MOTORIZED2WHEELE-SCOOTERWITHGPSTRACKING

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***Abstract*- The present work intends to study and create a solution to be used as a means of transportation adapted to the metropolis environment. This solution lies in projecting and building a prototype of an electrically assisted power cycle, mainly directed tobe used around the"Lastmile"concept.**

It was made a survey to perceive the legislation that concerns this type of vehicle, thiswas in order to understand the several different classifications that it can have and what were our constraints regarding the law. The market was also researched which showed that e-bike sales have experiencedamassivegrowthinsalesinthelastyears.

The components of bicycles and electrical bicycles were studied and compared, this waywe could do a correct and wise choice of components to be used in the project. Since the marketalreadypresentsseveraldifferentsolutionsintermsofthisconcept,itwasmadeastudyregardingsomeofthemarketavailablemodels, consideringits advantagesanddisadvantages.

Priortothecreationofthedesign,weestablishedsomemainrequirements,theseconstitutethepointswithmajorimportanceconcerningavehicleforthisspecificrangeapplications.

Due to some project constraints as time, capital available, access to building methods andmaterials, among other, it were developed two different models. One totally conceived fromscratch, and design taking in consideration the requirements established for the project. Thesecond design was intended to be build, creating a fully working prototype. This last was madefrom already produced bicycle components and was thought so that it would be similar to theconceived project and to maintain its must important features. Both models were structurallyvalidated using the finite element method with a static and frequency of vibration analysis. Foreach of the models was also chosen the best component configuration, this was made comparingeachof thealternativesthateachcomponentpresentsandtheadvantagesthatthey wouldprovide. A cost analysis was also made for both designs, which showed the different cost rates ofthetwodesigns.

CHAPTER - 01
INTRODUCTION

The demand and execution of electrical vehicles is extend more and more as the days goby. New technological improvement allied with growing concerns with the environment andphysical health had led to huge developments around this concept. Electrical vehicles are plays amojorroleinseveralindustries,especiallyinthetransportationfield.Theapplicationofelectricalmotorsinbicyclesandcarsopensupnewpossibilitiesandahugenumberofadvantages. Electric motor vehicles are a concept to take into world in the present and even morein the future, as they can open new possibilities or even replace the possibilities given nowadaysby the common internal combustion engines. In the current days, fully electrical cars can alreadydirectly compete with an internal combustion car or evencontrol andmake them look outdatedinseveralaspects.

The application of electrical motors in bicycles has many benefits linked to it. It canprovide assistance to the rider through tough mountains, to help fast achieve higher speeds or justto let the rider rest along the way, allowing him to do longer and unconditional ways with lesseffort. This concept can tell to be also very useful to people with movement difficulties, as it cantransform andimprove a common bicycle or similar vehicle tomeetpeople's needs,helpingthemontransportationandincreasingitsmobility.

A folding electrically help power cyclehasmany advantages, itdoesn'tpollute theenvironment, it's good for the health, allowing to exercise and to reduce the effort with theamount of power released by the motor. In a town environment it represents great mobility, it canbe folded up and carry it into public transportation to reach near the destiny. Or otherwise, to rideitto the destiny, with the electrical motorhelp through the route. As a bicycle,itis very usefulin traffic jams, as it allows to pass by stopped traffic and reach the destiny possibly even fasterthanpublic transportationlikecarandothertransportationvechicle.

It give a very small environment-friendly footprint, specially comparing with cars, oncethat they are less or practically non-pollutant. Another character that increases this difference aretheconsiderabledifferentworkrates.Carsgenerallypresent occupationratesaround 1 and 2 persons, representing 20 to 40 percent of its total capacity while bicycles use all its size rate,increasingorderandreducingthefootprint. One major problem is with the use of bicycles in big cities are the robbery's, leaving thebike in the outside it's always a risk, even the best locker can be overcome. With a foldingbicycle, this problem doesn't exist anymore as it can just be folded and taken inside with therider, secure its safety. Comparing with a moped or motorcycle, it's cheaper to buy in most of thecases and cheaper to maintain. You don't need any kind of documentation or requirements toapplyandtheyhaveverysimilarmobilitycharacteristicsthroughtrafficandinacapitalenvironmentingeneral.

Objectives

Thistheoryhastheobjectivetoconsiderthebestalternativestobeusedasadailymeanof transportation toreduce towork. We shouldcome up with a solution able tosolve theproblemsinherent to the common urban means of transportation,as public transports,privatecars or common bicycles and thus create a better alternative for this specific purpose. For such,we will be considering and study the best option from the several theory for an electricallyassisted bicycle. This theory also has the end of building a fully working prototype within thepossibilities that are given, this is, taking into consideration the time, capital available, access tobuildingmethods andmaterials amongotherconstraints.

This bicycle or, electrically help power cycle, is meant and draw for a very specific useand application: it is draw to be used as a daily mean of transportation to cover the distancebetween house to work and vice versa. It should be transform to urban transportation, creating andifferent to other normal and less attractive means of transportation in a town environment. Itshould be the perfect choice to be applied in the ”last mile” concept. This is a concept that refersto the last part of your daily work route. Whether it is straight from house to work or from thepublic transport or private car. The bicycle has the objective of making your way to work simple,easy and remove the problems basic in the use of a common bicycle. Nowadays we also have aexpand concern with the environmentand the pollution, by using an electrical vehicle,youwould have a vehicle with practically no pollution basic to it, making the way to work cleanedand greenedand thus decreasethe ecologicalfootprintbothofthe riderasofthecityitself.

Let's predict the following paln where you live corresponding near to your workplace(about 5 km or more). This would leave you with a small distance to cover to go to work but stilla large distance to cover by base. Therefore the usual option would be a public transport, acommon bicycle or a private car, but all these options can represent problems. Using the publictransportation, more likely a bus in this case, you would always have flexible that you can't andwon't control or control and that could lead to make you come late to the destiny. Variables suchas the schedule of the bus, possible but still common lates or even just the traffic, which is quitenormal in big cities. With public transportation you also would have morecost, just to go towork. The common bicycle would be a good option as it has more flexibility and can easilyovercome traffic or other urban barrier. Even so, using a common bicycle with hot weather or inmountainespathscanbefatigue,weakendowntheriderandmakinghimmoistureanduncomfortable,evenbeforearrivingtotheworkplace .Thislikelywouldhaveanegativeeffecton the presentation and heppiness throughout the work day. Another problem basic to the use ofbicycles in city environments is the safety, daily loads of bicycles are stolen and never recover.Taking your private car would also be a good choice but this also raises real problems. Problemssuchastrafficorfindingaspottopark.Anothercommonplan,istheoneof peoplethatworkina big city but live in its circumtences. These often take the public transport to get to the city, as atrain, boat or bus, but this transport doesn't take them to the final stop. Therefore they still have adistance to cover within the city. The option to this last part of the route, or ”last mile”, would betaking a second public transport, to near the destination or to use a common bicycle, by choicefoldable so that you could take in the public transport with any problems. These options wouldraise problems,justlikethe onesdescribedbefore.

All of these issues could be resolved with a foldable electrically assisted bicycle. Trafficwouldn't be an issue because a bicycle can easily pass halted traffic or take a different route thatneither vehicles nor public transport can. When compared to a regular bicycle, it would retain itskey characteristics, such as its manoeuvrability and practicability, but it would also make theroute simpler and require less effort from the rider, as the motor would do the bulk of the work,allowing him toarrive atwork rested and alert. Once the bicycle can befolded andbroughtinsidethebuildingorworkstation,issueslikerobberieswon'tbeaproblem.Therefore,thegoalofthisworkistodevelopasubstitutefortransportation.OnesuperiorsubstituteThechallenges andimpedimentsthatcanfrequentlybefoundinacityenvironmentcanbesolvedandovercomebythetypicaltransportationmethods.

Methodology

Frameproject

The frame is the most crucial component of a bicycle since it joins and holds together allthe other parts. It is not only the component that links all the pieces since it has a big impact onthe bicycle's performance, safety, and practically all other aspects. The diamond frame, whichconsists of two triangles as shown in the image but comes in a variety of sizes and shapes, is themostcommonchoice.

Figure1.1: Bicyclediamondframe

A bicycle frame's design and conception must take into account a number of factors,namely its weight,strength, and stiffness.Additionally,and specifically in this project, thecompactibility is crucial because a foldable bike must be as small and simple to store whenfolded.These are the primary characteristics that ought to be given more weight because theyhave a significant impact on the finished item and translate into the essential elements of afoldable bicycle.

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Despite having a lower density than steel, aluminium is more expensive in terms of boththe raw material and the tools required to work with it. Even though titanium has an excellentcorrosion resistance and high strength to weight ratio, it is still more expensive and difficult towork with than both steel and aluminium. Although carbon fibre has the advantage of being abletoadapttoalmostanyshape,itrequiresconstantupkeep.

DecisionMaking

We choose to employ a decision procedure in order to be able to make decisions in a lesssubjective manner. A quantitative method that is frequently used in engineering is the Pughmethod, also known as the decision-matrix [7] method. Stuart Pugh, a British professor whoworked in the departments of product design and development, engineering, and management atthe University of Strathclyde in Scotland, created the method. A series of pairwise comparisonsof the design candidates are the foundation of the Pugh technique. It enables the comparison ofthe various options using a wide range of criteria and, furthermore, manages to assign variousweights to the various criteria, permitting greater or lesser priority to a particular criterion. Thisenables us to examine the significance of each criterion separately while taking into account ourintendedobjectiveandpurpose.

