
- Now vs. What? (Similar products on the market vs. User requirements)
- How much? (What are the feasible targets in terms of engineering specifications)

In the first phase of analysis, User requirements and Engineering specifications are inspected for relationships (middle area of Table 6). First, each engineering specification was identified with its corresponding unit of measurement and the direction in which it should be improved. Furthermore, from the colours it is apparent that the diagonal line of strong relationship is due to each user requirement having its own engineering specification. From this the main points of focus became:

- High battery quality which has properties that compliment each other and will demonstrate performance
- The weight of the bicycle will have a large impact on all other requirements which means that it must be reduced as much as possible
- Suspension, overall comfort, and battery power will be able to reduce the effort of the rider which pairs with the main objective

Next, engineering specifications are evaluated for potential relationships (roof). This analysis further reveals the importance of reducing the weight, and further confirms how effort of the rider will be minimised. The latter requirement primarily requests for sufficient battery quality, which needs to be implemented into the final design. Lastly in terms of suspension, the safety of the rider will essentially be improved, by protecting the bike during operation and potentially reducing braking distances.

Potential buyers are then considered and scored based on how important they find the functional (user) requirements (left columns of table 6). In this case, 3 potential buyers are considered, and how they would potentially rank the importance of the selected requirements. The numbers sum up to 100, which means that an average importance lies at around 4. The following describes how the scores were evaluated:

- The target commuter will value high performance, battery quality, and comfort
- The recreational user will value battery quality, and ergonomics
- The retailer/sales person will require a balance bike, with good adjustability to market to his customers

In order to visualise where the final product would rank within the current market, competitors are scored based on how well they fulfil the same user requirements (right column of Table 6). Here, a low-end bicycle (Greenedge CS2), and a high-end bicycle (Trek Lift+ Men) are qualitatively judged, where 5 is excellent, and a 1 is poor. Since the bikes considered tend to a similar market, the rankings are based on customer reviews and individual specifications. Since the selected design is supposed to fill the price range between the two (see PDS), its ranking is also kept between them. Slight improvements in terms of luggage, centre of gravity, and ride quality over the high-end bicycle are desired in order to better fulfil the main objective.

Taking the existing information of the competitors into account, the targets for the design can be specified in the bottom rows of table 6.

Table 6: House of Quality

E-Bike for 55+ year old men

How	Direction of Improvement	Units
Fatigue Limit Cycles	↑	#
Number of Gears	↑	#
Turning radius at 20km/h	↓	m
Melting point of Material	↑	K
Based on material selection		Type
Amount of suitcases supported	↑	#
Effort required for acceleration	↓	%
Effort required for distance	↓	%
Material yield strength	↑	Pa
Braking distance from max speed	↓	m
Height of C.o.G. above ground	↓	m
Battery capacity	↑	Ah
Input choked at certain speed	↑	km/h
Recharge cycle time (full)	↓	h
Work input	↑	W
Material yield strength	↑	Pa
Structural vibrations	↓	Hz
Spring stiffness	↓	%
Amount of satisfied people	↑	#
Range of adjustment	↑	m
Assembly time	↓	s
Amount of tools required	↓	#
Overall weight of bicycle	↓	kg

Now: Greenedge CS2 -- x; Trek Lift+ Men -- o; Dutch Step-through (our design) -- v

Who: Sales person	Who: Recreational rider	Who: Target commuter	What		Now: 1	2	3	4	5
5	3	6	Performance	Bike parts will last for a long time	x			v	o
5	4	5	Performance	Adequate gearing for a city environment			x	ov	
4	5	5	Performance	Mobility at moderate speeds			x	o	v
4	3	4	Performance	Temperature resistant				xov	
4	3	4	Performance	Corrosion resistant					xov
4	3	4	Performance	Luggage space	xo		v		
5	4	4	Performance	High acceleration from rest		x	v	o	
3	3	5	Performance	Low-effort for commute			xv	o	
4	4	4	Performance	Supports the weight of the rider				x	ov
4	4	5	Performance	Good braking			x	ov	
5	5	5	Performance	Low centre of gravity		x			ov
5	5	6	Battery	High battery capacity/battery lifespan		x		v	o
4	4	4	Battery	Battery assists up to specified speed			xv	o	
5	5	5	Battery	Battery recharges quickly			xv	o	
4	5	6	Battery	Battery supports significant power	x		ov		
4	4	5	Suspension	No deformations due to vibartions		x		v	o
4	4	4	Suspension	Remains steady at high speeds		x	v	o	
4	5	4	Suspension	Smooth ride		o	x	v	
5	6	6	Ergonomics	Comfortable riding position		xo			v
6	6	2	Ergonomics	Height adjustable seat and handlebars			x	ov	
4	6	2	Ergonomics	Easy to assemble			ov		x
4	5	3	Ergonomics	Easy to maintain	x	ov			
4	5	2	Ergonomics	Easy to carry	x	v		o	

8 Detailed Design

8.1 Components

8.2 Material Selection

8.3 Calculations

In order to accomplish a functioning bicycle, apart from measurements based on the adult male body, chain length, and force simulations were considered.

