**Costing Analysis**

As specified previously, in the Market Analysis, the goal price for our product was £1,993.91. This price was extracted from the average price on the city bicycle market. The goal is to offer a high-quality product within this range, such that the designed electrical bicycle is economically competitive. It must be kept in mind that the market for classical looking e-bikes is underdeveloped, and therefore the product will also benefit from a smaller amount of competition.

The costing was carried out following one principle assumption: the bike is being designed by a large company which is looking to penetrate the e-bike market. Therefore, many overheads such as hardware, software, and rent will not be considered. Although this may not show the whole picture of the costing behind the bike design, it does a better job of focusing on the costing of the engineering design itself rather than incorporating other external factors. The approach and equations used are the ones provided in the PowerPoint slides of the Mechanical Design 2 course.

Overall, the selling price was calculated using the formula below:

Where, WCP stands for the work cost price. These factors will be introduced and calculated below.

*Calculating the Design Labour*

The cost of design represents the money invested into each bicycle in the forms of both the cost of research and development for designing the bicycle. Both the design labour costs have been calculated and are provided in Table 1 below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| tasks | hours | cost per hour (£) | 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 |
| muscle interaction | 5 | 20.00 | 100.00 |
| CAD work | 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 |
| driving testing | 20 | 10.00 | 200.00 |
| total | 411 |  | 8020.00 |

Table 1: Table highlighting the specific and total design labour cost

The hours necessary for the completion of tasks provided above, are based on approximations of the actual work invested by our team throughout the design process. Furthermore, a testing phase has been included in the design labour costs. Although testing, in general, is not expensive, it is very time intensive. Therefore, in certain situations this can lead to an accumulation of substantial costs. In this case, the testing was: 20 hours of CAE (computer aided design), 200 hours of mechanical component testing, and 20 hours of testing the final product in the environment of use.

*Calculating the Cost of Design Material*

The cost of design material was calculated and is provided in Table 2 below.

|  |  |  |  |
| --- | --- | --- | --- |
| component | specification | quantity | total price (£) |
| 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 shock absorber 270mm | 1 | 40.00 |
| frame | 7005-T6 Aluminium (Age Hardening) - 1500 g | 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 |

Table 2: Table highlighting the specific and total design material costs

The components included in this table are the ones mentioned previously in the component selection section. The prices for the raw materials used for the frame, wheel, and wheel hub have been obtained from CES software. Retail prices have been considered for the components not being manufactured. This means that the situation being considered is a worst-case scenario. The total cost could be expected to drop anywhere from 10% to 20% if wholesale prices were obtained from the providers.

*Works Cost Price*

Work cost price considers the costs of manufacturing and assembling every bicycle. This includes both the cost of processes, and the salaries of the workers completing these processes. The manufacturing processes considered are the ones selected in the component selection section. Time has been allocated for the mechanical assembly and electrical wiring of the bicycle. Furthermore, an additional 2 hours of mechanical testing of each bicycle has been included. This testing process could comprise of fastener testing, suspension testing, and overall performance.

|  |  |  |  |
| --- | --- | --- | --- |
| process | hours | cost per hour (£) | 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 |  |  | 120.00 |

Table 3: Table highlighting the specific and total work cost price

*Final Cost Calculation*

The retail price was calculated assuming a worst-case scenario where only 100 e-bikes are sold within the first year. Throughout several iterations it was determined that the highest profit margin that could be applied whilst maintaining the price within the specified target, was 50%. This is a healthy profit margin, which enables the business to grow and reinvest a portion of their profit into further research and development to remain competitive. The calculated price is shown below:

With a cost of production of £1,287.63, this leads to a total profit of £643.82 per bike. This price is slightly below the product price target that was set previously. Therefore, the goal of providing a quality product whilst maintaining industry standard prices has been accomplished throughout the design phase. Furthermore, a couple more factors must be kept in mind.

The figures obtained above have not considered wholesale prices or economies of scale. Therefore, the price could be expected to decrease by up to 30%. Nonetheless, it has been proven that the current design is economically viable. Therefore, the final selling price can be determined once prices are consulted with retailers, further market analysis is conducted, and focus groups are carried out to understand the current market tendencies.