Prior to using the procedure, it is required to rank each of the criteria (from 1 to 5, forexample),takingintoconsideration its significance to the decision-making process.A veryimportant criterion that significantly influences the decision would receive a five, whereas acriterion of marginal importance would receive a one, and so on. This is known as the criteriaweight, or, more specifically, how significant and impactful this particular factor will be on thedecision-making process. It's time to rate how well or poorly each choice satisfies the criteriaafter each criterion has been chosen and ranked according to its value. This implies thatanoption should receive a high grade if it is an excellent alternative just based on this particularcriterion. On the other side, a choice should receive a low grade if it doesn't meet the relevantcriteria. This value so shows how each choice is categorised in light of a specific criterion. Afterthematrixhasbeencompletelyfilledoutandgradedproportionally,theoutcomescanbe determined. The calculation is done by dividing the weight of the criteria by the grade that thechoice in question got. The multiplication results from each of the criteria must be added up inorder to get the outcome. Wemay quickly reach a choice by comparing the sums of eachalternative, a judgement that is the consequence of comparing all the options and taking intoaccountallthecriteria.

GlobalPositioning SystemGPS

Since e-bikes have a power source, they present special opportunities for monitoring andunderstanding usage as well as their interaction with the urban environment, which may beadvantageous to both e-cyclists and traditional cyclists. Understanding and communicating thepotential advantages of e-bikes for sustainable transportation and beyond requires a thoroughunderstandingofhowtheyareusedincertaingeographicalandculturalsituations.

In this paper, the term "e-bike" refers to bicycles with a small motor and battery whereriders always have to pedal but can engage electric assistance (often with a choice of low,medium, or high settings) if they so choose. When the peddling stops or a speed of 15 m/h (25km/h) is reached, the assistance stops. These electric bicycles, often known as pedelecs, are usedin several European nations. There are other e-bike models available, such as those that allowassistance tobe utilisedwithoutpedalling; these are particularly commoninseveralAsiannations (see, for example, [1]), but they are outside the scope of this study. On e-bikes, a varietyof motor and battery configurations are possible [2, p. 5], and the models used in this studyrepresenttwo of themostwell-liked types: (i) afront-hub motor with a rack-mounted battery;and(ii)acrank-drivenmotorwithacentralbattery.

InEuropeannationswithestablishedridingtraditions,e-bikesarequicklygainingpopularity among both experienced and novice cyclists [3]. For instance, in the Netherlands, thevalue of e-bike sales is on par with or higher than that of traditional bicycle sales; in Germany,one in ten bicycles sold is an e-bike; and it is believed that there are more than a million e-bikesin use throughout Europe

[3]. They are still relatively unknown in England, nevertheless. A betterunderstanding of how people in the UK engage with e-bikes could help to identify issues for policy,design and research that could lead to a higher uptake of e-bikes. The 2011–2014 ‘Smart e-bikes’researchproject[4]worksonthisandthesmarte-bikemonitoringsystem(SEMS)hasbeendeveloped as part of this work. The monitoring system is implemented on a fleet of 35 e-bikes inBrighton(UK)

ELECTRICALBICYCLES
CHAPTER 2STATEOFART

Since they havebeen aroundformore than 200years,bicycles havebeen a significantand widely usedmode of transportation. Whocreated the ideais up for debate andcannotbe known for sure. It is undeniable that they have changed significantly since theirinception and continue to play a crucial part in contemporary life. More than 1 billion bikes—twiceasmanyasautomobiles—hadalreadybeenbuiltgloballyby 2003[8].They offernotonlya practical mode of transportation but also a highly well-liked type of entertainment. They hadbeenmodifiedfornumeroususes,includingthoseingeneralfitness,militaryandlawenforcement,courierservices,bicycle racing,andmanymore.

An electric bicycle is a bicycle with an inbuilt electric motor that helps the rider push thebicycle.Pedelecs andE-bikes are the twoprimary categories of electrically assistedpowercycles; the difference between them is how the motor is activated. Pedelecs use a PAS, whichmeans that as long as the driver keeps pedalling, the motor automatically aids him, and the motorshuts off if the driver stops. The sensors builtinside the motor, which typically gauge thepedallingrate,bikespeed,ortorqueappliedbythedriver,automaticallyalterhowmuchassistance is provided. These three types of sensors are not included in all designs, but morecurrentdesignshavethemoperatingtogether,whichleadstoamorecontrolleddrivingexperience and an improvement in certain key features of an EAPC, like as range and comfort.E-bikes,oftenknownas"power-on-demand"or"twist-and-go"bikes,useathrottleortriggerthat the rider pulls to move the vehicle forward. Additionally, some designs offer both operatingmodes.

Ogden Bolton Jr. of the United States published the first e-bike patent on December 31,1895 [9]. It has a straightforward construction and a rear-mounted direct current (DC) brushedhub motor. The motor could draw up to 100A from a fixed 10V battery and had no gears. Thisdesign,asshown inthefigure,isquite similartothemodelswehave today.

Thefirstbrushedplanetary-gearedhub-motorwithatotalRPMreductionof5.6:1debutedbarelyoneyearlaterwiththeaimofboostingthepowerandefficiencyofhubmotors[10]. Surprisingly, the first electric bicycle with a mid-drive motor emerged just one moreyear later. Hosea W. Libbey re-filed the patent in the United States, but it was not successful inreaping the benefits of the mid-drive motor because it only spun at the same speed as the bikewheel [11]. Even though the first bicycles with integrated electric motors were mentioned inpatents dating back to the 1890s, it wasn't until the late 1990s that EAPCs really began to catchon. The development of better, more dependable, and more consistent electrical bicycles wasmade possible by new technologies. The idea of an electrically assisted motorised cycle began toexpandsignificantly,andThesebegantobeacceptedaslegitimatemodesoftransportation,beginningtocompetewithregularbicycles,mopeds,motorcycles,andevenautomobiles.However, in some countries, the most recent ten years or even just recently,have seen thehighest growth. As a result, the regulation related to this new class of vehicles is somewhatpremature and is continually adjusting and attempting to keep up with market developments andchanges. In an effort to harmonise the laws and safety surrounding this notion across all ofEurope, the EU developed regulations and standards, which are now practically complete. Whenusing EAPCs in environments where different parts are present, such as vehicles, pedestrians,otherbicycles,and various other types of obstacles, the safety conceptis one of the mainconcerns oftheEU.

In addition to playing a significant influence in the market's expansion, new technological advancementscoupledwith"sexier"designshaveincreasedinterestinanddemandforelectrically assisted power cycles. Components like the torque sensors, batteries, power sensors,and the motor itself were some of the most significant and recent inventions that played asignificant role in the EAPC sector. The development and enhancement of these componentsallowed the sector to advance even further and gain prominence that it had not previously had.These innovations were extremely significant to the sector since they improved the idea and gaveridersmorefunandcontrolwhile riding.

Theelectricbicyclesimprovedintermsofdependability, cost, and energy efficiency. They also had longer ranges, which allowed for newuses. As more people become aware of the numerous benefits that these types of vehicles have ina city setting when compared to a car, a regular bicycle, a moped, or a motorbike, the demand forelectric bicycles is currently expanding ata level thathas neverbeen witnessed before. Inbusinesseslikepostofficesandvariousurbantransportationandcourierservices,electricbicyclesare alsobeginningtobe usedinanindustrialcapacity.

Electricbicycleshaveanumberofadvantagesovermopedsandlow-poweredmotorbikes,andnew,improved,andimaginativedesignsaremakingthemtheindustry leaderina few years. There are already new designs with amazing capabilities that letyou connect thebike with your smartphone so you can control the electrical functions of the bike or charge yourphone.Therearealsoemergingnewtypesofelectricalbicycles,such ashybridelectricalbicycles, in which the rider only pedals to charge the motor because the crankset isn't connectedto the wheel, or retrofit kits, which are also becoming increasingly popular as they develop andshow betterefficiencyrates,resultingina significantlylargerbicycle.

The expenditures associated with this kind of vehicle are currently its biggest drawback.Due to two primary components, the motor and the battery, purchasing an electrically assistedbicycle or converting a conventional bicycle to one can prove to be very expensive. Although themarket is displaying an increasing number of different hypotheses, each with a different cost andpoweroutput,theconcepthasalwaysrequiredasignificantinvestment,particularlywhencompared to conventional bicycles. This is a problem that will only get better with time and in amarket where the top brands in the sector are competing with one another. Fortunately, and aswill be detailed further, the business for electrically powered bicycles is rapidly evolving withexpanding designs and advances. As a result, it is anticipated that prices will decrease andbecome more attractive for this sort of car as the key components that drive up the price becomemore accessibleandubiquitous.

LEGISLATION

Because electrically assisted power cycles are a relatively new idea and are constantlybeing improved and evolving, the legislation governing them is still a little premature and isconstantly being adjusted to the frequent changes and to the new risks associated with them.However, there are laws that set this mode of transportation apart from the others. Legislation forEAPC is difficult to establish since there are so many various types of bicycles, each of whichposes a unique set of risks to both riders and the environment. These bicycles also have varyingpower outputs, work modes, and uses. The laws governing thesekinds of vehicles will be briefly described in this section, with a focus on Europe, Portugal, andsome of the major producers and consumers of this technology, including the United Kingdom,the Netherlands,China,andthe UnitedStatesofAmerica.