8.4 Standards Considered

As mentioned in Section 3.2, there are certain standards that must be considered in order to sell this design as legal bicycle in Europe.

9 Costing and Implementation

The intended product price from the Product Design Specification is between £1,700 and £2,200. This price range was selected to be competitive in the e-bike market, by being placed slightly over the average price. Additionally, it is expected that the designed e-bike would not have much competition due to this being an undeveloped market; classic e-bikes as opposed to sport e-bikes.

The calculations are based on an assumption, where a new product is being developed for a large company. Therefore, the overheads will not be considered as the bike will be one of their many products. Furthermore, all the hardware and software have already been purchased.

$$\text{Selling Price} = \text{Profit} + \left(\text{Works Cost Price} + \left(\frac{\text{Cost of Design}}{\text{Quantity}}\right)\right)$$

9.1 Cost of Design

The cost of design describes the price which is invested into each bicycle. This includes the design labour (i.e. the hours spent by engineers directly working on the product), and the cost of the design material. Values for these are provided in the tables below.

Here, retail prices have been taken for components. Therefore, the worst-case scenario is being portrayed. In the case where wholesale prices were to be obtained from the providers, the total cost is expected to drop anywhere from 10% to 20%.

Table 7: Specific and total design labour cost

Tasks	Hours (h)	Cost per Hour (£/h)	Total Cost (£)
Developing PDS	3	20.00	60.00
Initial Research	20	20.00	400.00
Market Analysis	6	20.00	120.00
Component Selection	8	20.00	160.00
Material Selection	6	20.00	120.00
Morphological Analysis	3	20.00	60.00
Biomechanical Analysis	5	20.00	100.00
CAD	20	20.00	400.00
Further Development	100	20.00	2000.00
FEA Simulation	20	20.00	400.00
Component Testing	200	20.00	4000.00
Drive Testing	20	10.00	200.00
Total	411		8020.00

Table 8: Specific and total design material costs

Component	Specification	Quantity	Total Cost (£)
Motor	Bosch ActiveLine 250W BLDC	1	250.00
Battery	Bosch Powerpack 300Wh (40 km range)	1	400.94
Charger	Bosch Charger 4A	1	100.00
Front Suspension	SR Suntour XCR-RL Fork Suspension	1	114.95
Back Suspension	M2R Rear Schock Absorber 270mm	1	40.00
Frame	7005-T6 Aluminium (Age Hardening) - 1500g	1	2.93
Wheel	Cast Aluminium - 800g	2	3.12
Tyre	Schwalbe Marathon GreenGuard City (26 in)	2	17.99
Wheel Hub	Cast Aluminium - 300g	2	1.17
Seat	Bioflex Websprung Gents Comfort	1	19.96
Handlebar	Aluminium and Leather Coated	1	25.00
Chain	Shimano HG93 (9 speed) Roller Chain	1	10.99
Headlight	Bobbin Retro Front Light	1	19.99
Brakes	Clarks CMD-11 Mechanical Brake Disc + Rotor	2	11.99
Brake Handles	Shimano BL M425 Acera Brake Lever	2	14.44
Cables	Shimano PTFE Coated Stainless Steel Wire	1	6.99
Pannier Rack	Tortec Velocity Rear Pannier Rack - Silver	1	21.59
Mudguard	SKS Bluemels Mudguard Set	1	25.38
Total			1087.43

9.2 Works Cost Price

The Works Cost Price includes the price for the salaries of workers which are involved in building the bicycle. Hence, it must include welding costs, casting costs, assembly costs, and testing costs per bike.

9.3 Final Cost

Assuming a worst-case scenario where only 100 e-bikes are sold in the first year, the retail price is calculated below assuming a healthy 50% profit margin.