**Break Even Analysis**

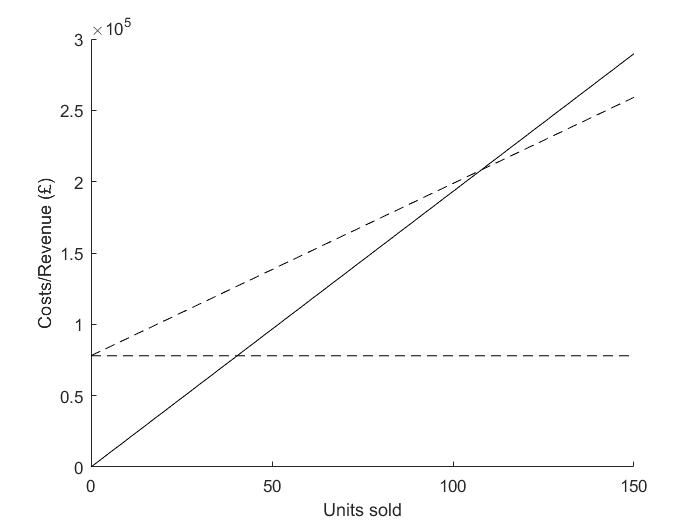
Using the costs and prices laid out in the previous sections, a break-even analysis was conducted. It was assumed that for the given production capacity of 100 units per year, there would be three employees working full time at a standard wage of £23,333.00 per year. The graph for the break-even analysis is provided in Figure 1 below.

Figure 1: Graph displaying the break-even analysis. Costs are represented by the dotted line, and revenue by the full line. Break even achieved after 108 units sold.

As obtained from the graph, the break-even is achieved after 108 units are sold. The final pricing calculation was conducted assuming that only 100 bikes were sold in the first year. Although it was mentioned that this was a worst-case scenario, there seems to be a slight discrepancy as the break-even point is greater than the units we assumed were to be sold. This problem was further assessed by conducting profit and loss accounts in the following section.

**Profit and Loss Accounts**

The profit and loss account have been created for the first three years of the forecasted sales. Three different expected sales have been considered throughout the years, these are 100, 1,000, and 10,000. A profit and loss account has been calculated for each on of them. For each scenario, the same rounded selling price of £1,930.00 was used, despite it being calculated only for the 100 units sold scenario. This provided some consistency throughout the three considered scenarios. 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. The first was the design labour costs of £8,200 and the second was a cost of tools of £100,000. They are paid off in the first year and from then on, they do not appear again in the profit and loss account. Taking a conservative approach, a contingency of £10,000 was included for every 100 bicycles produced. Finally, a 20% discount off raw materials was assumed for the 1,000-purchase scenario, whilst a 30% off was assumed for the 10,000 units scenario. The profit and loss accounts are shown in Table 4 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 economic loss, with two of them being a minimum loss of £7,743.00.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PROFIT AND LOSS ACCOUNT YEAR 1 | No. | |  | | --- | |  | | No. | |  | | --- | |  | | No. | |  | | --- | |  | |
| units sold @ £1,930.00 | 100 | 193,000.00 | 1,000 | 1,930,000.00 | 10,000 | 19,300,000.00 |
| costs of sales @ £1,207.43 |  | 120,743.00 |  | 965,944.00 |  | 8,452,010.00 |
| 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 AND LOSS ACCOUNT YEAR 2 | No. |  | No. |  | No. |  |
| units sold @ £1,930.00 | 100 | 193,000.00 | 1,000 | 1,930,000.00 | 10,000 | 19,300,000.00 |
| costs of sales @ £1,207.43 |  | 120,743.00 |  | 965,944.00 |  | 8,452,010.00 |
| 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 AND LOSS ACCOUNT YEAR 3 | No. |  | No. |  | No. |  |
| units sold @ £1,930.00 | 100 | 193,000.00 | 1,000 | 1,930,000.00 | 10,000 | 19,300,000.00 |
| costs of sales @ £1,207.43 |  | 120,743.00 |  | 965,944.00 |  | 8,452,010.00 |
| 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 |

Table 4: Expected profit and loss accounts for various units sold over the first three operational years.

**Return on Investment**

The return on investment (ROI) has been calculated for each year of each of the three expected sales scenarios. The ROI was conducted considering a cumulative approach. This meant that both the investment and profit calculated from year 1 are carried on into year 2. Therefore, the investment and profit in year 2 are equal to the sum of the investment and profit in year 1 and year 2, respectively. Similarly, year 3 considers the effect of the product on the business throughout all three years. For each year, the ROI was calculated as a ratio of profit to investment. The results are shown in Table 5 below.

|  |  |  |  |
| --- | --- | --- | --- |
| year | 100 units sold ROI | 1,000 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 |

Table 5: Table displaying the cumulative ROI over the first 3 years of product launch.

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 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. Therefore, the profit margin could be decreased to attract more customers and establish the brand better within the market.

Although many assumptions have been made throughout the cost analysis section, worst-case scenarios were constantly considered throughout. Therefore, in practice, most costs could be expected to decrease, and the ROIs to improve. Meaning, that even the 100 units sold scenario could become profitable. Nonetheless, it is important to conclude that this analysis showed that the design is economically viable. And although the selling price is not fixed, it has met the target selling price and quality goal; meaning that final and more refined selling prices can be implemented after further market and economic analysis.