Europe

TheEuropeanDirective2002/24/ECdistinguishesbetweenbicyclesthatmustberegardeddifferentlythanotherbicyclesduetotheassistancemotor,suchasmopedsormotorbikes, and those that can continue to be treated legally as conventional bicycles. "Cycleswith pedal assistance that are equipped with an auxiliary electric motor having a maximumcontinuous rated power of 0,25 kW, of which the output is progressively reduced and finally cutoff as the vehicle reaches a speed of 25 km/h, or sooner if the cyclist stops pedalling," is how thedirectivedefinesthemaintechnicalcharacteristicsforelectricalbicycles[12].Ifabicyclefits these criteria, the laws thatapply are the same as those thatapply toa regular bicycle withoutanysortofassistedmotor.

Directive 2002/24/EC stipulates that bicycles with stronger engines or different operatingsystems are regarded as mopeds or motorbikes. The restrictions that the driver must follow varydepending on these groups. It has an age restriction that varies by country, and the driver musthave a driving licence and wear a helmet when driving. The car must be insured and have alicence plate. In this situation, the vehicle must also go through a type-approval by an authorisedbodythatcheckstoseeifitcomplieswiththerequirementsforthecategoryitisplaced on.

However,inthemajorityofthememberstates,thereisnolegalrequirementtofollowthisstandard.However,theGeneralProductSafetyDirective,2001/95/EC,isarequirementthatmustbefollowedbyallmanufacturersintheEU[14].Inessence,thislawmandatesthatproducersmakecertainthatthegoodstheyreleasetothemarketaretrustworthyandsafetouse.Inthemajorityofthememberstates,manufacturersarefreetoself-certify their goods by putting them through internal testing or hiring outside testing agencies.EAPCisdividedintotwoseparategroupsunderEN15194.Bothclassificationsareincludedinthepreviouslymentionedcategoryofmotorsupto0.25kW,whoseoutputgraduallydecreasesandthenisshutoffassoonasthevehiclereachesaspeedof25km/horsooner.This distinctionresults fromtherelativedifferences inthemotor'sactuationmethods:

- Pedelec: The motorised assistance only kicks in with this sort of bicycle while the rider ispedalling. The motor shuts off when the driver stops peddling. These bicycles typicallyhaveamid-drivemotorsystemattached to the crank andlinked tothegearbox.
- E-bike: In contrast, these bicycles have a motor that can move the vehicle forward on itsown,i.e.,withouttheriderhavingtopedal.Hub-motorsarefrequentlyinstalledinthe front hub, the rear hub, or both. Due to their resemblance to mopeds or low-poweredmotorbikes, they are also known as "twist-and-go" bicycles, and in some countries, thelawsgoverningthemaresubstantiallydifferent.

As previously stated, EN15194isconcernedwith thebicycle'selectrical components.The bicycle's performance and safety, as well as the tests it must pass to be deemed safe foruse, as outlined in EN14764 [15]. This standard demands high-quality items and stringentsafety criteria in order to guarantee the strength and durability of both individual componentsand the bicycle as a whole. The standard was created to provide the highest level of safety forbicyclesmadeintheEU.

UnitedStates

The term "Low speed electrical bicycle" is used to describe the category of electricalbicycles that is most similar to those in Europe. All two- or three-wheeled vehicles with fullyfunctional pedals thathave an electricmotor that producesless than 750W and a top speed ofless than 20mph (32 km/h)fall into this category. A bicycle thatnevertheless complies withthese requirements is covered by the CPSC's consumer product standards for bicycles and isexemptfrom being categorised as a motor vehicle. States have different laws governing the useof electrical bicycles on sidewalks, public roadways, and other surfaces. Over these power andspeed limits, all commercially produced electrical bicycles are subject to USDOT and NHTSAregulationasmotorvehiclesandare subjecttoadditionalsafetyrequirements.

MARKET

With an estimated 85% of all electric bicycles sold worldwide being sold in China, Chinahas long dominated the global market for these vehicles. This is owing to a number of factors,includingthegovernment'sofficialdesignationofdevelopmentinthisareaasatechnicalobjective in 1991 and the recent legalisation of petrol-powered mopeds and scooters in manycities. The Chinese market started to expand exponentially in the year 2000, going from 300,000salesin2000toanastounding30millionsalesin2012[18].

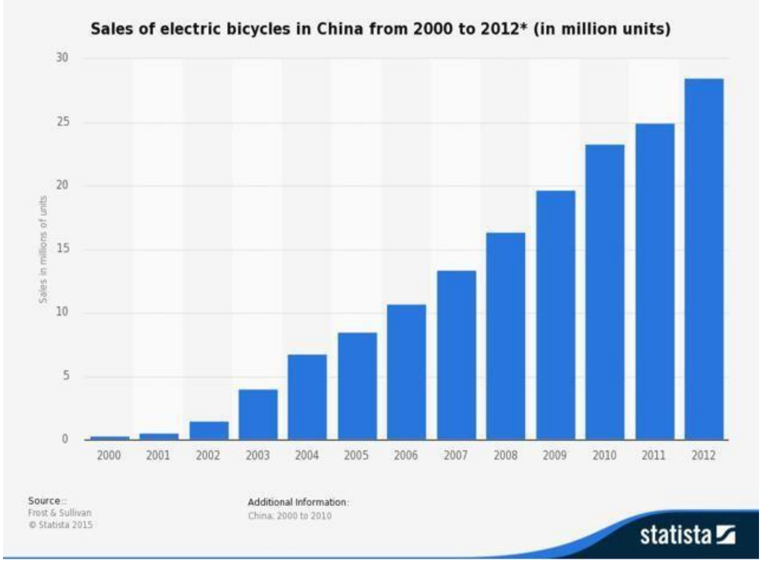


Figure2.3: Evolutionofthechinesemarket

Despite the delay, the market in Europe and North America only recently began to takeoff and is now a multi-million dollar industry, particularly in the northern European nations likethe Netherlands, the United Kingdom, Germany, and Belgium where cycling has a long history.According to estimates, 83.2% of all e-bikes imported into the EU in 2014 came from China[19].The high cost of petrol in the majority of European nations was another significant element thatcontributedtotherapidgrowth of thee-bikebusiness. This,combinedwithanincreasingawareness of environmental issues, led individuals to start looking for less expensive alternativesto vehicles and motorcycles that pollute less. Costs, which are quite pricey when compared to astandard bicycle,were oneofthe keyissuesthatlimitedmarketexpansion.

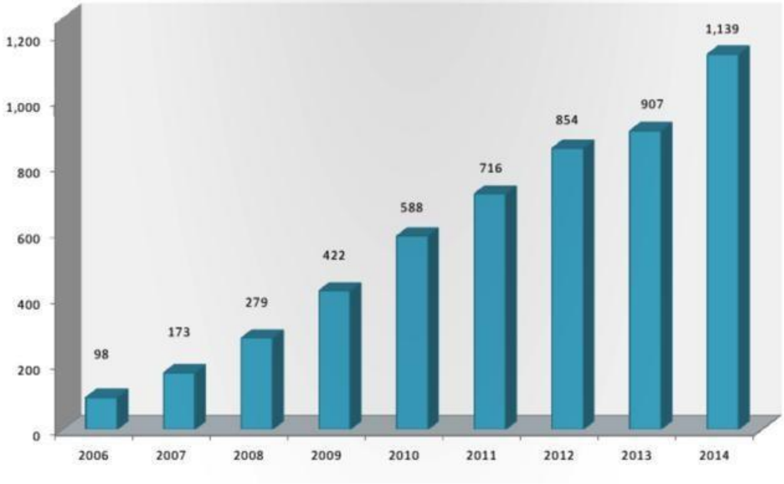


Figure2.3.1:EvolutionoftheEuropean market[20](1000unitsperyear)

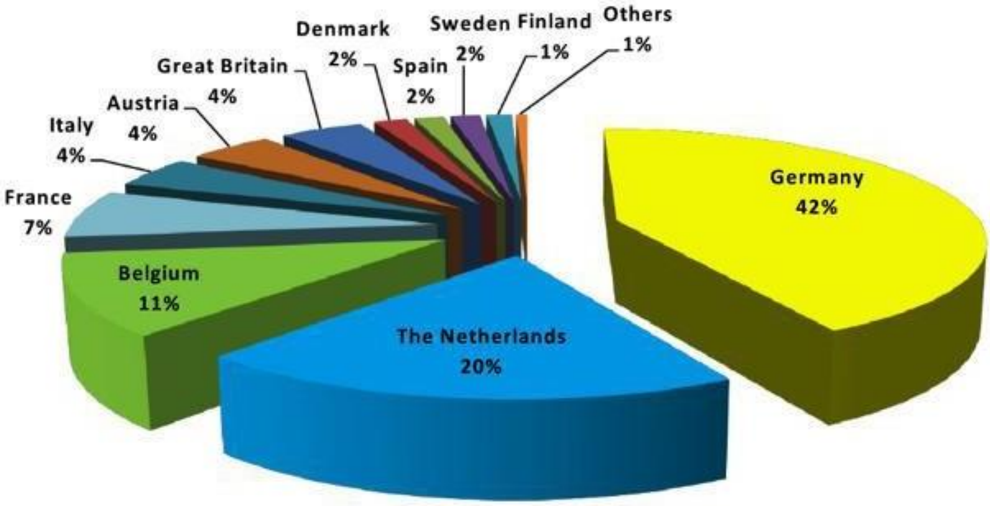


Figure2.3.2:European EPACsalesin2014 percountry.[20]

According to Navigant Research, a base scenario predicts that annual sales of e-bikes willincrease from little under 32 million in 2014 to more than 40 million in 2023. The market growthhasbeenfueledby innovativetrendsandwillremainso.E-cargobicyclesarenowbeingemployed as a form of transportation by a number of businesses, including the post office, thepolice, security firms and others. The e-bike industry is becoming even more appealing thanks tohybrid designs and retrofit kits, and as time goes on, more and more designs with variouscharacteristics proliferate, making EPACs more practical and with a wide range of applications,notjustinprivatetransportation.