Table 9: Specific and total works cost price per bike

Process	Hours (h)	Cost per hour (£/h)	Total Cost (£)
Mechanical Assembly	2	15.00	30.00
Electrical Wiring	1	15.00	15.00
Gas Metal Arc (MIG) Welding	1	30.00	30.00
Low Pressure Die Casting	1	5.00	5.00
Testing	2	20.00	40.00
Total	7		120.00

$$\text{Selling Price} = 1.5 \times \left(1087.43 + 120.00 + \frac{8020.00}{100}\right) = £1,931.45$$

This leads to a net profit of £643.82 per bike.

Although this is an elevated price, the following conclusions can be drawn. The cost of producing each bike is £1287.63. This figure has been obtained without considering wholesale prices or economies of scale. Therefore, the total production cost could be expected to decrease by up to 30%. Nonetheless, with the current information, the design fits within the price range specified in the PDS, whilst maintaining a profit margin of 50%. With a maximum profit margin of 80%.

The final selling price can be determined once further market analysis and focus groups are conducted, to understand the current tendencies in the market.

9.4 Break Even Analysis

The following is the break-even analysis conducted for the costs and prices which have been laid out in the above sections. It was also assumed that for the given production capacity, there would be three employees working full time at a standard wage of £23,333 per annum.

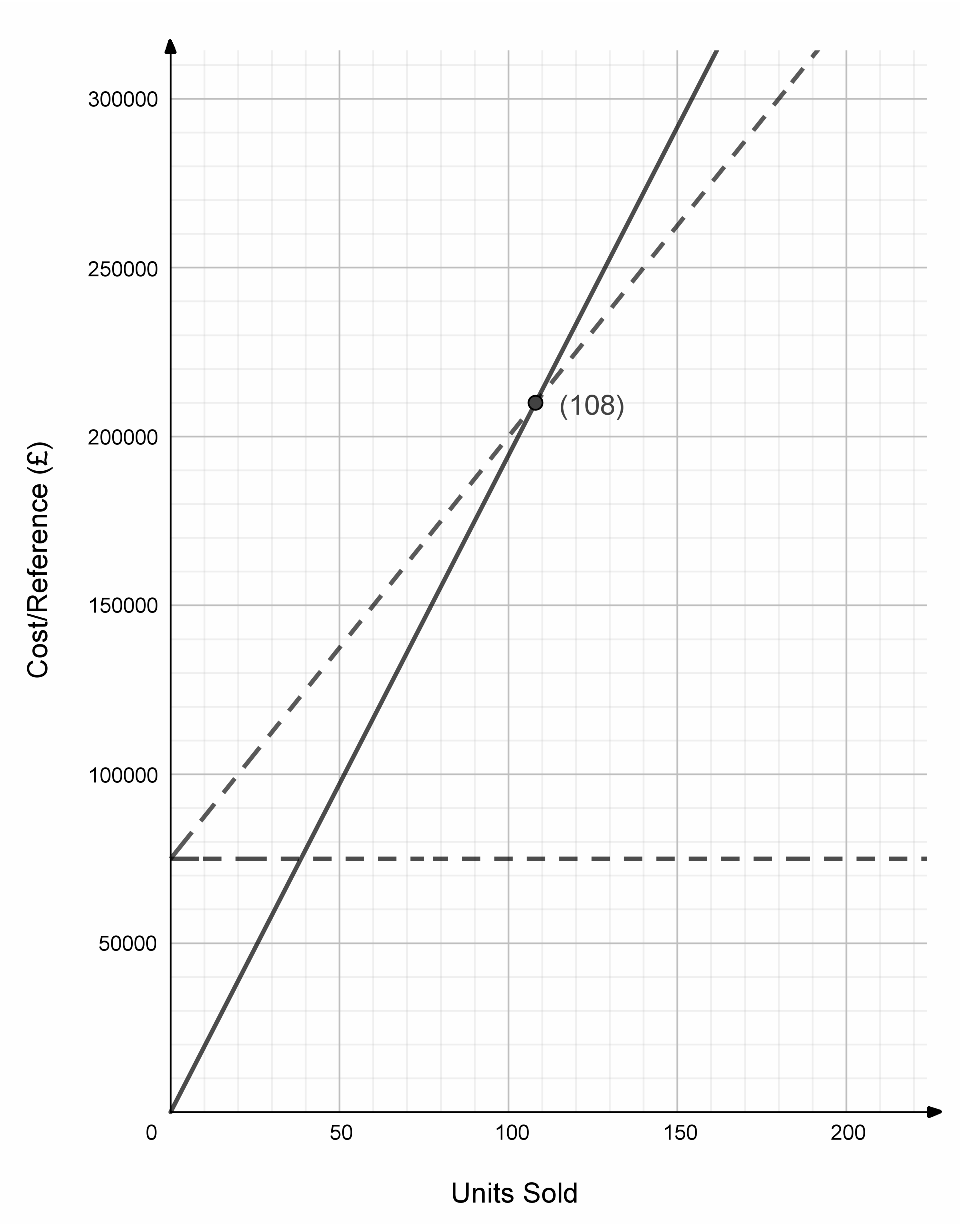


Figure 4: Break even at 108 units sold.