BICYCLECOMPONENTSNOMENCLATURE

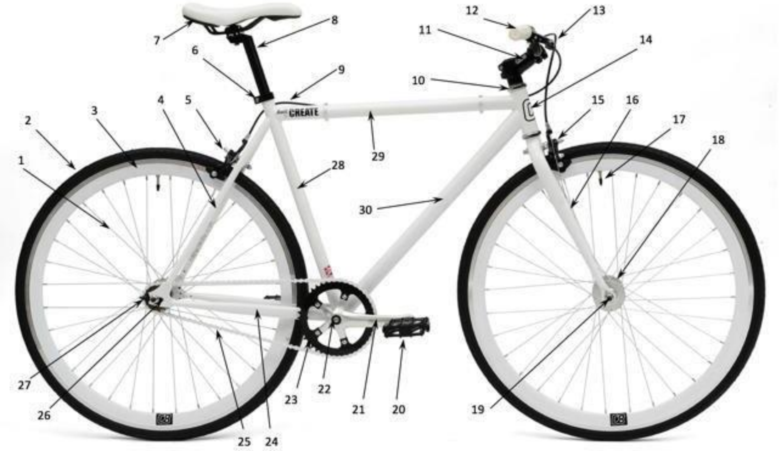


Figure2.5:Bicyclecomponents

igure2.5:Bicyclecomponents

1. spoke
2. tire
3. rim
4. seatstays
5. rearbrake
6. seatpost clamp
7. seat
8. seatpost
9. brakecable
10. headset
11. stem
12. handlebar
13. brakelevers
14. headtube

16.forkblade
17. valvestem
18.fronthub
19.front dropout
20. pedal
21.crankarm
22.crankset
23.chainring
24.chainstays
25.chain
26.reardropout
27.rearhub
28.seattube
29.toptube

15. frontbrake 30.downtube

ELECTRICALLYASSISTEDBICYCLECOMPONENTS

Motor

There are various ways to power a bicycle; the ones taken into consideration in this workand more frequently employed include mid-drive motors, hub motors, and friction drive motors.In order to be able to select the motor that will best meet the demands placed on the bicycle, wewillbelooking atboththebenefitsand drawbacksofthesedifferentmotortypesinthispart.

The city of Lisbon, which is well-known for its steep and lengthy hills and is sometimesreferred to as "Cidade das setecolinas" ("City of the Seven Hills"), served as inspiration for thedesign of the bicycle.The Portuguese capital's roadways have seen betterdays,and some ofthem currently have very shoddy pavement. In the Portuguese city, potholes and broken rails area common sight. While they don't pose a severe threat to automobiles, they can be extremelydangerousformotorbikesandbicyclesandresultinseriousaccidents.

Thesimplicityof**frictiondrivemotors**—boththemotoritselfandthemountingprocedureneededtobuildthemotor—istheirprimary distinguishingfeature.Despiteitseaseof use and small size, this type of motor is the leastpopular of the three under considerationbecause it has a number of shortcomings compared to the others. A spinning roller that is placedagainst the bicycle's tyre and causes it to spin is how the motor transfers power to the bicycle.Despite having benefits like their small size, light weight, and high power-to-weight ratio, theyare primarily noted for their poor efficiency at transmitting power to the bicycle. This frictioncoefficientcansoondiminishandwon'tbeenoughtopushthebicycle,especiallyinwetconditions. Power transfer is made possible by friction between the motor drive and the bicycletyre. Typically mounted in the seat post, they are very simple to mount and demount on a bicyclewithouttheuseofanytools.

Figure2.5.1 Motor

Figure2.5.2:Frictiondrivemotormountedon seat-post.

Mid-drive motors, Located inside the crank shaft, these devices are also known as crank motors.The fact that mid-drive motors drive the crank rather than the wheels allows them to take use ofthe 16 gears on a bicycle, which multiplies their power, is one of the main factors contributing totheirhighperformanceandtorquerates.

Figure2.5.3:Exampleofamid-drivemotor.

Thissortofmotor's placementwithinthebikeandimpactonthemass centreareadditionalbenefits.Itisinstalledinthemiddleofthebike,whichlowersthemasscentreand

keepsitinthemiddleofbothwheels,improvingtherider'scontrol,stability,andmanoeuvrability. These offer noticeably higher torques and speeds compared to hub motors withthe same motor power, despite being more expensive. The crank and chain of a bicycle are theonly parts thatcan exerta certain amountof force after the poweris transferredto them.Additionally,thissuggestsincreaseddeteriorationofthebicycletransmission'sparts.Onestrategy to alleviate this wear and tear is to briefly reduce the power when shifting,much likeyou would on a regular bicycle. Mid-drive motors are very advantageous when used with abicycle thathas suspension because the suspension wouldlessen the vibrations and shocks feltby the motor and leave the wheels lighter, allowing them to rebound quickly and efficiently,creatingamore fluidandcomfortable ride.

There are two types of mid-drive motors: those that are designed to turn a regular bicycleinto an electrically assisted bicycle. These can be used with the majority of modern bicycles andare mounted in the bottom bracket. The second group includes motors that need a particularframe with the correct mountings and space to fit the particular model of the motor in the frame.In this instance, the bottom bracket acts as the motor itself, opening up the possibility of using atorque sensor togauge the torque a rider applies.

Figure2.5.4:Exampleofahub motor.

Using a differentparameter of the rider'sactions or modifications to the bicycle, the The motor has far more control over how to behave inorderto supporttherider.Aproductbecomesmoresensitive and user-friendlyasaresult.

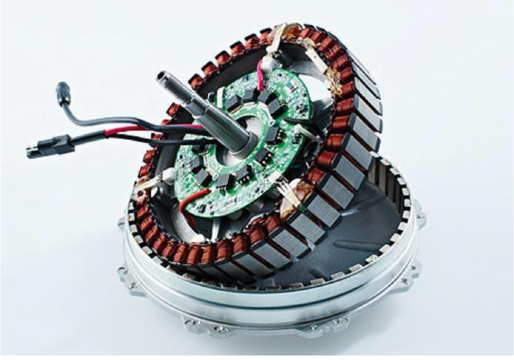
There are two types of mid-drive motors: those that are designed to turn a regular bicycleinto an electrically assisted bicycle. These can be used with the majority of modern bicycles andare mounted in the bottom bracket. The second group includes motors that need a particularframe with the correct mountings and space to fit the particular model of the motor in the frame.In this instance, the bottom bracket acts as the motor itself, opening up the possibility of using atorque sensor to gauge the torque a rider applies. The engine may be controlled considerablybetter to operate in a way that will support the riderif another parameter of what the riderisdoing or applying to the bicycle is used. A product becomes more sensitive and user-friendly as aresult.

Hub motors typically havelow power outputs (250 to 350 W), especially those used inthe front wheel since excessive power would cause the front wheel to spin and the bike to losecontrol. However, there are much more potent motors on the market that can produce up to 1000W of power. This type of motor has a long history, dating back to the original electric bicycles,and is currently the most often used alternative since it has been "tried and true" and is thereforethe most economical option. They are made in great quantities in China, making them quiteaccessible andinexpensive.

These motors feature fewer moving parts, which reduces wear on the motor, the chain,and any other transmission-related equipment. Although they are mounted in sealed cases anddon't need any maintenance, the sealed case can be dangerous and cause overheating problemsbecause there is no easy way for the heat to escape. With these motors, it is simple to turn almostany regular bicycle into an electric bike, especially when using a front hub motor. due to the factthat they do not obstruct the pedals or the gearbox. The potential loss of front wheel tractionwouldbethemajordrawback.Arearwheelhubmotorcanmakemountingabicycle'sderailleura little more difficult, but it also reduces the possibility of the wheel spinning and losing traction.Regarding weight distribution, they might throw off a bike's balance in the front or the back,making it more difficult to handle and control. Another disadvantage is that they will absorb allthe stress and vibration produced by the ground track after they are positioned in the centre of thewheel. Over time, this could result in issues or malfunctions. Hub motors make changing a flattyremuch moredifficult,primarilydue to thewiringthatisattachedtothewheels.

Geared hub motors, Unlike gearless hubs, they don't produce drag when the power isoff. For every rotation of the case, the motor inside will actually turn many times faster, makingthembetter suitedfor hillsthangearlessmotors.Typically,theyhavetheir casesconnectedtothe stator through a planetary gear reduction system.This enables the motorto operate at faster,more effective speeds, resulting in smaller, lighter motors that can create more output, but it alsocausesmorewear,noise,andfriction.

(a)Geared hub motor



(b)Gearless hubmotor

Gearless or direct-drive Since hub motors lack a gear system, as their name implies, onerotation of the motor corresponds to one rotation of the wheel. Compared to geared motors, arerecognised for being exceedingly simple and having essentially no moving components. Sincethey need to have a large diameter in order to produce enough torque, direct-drive motors aretypicallybiggerandheavier.Theygeneratedragwhenunpoweredbecausetheyonlyuseelectromagnets and may not have a freewheel mechanism. Some suggest using regenerativebrakingtorechargethebatteries.

Frame

The bicycle frame, which connects all the other bicycle elements and is where these areinstalled, is the primary component of a bicycle, as was previously stated in Chapter 1. It greatlyaffects the bicycle's functionality, safety, and almost every other element. Once the frame is whatmakes the bicycle foldable, it has a significant impact on the bicycle as a whole, especially incases where the bicycle is a foldable one. The weight, rigidity, strength, and, in this case, thecapacitytofoldintoasmallspace are thekeycharacteristicsofa bicycleframe.

The most popular materials used to make bicycle frames are carbon steel, chromoly steel,aluminium, titanium, and carbon fibre. Steel is the material most frequently found in bicycles; ithas been in use for a very long time and is also the least expensive of those mentioned above.Itis made of a durable substance. In comparison to other materials, it is known to be simpler toworkwith,andthetoolsrequiredtodoso(weldingmachines,weldinggases,etc.)arealsolessexpensive. His great density, which makes it the heaviest substance taken into consideration, isone ofits maindrawbacks.

Although aluminiumisless dense andless strong than steel alloys,ithas a higherstrength-to-weight ratio, allowing for the construction of lighter frames. Although it is moreexpensive than steel alloys, it is becoming less expensive and is used on a lot of modern bicycles.It is among the greatest materials for this kind of application since it is lightweight, sturdy, long-lasting,andrigid.

While titanium is stronger than steel, it is also lighter. Ti frames stand out for theirstrength,dampingability,andlightweight.Sincethematerialnaturallyresistscorrosion,titanium frames are typically not painted, so they don't require any additional protection. He canbend while preserving his shape thanks to his damping ability, which makes the ride morecomfortable and shock-absorbing. The price is the main drawback. In addition to being a priceymaterial,workingwith itcallsforspecialised equipmentand abilities.

The most often used material for performance road bikes nowadays is carbon fibre. It isextraordinarilylight—somecarbonfibrebicycleframesweighlessthan700g—andsturdyenough to be pushed to the limit in some of the world's most difficult competitions. The majordrawback is that, in contrast to metals, it is exceedingly fragile and readily breaks. This is so thatloads in one direction can be supported by the carbon fibre frames, which cannot be outweighedbyloadsinotherdirections.

(a)Diamondframe (b)Step-throughframe (c)Cantileverframe

Figure2.5.5:Frameshapes

The ability to fold the bicycle is the primary feature of folding bicycles. The bicycle canbe folded and compressed in an infinite number of ways. The ones where the bicycle foldshorizontally, vertically, or both ways are the mostprevalent. Another typical application oftelescopic tubes that enables the frame to retract. The most frequent fold is the horizontal one,which typicallyoccursatthecentreoftheframeon asinglehinge,leavingthewheelsveryclose together and practically concentrically aligned. The ability to move the folded bicycle as a sort oftrolley is made possible by having the wheels lined up, making it easier to transport. The wheelswould be close but in a different alignment if the frame were to just fold in half, which wouldprevent this from working properly. To enable the wheels to be completely aligned, a fold mustbemadeinadimensionparalleltothewheelalignment.

Wheels

A bicycle's wheel is a crucial component, so care must be used while choosing its size.One of the major aims of a folding bicycle is to minimise the space that it takes up and theweight.Atfirstglance,using small wheelsseemslike the sensible decision,butthey havevarious drawbacks when compared towheels with larger diameters. Small wheels reduce abicycle's mobility, which is one of the main benefits of riding one as a mode of transportation,particularly in an urban setting, where that is what it is designed for. Simple obstacles likepavements or tiny steps can be difficult to navigate with small wheels. Any crack or stone in thepavement, no matter how small, can throw the rider off balance and put them and anyone elsenearbyindanger.

Figure 2.5.6:Wheelsize

Although using wheels with large diameters makes the ride safer, more stable, and easierto manoeuvre around obstacles, as was already mentioned, one of the main objectives of thiswork is to reduce the amount of space that the bicycle takes up. Therefore, we must select awheel size that is as small as possible, maintaining the bicycle's compactness while still beinglarge enoughtoallowforeasymanoeuvrabilityanda comfortable ride.

Two measurements are necessary to define a bicycle wheel: one to specify the wheel'sdiameter and the other to specify its width. The dimension that stands out the most and has thegreatest impact on a bicycle is its diameter. The available sizes range from 8, 10, 12, 16, 20, 24,26, 28, 29, and 32 inches, with some intermediate sizes, typically from vintage or extremelyspecialised bicycledesigns.Thelowersizesmostlyonlyfinduse inchildren'sbicyclesandwheelchairs and have limited applications. The 16" and 20" sizes are typically utilised in BMX, kids'bikes, and light-weight riders. The majority of mountain and road bicycles utilisetyres in thesizes 24" to 29", which have the most market uses. Unicycles and various novelty bicycles mayhave sizes as uncommonas 32" oreven36".

Figure2.5.7:Different wheelsizes

3 Fig 2.5.8: Watts, 9Amps Battery

Batteries

Any electric bicycle's heartis its battery. Without the entire amountof energy stored inthe battery, the motor is worthless. It is frequently the most expensive and one of the hardest togetcomponents.Any electricalbicycle's choiceof this essential componentmusttake intoaccount the function for which the bicycle is intended as well as the desired range. Of course, itmust also be compatible with the bicycle's other parts, including the controller, the motor, and allof the electrical parts. Lithium,nickel, andleadacidbatteries are the three mostpopular andoftenused typesinelectric bicycles;eachhasa numberofbenefitsanddrawbacks.

Li-ion batteries, like the others mentioned, are rechargeable; during discharge, lithiumions migrate from the negative electrode to the positive electrode; during charging, they moveback.Manylaptopbatteries,cellphones,electriccarsliketheTeslaModelS,andotherapplications use them. They come in a variety of sizes and shapes and are all often referred to as"li-ionbatteries," a termusedtorefertoanentireclassofbatteries.

(a) (b) (c)

(d) (e)

Figure2.5.9:Examplesofdifferent lithiumbasedbatteries

Lithium batteries come in a variety of material and chemistry combinations, and as timepasses, more and more of them with unique and arguably better properties appear on the market.Though they may only account for a small portion of the market, the following alternatives aresome ofthemostpopularandwell-known,particularlyinthe e-bike sector:

- Lithium Iron Phosphate (LiFePO4) – One of the first extensively used materials in the e-bike industry, and one of the most common today. With a lifespan of 2000 charge cyclesor more, this particular type of li-ion battery has thelongestlongevity of the others.These li-ion batteries are the safest when compared to other li-ion batteries because oftheir naturally safe and nearly fireproof chemistry. Additionally, they are among thebiggest and heaviest members of the lion class. One disadvantage is that most of themhave ratherlow discharge rates, making them unsuitableforelectrical bicycles withsignificantpoweroutput.Despitethis,theyworkperfectlyforeverydaybikes.Additionally, these cells require a protection system, commonly referred to as a BatteryManagement System (BMS). By doing this, the cells are prevented from going out ofbalance, from being overcharged, or from being discharged throughout the subsequentcharge and discharge cycles. The majority of lithium-ion batteries require this protectivecircuit in order to avoid becoming harmful and having their life expectancy suddenly cutshort.
- Lithium Manganese Oxide (LiMn2O4) - This form of lithium-ion battery is a reasonablecompromise between the other types in terms of size, weight, safety, and price. The maindrawback is that it has a relatively short lifespan compared to other

lithium-ion batteries,typically only permitting 600–800 charge cycles. Despite being able to handle more evenchargingandddischarging,mostbatterypacksinclude a BMS.

- Lithium Nickel Manganese CobaltOxide (LiNiMnCoO2) is a relatively novel materialfor these kinds of applications. It sprang to fame around 2013–2014 but is now quicklydominating the electric bicycle sector. They have a secure chemistry that enables them tooffer great power in a lighter and more compact form factor than the first two types. Dueto their extremely low rate of self-heating, these batteries are also frequently chosen foruseinelectricvehicles.
- Lithium Polymer Batteries (LiP o) - Of all the lithium batteries mentioned, these are thesmallest, least expensive, lightest, and most potent. However, they have a number ofdrawbacks, such as a limited lifespan (a few hundred charges) and a propensity to catchfire and explode into enormous fireballs. This is because of their unstable chemistry; ifthey are not handled carefully and correctly, they will ignite and catch fire if they areovercharged or overdischarged, pierced, or dropped. In essence, they must be handledcarefully or else they might become highly dangerous, and in this particular use, wheretheyareintendedtobeemployedclosetotherideroreven betweenitslegs,they arenota secure option. In the remote control sector, as well as in vehicles, planes, and otherthings,thesearefrequentlyutilised.

Another variety of rechargeable batteries on the market are nickel batteries. These were usedbeforelithiumbatteriesandareprimarilyfoundinportableequipmentlikepowertools,flashlights, electric vehicles, and remote-control toys, among other things. They have gainedappeal aslead acid battery replacements since they offer significantly better features. Despitethis, lithium batteries have largely taken their position in most uses and applications. They needtobe assembledandchargedcarefullybecausetheyhave a shortlifespan.