9.5 Profit and Loss Accounts

The profit and loss accounts have been created for the first three years of the forecasted sales. The expected sales considered as a possibility throughout the first year are 100, 1,000 and 10,000; and a profit and loss account has been calculated for each individually. It was assumed that the number of full time employees required to manufacture 100 bicycles per year were 3, each having a salary of £23,333 per annum (total of £70,000). 30 were required for 1,000 bicycles (total of £700,000), and 300 for 10,000 bicycles (total of £7,000,000). Furthermore, the first year presented two extra costs. This included: design labour costs of £8,200 and tooling costs of £100,000. They are paid off in the first year and from then on, are not considered again.

Taking a conservative approach, a contingency of £10,000 was included for every 100 bicycles produced. Finally, a 20% discount for raw materials was assumed for the 1,000-purchase situation, whilst a 30% discount was assumed for the 10,000 units calculation.

The profit and loss accounts are shown in Table 10 below. Due to the healthy, and comfortable, 50% profit margin imposed on the selling price, only three of the nine considered years would result in a negative profit, with two of them being a minimum loss of £7,743. Therefore, it can be concluded that the product has enough of a profit margin while maintaining a competitive selling price. Additionally, the initial cost projection stated in the PDS has been met in the final design.

Table 10: Expected Profit and Loss accounts for units sold over the first three years

Profit & Loss Account Y1	No.	£	No.	£	No.	£
Units Sold at £1,930.00	100	193,000.00	1,000	1,930,000.00	10,000	19,300,000.00
Costs of Sales at £1,207.43		120,743		965,944		8,452,010
Total Direct Costs		78,020.00		708,020.00		7,008,020.00
Gross Margin		-5,763.00		256,036.00		3,839,970.00
Contingency (with tools)		110,000.00		200,000.00		1,100,000.00
Net Profit/Loss before Tax		-115,763.00		56,036.00		2,739,970.00
Profit & Loss Account Y2	No.	£	No.	£	No.	£
Units Sold at £1,930.00	100	193,000.00	1,000	1,930,000.00	10,000	19,300,000.00
Costs of Sales at £1,207.43		120,743		965,944		8,452,010
Total Direct Costs		70,000.00		700,000.00		7,000,000.00
Gross Margin		2,257.00		264,056.00		3,847,990.00
Contingency		10,000.00		100,000.00		1,000,000.00
Net Profit/Loss before Tax		-7,743.00		164,056.00		2,847,990.00
Profit & Loss Account Y3	No.	£	No.	£	No.	£
Units Sold at £1,930.00	100	193,000.00	1,000	1,930,000.00	10,000	19,300,000.00
Costs of Sales at £1,207.43		120,743		965,944		8,452,010
Total Direct Costs		70,000.00		700,000.00		7,000,000.00
Gross Margin		2,257.00		264,056.00		3,847,990.00
Contingency		10,000.00		100,000.00		1,000,000.00
Net Profit/Loss before Tax		-7,743.00		164,056.00		2,847,990.00

9.6 Return on Investment

The return on investment (ROI) has been calculated for each year of each of the three expected sales scenarios. The results are shown in Table 11 below.

The scenario where 100 bikes are sold never quite becomes profitable. The ROI does improve significantly over the first three years, however, from then on it will tend to a value slightly smaller than one over the years. Therefore, this would require for a slightly higher profit margin. However, the 1,000 bikes sold scenario has a steady increase in ROI, which although not big, still accounts for a 7.11% improvement over the first three years. Therefore, the selling price is well selected for this situation. On the other hand, the 10,000 units sold scenario has a very big initial ROI with a very slight increase over the years. As a result, the profit margin should be decreased to attract more customers and establish the brand better within the market.

Table 11: Cumulative ROI over the first three years of Product launch

Year	100 Units Sold ROI	1,0000 Units sold ROI	10,000 Units sold ROI
1	0.6251	1.0299	1.1655
2	0.7576	1.0605	1.1693
3	0.8152	1.0711	1.1705

10 Project Evaluation

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