(a) (b) (c)

Figure2.5.10:Examplesofdifferentnickelbasedbatteries

Another choice would be lead acid batteries, which date back to circa 1860 and are the oldestof the three battery types previously mentioned. Despite being an outdated technology, theycontinue to see advancements and are still widely used across the globe. Because most fuel carsuse the same kind of battery, they are widely available and simple to access. are significantly lessexpensive than Li-ion or nickel batteries, which is mostly owing to their weight and capacity.They weigh three times as much as lithium batteries and twice as much as nickel batteries due totheirlow energy-to-volumeand energy-to-weightratios. A crucial componentthatmustbeensured, particularly for this kind of use, is that the battery is what is known as a Sealed LeadAcid(SLA).Ifnot,theacidmaystartto leakfromthebatteryandcreateahazardoussituation.

Throttle/Pas

(a) (b)

Figure2.5.11:Examplesofdifferent leadacid batteries

Wewilldiscusstheoptionsforregulatingthelevelofmotorassistanceinthissection.Itis a very significant feature, and with the appropriate control, you can either use the motor to itsfull potential or only lightly, greatly extending the range. There are two major techniques tomanage how much aid the motor provides to the rider, albeit there are minor variances betweenthetwo.

- **Throttle** - The idea is essentially the same as with a regular motorcycle. These make itpossible to instantaneously and directly control the motor's output of power. There are afew different kinds, including thumb throttles (where the throttle is engaged by pushingthe lever forward with your thumb), full twist throttles (found on most motorcycles), andhalf twist throttles (where the throttle is engaged by twisting the throttle grip, in thisinstanceonlythelowerhalfofthegrip).Thesearethemosttypicale-bikethrottlesinuse.

(a)Thumbthrottle (b)Fulltwistthrottle (c)Halftwistthrottle

Figure2.5.12:Typesofthrottles

- **Pedal Assist System (PAS)** - The term "pedelecs" (pedal electric cycle) is also used todescribe a mode in which the motor only operates when the rider is pedalling; otherwise,it will shut off. The degree of help is controlled by an electrical circuit that considers datafrom three different sorts of sensors: speed, cadence, and torque (not all models have allthree types of sensors combined). The controllerwill cause the motor tospin morequickly the faster the pedal cadence, just as it will with a torque sensor or a speed sensor.You can pedal very lightly or extremely forcefully and still receive the same degree ofassistance since the cadence sensor measures the number of times your pedals are turnedeach second. It is fixed to the bicycle frame, and the crank, which may have one or moremagnets mounted, counts the crank's rotations. The torque sensor, which gauges howmuch torque the rider is applying to the pedals, is typically located on the pedal crank ornext to the rear dropout. The speed sensor, which operates on the same principles as thecadence sensor but monitors the real speed of the bicycle, is typically put in the spokes ofthe bicycle.

(a)Torquesensor (b) Cadencesensor (c)Speedsensor

Figure2.5.13:Typesofsensors

You can pedal very lightly or extremely forcefully and still receive the same degree ofassistance since the cadence sensor measures thenumber of times your pedals are turnedeach second. It is fixed to the bicycle frame, and the crank, which may have one or moremagnets mounted, counts the crank's rotations. The torque sensor, which gauges how muchtorque the rider is applying to the pedals, is typically located on the pedal crank or next to therear dropout. The speed sensor, which operates on the same principles as the cadence sensorbutmonitorstherealspeedofthebicycle,istypicallyputinthe spokesofthe bicycle.

Due to their resemblance to standard motorcycle throttles, hand throttles were the first tobe utilised in EPACs. However, due to EU regulations—which were previously mentioned inthe section "Legislation"—the motor could only assist the rider when they were pedalling,whichgaverisetothe pedalassistsystem.

In comparison to throttle mode, PAS offers a number of benefits, including being morehealthierforbatteriesduetothepowerdemandbeingmuchmoresteady andwithoutsignificant power peaks. The pedal assist mode will typically have more range if the rideralways needs to pedal, enabling them to cover more distances with the motor's aid. It's also aloteasier andmore intuitive to drivein this mode, much like on a regular bicycle, becausethe driver only needs to pedal and pay attention to his surroundings. In some E-bike models,the two controller types are combined. This is particularly helpful because it allows the driverto alwayshave PAS assistance and stilluse themanualthrottleforanextra boost.

CHAPTER - 03

ELECTRICALBICYCLEPROJECT

It is not simple to create a cutting-edge electrical bicycle with a concept design andfeatures that could directly compete with the rivalry and the modern advancements that themarket is currently exhibiting. It demands more time and money than is available for this kind ofundertaking, as well as a substantial financial expenditure. It would also need access to cuttingedge tools, materials, and construction techniques, as well as highly trained labour. As a result,and in the event that we are unable to overcome all of these hurdles, at least part of them, we willbe comingupwithtwodistinctdesigns.

Thefirstdesignwascreatedfromacompletelyoriginalconceptwiththeaimofdeveloping a special electrically assisted power cycle. This one was anticipated without payingparticular attention to the previously mentioned challenges, that is, taking into account a higherdelivery cap, sufficient financial inputs, and availability to building techniques, machinery, andskilled labour. Even so, we made an effort to employ materials and construction techniques thatare generally accessible and ubiquitous. With this, we aimed to create an electrically assistedbicycle that could compete with the present market while also meeting all the demands andspecifications we had presumptively identified for a bicycle made for thisparticular use. It isvital to remember that this design only represents a base case; more testing and refinement arerequiredtoproducea goodandtrustworthyfinalproduct.

When it becomes clear that we won't be able to construct a prototype in this manner, wemust think about an alternative design that falls within our realm of possibilities. We'll make aneffort to preserve the primary elements and top qualities of the earlier design in this one. Tocreate a completely functional prototype, it should be as similar to the one we've created fromscratch as feasible while still being within the realm of possibility. This prototype is meant to beconstructed using existing bicycle components and modified to provide a testable and practicalprototype.

After identifying the project's primary criteria, we will show both designs in this section,outlining their key characteristics, the judgementswe had to makefor each component, as wellas thefactors thatinfluenced our choices. Additionally, we will assess the key distinctionsbetween the two designs and the practical effects these modifications would have on how thebicycleis used.

PROJECTREQUIREMENTS

There are a number of aspects that go into projecting a vehicle, and those factors increaseif the vehicle is made for a particular use or application, as itis in this work. Therefore, it'scrucial to establish some fundamental requirements, even though some are more crucial thanothers. We shall outline the principal specifications and goals that the vehicle must be able todemonstrateoraccomplishinthecourseoftypicaluse:

- Autonomy - This element is crucial in all types of vehicles, but it is crucial in electricalones because it restricts the rider's options and limits the vehicle's range. Additionally,charging the battery takes time and requires a power outlet and a battery charger; in otherwords, if the battery completely discharges while travelling, it cannot be charged withoutcertain conditions and equipment. We've thought about the idea that a bicycle has adefined use, two daily routes, and a constant path, such as home-work-home or home-public transportation-work, then returning home. According to a 2011 census analysiscovering the areas of England and Wales, those living and working in London had anaverage daily distance to cover of 11 km when travelling to and from their place ofemployment[29]. With this in mind, we established a minimum autonomy of 25 km,figuring that it would be sufficient for daily operations or provide for the ability to travelfurther if necessary. This autonomy can be readily increased by utilising two sets ofbatteries, with one setserving as a backupfor the other while itdrains, or by using alarger battery with a higher capacity, but larger capacities result in heavier batteries,whichareinconflictwiththeweightrequirement.
- Weight–Thiscrucialcriterionisonethatisfrequently usedtodescribeandrankbicycles. The bicycle must, of course, be as light as possible, but we must be realistic andrealise that we won't be able to design a truly light bicycle in comparison to those on themarket now if we are constrained by the production procedures and materials that arecurrently available. However, the weight will be a constant worry throughout the projectand willhave a significantimpactoneverydecisionwehave tomake.
- Convenience of transportation - The bicycle will be quite heavy when it is complete,maybe too heavy to be carried over long distances. Therefore, a solution should be foundtomakeitportablewhenfoldedwhilecompensatingforitsweight.Itisbesttofoldthe bike in such a way that it can be transported folded, in a small package, with both wheelsonthe ground,andinaformthatisbothbalancedanduser-friendly.
- Easy to fold – A folding bicycle's folding system is an essential part. To maintain thebicycle rigid and stiff, it needs to be sturdy and safe, but it also needs to be practical andsimple to lock and unlock. The bicycle must be able to be folded and unfolded quicklyandconveniently,butitmustalsoprovideassurancethat,oncelocked,itwon'taccidentallyorunintentionallyunlock,whichcouldput theriderindanger.
- Safe - As with any vehicle, safety is a key and important necessity. Because bicycles areintended to be used in public settings, every project must be developed and conceivedwiththerider's safetyandthesafetyofanybystandersinmind.

CONCEIVEDDESIGN

ComponentAndMaterialSelectionMotor

A motor is an essential part of an electrical bicycle, thus care and consideration must be usedwhile selecting one. The frame, tyre size, and gear scheme of the bicycle must all be consideredwhile selecting the best motor. The reason for which the bicycle is to be used is just as crucial as,if not more so than, the motor choice. A bicycle made for weekend rides or riding in off-roadterrain, for example, has a significantly different set of features and characteristics than one madeforuseas amodeoftransportationinacitycontext. Therearethreedifferentmotortypesthatcanbeusedinbicycles,asdescribedinsection

These include mid-drive, hub, and friction-drive motors. Each of the three has distinctbenefitsanddrawbacksandisbettersuited forparticularusesandcircumstances.

Thefriction-drivemotorsarethefirstof thethreeoptionstoberuledoutsincetheyhavea number of drawbacks when compared to the other two. They are more prone to failure than theother motor types even though they are simple—both the motor and the process of converting aregular bicycle into an electrical one are simple. The power gearbox occurs due to frictionbetweenthebacktyreandmotordrive,aswaspreviouslydiscussedinthechapter.Theperformance and output of the motor are significantly influenced by the friction coefficientbetween these components. The motor drive may slip on the tyre, defeating the function of themotor, if the friction coefficient varies considerably, is easily diminished, or even disappears.SuchSituationsthatareproblematicforbicycleusecanhappenfrequentlyforavarietyofreasons, including wet weather, tyre tracks, vibration from uneven ground, and even trying tomove up a steep hill. These situations call for high torque rates, which can easily overcome thefrictionrequiredtomovethebicycleforward.

Hub motors and mid-drive motors are the only remaining motor types. Both are regardedas viable options and the best options for the given situation. Each one has its own benefits anddrawbacks, and we will use the Pugh Method to help us weigh all the factors that will influenceour decision. With this, it is anticipated that we will be able to make an intelligent and justifiabledecisionbetweenthetwooptions.

Prior to choosing a motor, it's crucial to establish the criteria that will be considered, aswell as the relative weight and significance of each criterion in light of the intended use andpotential uses of the bicycle. In this study, we took into account nine different factors, each ofwhich was given a weightingof 1to5 (with1beingtheleastimportantand5 themostimportant) basedonhowsignificantaroleitplaysinselectingtheoptimummotorchoice.

- Weight - When discussing a bicycle, weight is always a crucial consideration. The weightof the motor, which typically accounts for 25% or even more of the total weight of thebicycle, has a significant impact on the overall weight of an electrical bicycle. This aspectwas thus identified as having the mostsignificance among the others for the motorchoice. Given that it will likely need to be carried in weight at some point along the path,thisbicycle'sintendedusemayrevealittobeevenmoreimportant.Intermsofclassification, hub motors received a score of 5, whereas mid-drive motors received ascore of 4. Hub motors typically tend to be lighter, despite the fact that both motor typesgenerally show equal weight fluctuations. Nevertheless, a lot depends on the motor itselfand which manufacturer made it. As a result, the motor type has less of an impact onweightvariationthanthemotoritself.
- Mass centre – This criterion focuses on the impact that the motor's mounting position hason the mass centre of the bicycle. As previously mentioned, the motor often makes up25% of the total weight of the bicycle, thus it has a significant impact on how the mass isdistributed over the frame. The location of the bicycle's mass centre, or the combinedmass of the rider and the bicycle, affects how the bicycle handles and responds to therider. Thus is another crucial element in the decision regarding the motor. Hub The massdistributionisshiftedclosertoeitherthefrontortherearwheeldependingonwhich wheel has the motor placed in the hub. This is not the greatest choice, especially whenconsidering the mid-drive alternative, because our goal with regard to mass distribution isto have the mass centre as low and centred in the bicycle as possible. As was previouslysaid, this type of motor is situated close to or inside the crankset, which is thought to bethe finest location to be once it lowers and centres the mass centre. Due to this, we havegiventhehubmotorascoreof1andthemid-driveoptionascoreof5.
- Performance - Mid drive motors are able to produce better outcomes and with highertoques when it comes to performance. This is primarily due to the fact that they cantransmitmorepowerbecauseitispasseddirectlytothecrankandchain, enablingthemtooperate with the bicycle's built-in gear system. Hub motors, in contrast, are situated in thecentre of the wheel, requiring the motor to exert more energy to provide the same output.When contemplating a front hub motor alternative, a motor with high torque rates wouldcause the frontwheel tospin andlose traction,hence hub motors are unable toachievethe same torques that mid-drive systems can. We have allocated 2 to hub motors and 4 tothe mid-drivealternative as aresultofthis.
- Price - Hub motors are more affordable than mid-drive motors in terms of price. Hubmotors are a form of motor that is now widely accessible on the market and are simplerthan other types of motors, which accounts for their various cost rates. According to thepreceding chapter, these motors originally arrived with the first electric bicycles around1900, making them considerably more accessible now and less expensive than mid-drivemotors.Mid-drivemotorswere givena3and hubmotorsa5,respectively.
- Wear and tear - Although this criterion initially appears to have no bearing on the bicycle,it might later disclose to be troublesome and result in additional costs. A continuouslubrication and inspection on the components that suffer from significant wear and tearcan avoid or forecast accidents. Of course, there are techniques to prevent or decreasewear and tear as much as feasible. Since all the parts of a hub motor are contained insidethe hub and there aren't many moving parts, neither the motor nor the bicycle's parts aresubjected to much wear and tear. Because mid drive motors have more moving parts and,asis common knowledge, transmittheirpower through bicycle partslike the crank,chain,andchainrings,thissystemrequiresmoremaintenanceandcausessomebicycle parts to wear out more quickly. As a result, we assigned 2 to the mid-drive motor optionand4tothehubmotor.

We can infer that the optimal option for the motor would be a mid-drive system afterconducting this comprehensive research and taking into account the choice method findings,which were 100 for hub motors and 117 for mid-drive motors. This is not to say that hub-motors are bad systems or that they are a poor choice for electrically propulsion of a bicycle;on the contrary, they are a good choice and a "tried and true" system. Even so, mid-drivemotorsshouldbeasuperioroptiontomeetourneedsforthisparticularspectrumofapplicationsand whentakingintoaccountthe criteriachosen inthedecisionapproach.

Knowing that we would utilise a mid drive motor, the decision now centres on which ofthe many motors on the market we will employ. They can be broadly split into two groups:those thatrequire a specificframe with fixation points and contours thatmatch themotor,and those that can be put in the bottom bracket of the majority of bicycle types, turningvirtually any regular bicycle into an electrically assisted bicycle. We chose this option sincethe first group includes the better and more inventive motors now on the market, and becausebuilding the frame would make it easy to create the proper fittings and mountings. The"Bosch ebike system," "Shimano Steps," or "Yamaha ebike system" were among of themotor's potential makers. These are well-known companies, and their products appear to beamong the best available on the market. The three systems under consideration use threedifferenttypes of motorsensors—cadence,speed,andtorque—andall three have quiteeffective systems. These contribute to the creation of a simpler, more user-friendly interfacebetweentheriderandthe bicycle,producinga veryuser-friendlyendproduct.

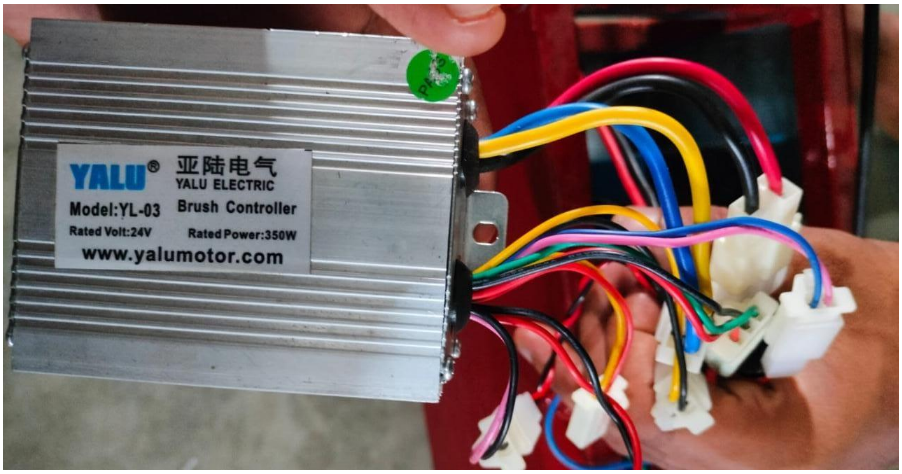


Figure3.1:Brush Controller

Battery

Asforthebattery,wewanttocreatethebatterypackoncetheframeisconstructedentirelyfromscratch.Aspreviouslymentionedinthechapter ,thebatterypackisintendedtobeinstalled inside the frame, therefore doing so would enable us to customise its shape and adjust it to betterfit the frame, making it invisible during assembly. The whole battery wiring and connections tothe motor would be concealed and inaccessible from the outside by being housed inside theframe. All batteries share the characteristic that increased power and storage capacity result inincreasedweightandvolume.

First, the choice relies between the three major types presented: Li-ion, Nickel or Leadacidbatteries.

Being the oldest battery type among the others, lead acid batteries also have the fewestbenefits and the most drawbacks. They are far heavier and larger than lithium or nickelbatteries, and as was previously stated, weight and volume are crucial requirements for thisproject. Due to the fact that they typically only permit up to 500 charge cycles, they also havesubstantially lower life expectancies. Lead acid batteries are less effective in transmittingpower and lose energy during both charging and discharging than lithium batteries, whichhave efficiencies that are very near to 100%. Lead-acid batteries have another significantdrawback in that their voltage consistently decreases during the discharge cycle. This has animpactof ridingconditionsbecausethebicyclelosespowerasthebatteryisbeingdischarged,butitcanalsocauseissueswithotherelectricalcomponent slikethemotor.

When choosing between nickel and lithium batteries, the main distinction is in how muchenergy can be stored in each type of battery. Because nickel has a lower energy density thanlithium, nickel batteries are larger and heavier than lithium-ion batteries with equivalentpower and energy storage capacities. Comparing lithium batteries to nickel batteries revealsvariousbenefits.Lithium batterieshavealongerexpectedlifespan,aremoreeffective,produce greater voltages, and require significantly less time to recharge (up to 70% less time,depending on the batteries). Nickel batteries must be completely depleted before charging inorder toavoid thememory effect,which occurs when batteries arefrequently rechargedwhile still only partially discharged. maximum amount of energy. However, lithium batteriesalso have drawbacks. For example, they are more expensive than nickel chemistry batteriesandneedanadditionalpartcalledaprotectivecircuit,alsoknownasaBMS(batterymanagementsystem), which was coveredin the chapter before. In terms of their effects onthe environment, lithium batteries are secure and free of dangerous substances, but the samecannotbesaidofthenickelchemistry,particularlythe(NiCd)battery,whichcontains6to 18% of thedeadlyheavy metal cadmium.Thesenecessitatespecial careduringbatterydisposal, and in some nations, like the United States, a fee for the battery's proper disposal atthe endofitsservicelifeisincludedinthe price ofthe battery.

Following this analysis and takingintoaccount the three battery types' benefits anddrawbacks, it is clear that lithium batteries are better suited for the type of use that they areintended for.However, because there are numerous variations and material combinations forlithium batteries, we must select the battery pack's chemistry and format based on theirsuitability.Wehavedecidedonlithiummanganeseoxide($LiMn_2O_4$)aftercarefullyweighing the qualities and formats offered by each lithium battery chemistry. In the world ofelectric bicycles, this is the most typical lithium battery chemistry. It is a battery type that isextensively used and has favourable qualities in general, including size, weight, and price.Also among the safest of the lithium battery alternatives, this chemistry. We chose the 18650battery type for the battery.

It is a battery design that is well known for the advantages itoffers,includingtheaffordability,thevarietyofapplicationsitmaybeusedfor,thepossibility of purchasing from reputable manufacturers, and its longevity. This design wascreated by manufacturers to produce a dependable and multipurpose battery. Although thecharacteristics of 18650 batteries can vary depending on the model type or manufacturerspecifications, their key characteristics can be generalised. They developed into a reliable andsecure alternative, which inspired some reputable manufacturers, like Sony and Panasonic, todevelop and produce the lithium-charged battery. Higher production rates and lower pricingwere the result. The 18650 battery continues to be produced in greater quantities and at lowercosts as researchers discover new applications for it, making it very well-liked by electronicgadgetbuyers. Liquidleakage from electrodes are prevented by the battery's cylindricalshape. The size of 18650, which is 18mm in diameter and 65mm in height, is how it acquireditsname.fabricatethelithium-ionbattery.

Figure3.2: 18650battery

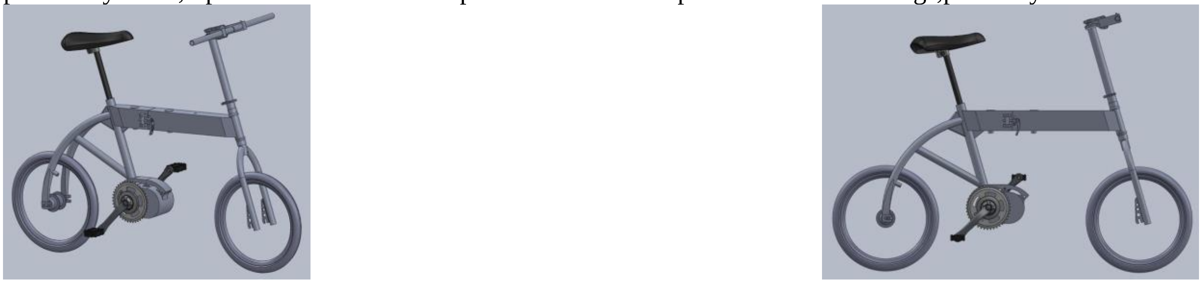
Today, there are already a number of alternatives and businesses that produce and sellbatterypackssimilartotheonedescribedandthatweintendtobuild.However,by purchasingabatterypackthathasalreadybeenmade,wewouldnotbeabletocustomiseittofitinsidetheframeandbeunnoticeable.

Wheels

As previously mentioned, wheels and wheel size play a significant role in the bicycle.They significantly affect how the bicycle rides, handles, and feels in terms of comfort andsmoothness. We should choose a small wheel size if one of our key goals is to minimise theamount of space the bicycle takes up. Despite this, narrow wheels make it difficult or unsafeto manoeuvre a bicycle around obstacles like kerbs and potholes in the road. Therefore, wedetermined that 20" was the best size for a bicycle with these kinds of applications. Thebicycle's modest size is sufficient to keep it compact, but it is still large enough to be safe andreadilynavigatemostchallenges presentedbyacitysetting.

ModelDescription

Only theframein thismodel wascreated in aCAD programme with theintention ofbeing built, despite the fact that all of its components are depicted in a 3D model. This framewas planned and thought out in order to meet the criteria of our project and, as previouslystated,toprovideaworkableandsuperiormethodoftransportationinurbansettings,primarilyfocusedonthe"lastmile"notion.



(a) (b)

Figure3.3:Conceiveddesign

The frame was constructed taking into account the normal measurements and typicalcomponents in bicycles because it was the sole component intended to be built and conceivedfrom scratch. Making it simple to locate and match the remaining parts, such as the wheels, seatandseatpost,headset,fork,stem,andbrakingsystem,totheframe**.**

Costestimation

In this section, we'll estimate the cost of producing this particular bicycle. However, itcannotbepredictedwithaccuracybecausesomecosts,includinglabourandbuildingprocesses,amongothers,cannotbepreciselyestimated.Nevertheless,wewillmakeeveryefforttobeasaccurate andconservativeaswe cangiventhe unforeseencosts.

Table3.4: Component costs

Component	**Price**
Motor	1500upto2000e
Batterypack	160e
Gearsystem	60e
Foldingpedals	15e
Brakingsystem	50e
Wheelsandrims	40e
Seat	10e
Chain	10e

Headset	20e
Stem	10e
TOTAL	1900e

Thereby,thetotalcostforbuildingandassemblingthebicycle,consideringgenericpricesforthecomponents,willbearound3310e.

PROTOTYPEDESIGN

This section will describe themodel thatwe created in order to build a completelyfunctional prototype. outlining the model's primary features and qualities and explaining thedecisions we had to make regarding its component parts. We decided to use a frame and partsfrom an old bicycle because we had to deviate from a frame that had already been constructed.Wemade an effort topreserveits traditional aesthetics andfundamental aesthetics. By doingthis, we hope to create a low-cost prototype that maintains its vintage appearance while beingupgradedandrestored.Inthismanner,theendresultwillbuildalinkbetweennewandantiquatedtechnologyinordertoproduceasuperiorresult.

COMPONENTANDMATERIALSELECTION

Frame

As previously mentioned, the scope of our project is limited, thus we won't be able tocreate a completely functional prototype like the one we've already modelled and presented. As aresult, a different design will be offered in this part that takes our restrictions into considerationand considersmore practical and realistic alternatives. However, themain features and benefitsoftheenvisioneddesignwillbeattemptedtomaintaininthisprototype.Itismeanttobeconstructedusingpartsfromexistingbicyclesthathavebeenmodifiedtofitourneedsandtheproject'sspecifications..

Figure3.11: Originalbicycle Motor

A mid-drive motor is still the only option in terms of the motor. But in this case, since weare constructing the bicyclefrom aframe that has already been constructed, we will choose touse a mid-drive motor that will be mounted in the bottom bracket rather than a motor that needsan adjusted frame with special mountings. This makes it simple to fit in the frame and requiresfew adjustments.

Figure3.13:Selectedmotor

The motor was made by the Bafangcompany, which has a solid reputation in the e-bikeindustry. The "Bafang BBS01B" weighs 3,7 kg and has two different kinds of sensors: cadenceand speed. The bicycle is powered by 36V and 250W. It has a torque capacity of more than 80 Nand an efficiency of more than 80%. The motor includes crankarms, a chain wheel, a speedsensor

that mounts in the rear wheel, brake levers that are connected to the motor and cut power.
when thelevers are actuated,a thumb throttle thatallowsforthe management of themotoroutput and can be used for a "extra push" if necessary. The motor also has a built-in controllerand PAS. Additionally, it includes a handlebar-mounted LCD display with three assistance levelsthat can be used to control the level of assistance provided by the motor. The LCD display alsoprovides additional information such as the current vehicle speed, battery charge, and mileage.This motor features an additional assistance mode thatshould be employed when the riderdismounts from the bicycle and is moving the bicycle through the handlebars while walking onfoot. The motor provides nimble helpin this mode,makingiteasier andless laborious totransportthebicycle.

Figure3.14:Handlebarassembly

Battery

In terms of the battery pack, we have chosen to purchase onethat has already beenconstructed. This choice was made for a number of reasons, including the constraints on buildingmethods and equipment. For example, building a battery pack according to our original designcalls for a spot welder machine to connect the batteries, a battery management system, as well asthe skills and knowledge necessary to create a marketable product.

Figure3.15:Selectedbatterypack

The item weighs 2.8 kg and has measurements of 24.5 x 7 x 10 cm. The battery pack thatis selected includes a mounting bracket that is used to secure the battery to a tubular support inthe bicycle frame. The frame tube is enclosed by the holder, which is bolted to it. Sliding thebattery from the holder allows for simple removal. The battery holder also contains a key lockthatmakessurethe batteryissecurelyfastenedandlowers the riskoftheft.

36V and 9Ah together produce 324 Wh (324 Wh = 36V x 9Ah). The motor may run for1,3 hours on a single charge if the battery pack range is predicted using the same calculationmethod:324Wh_250W'1:3h.Withamediumspeedof20km/h,thepredictedrangeisapproximately 26 km (20 km/h _ 1:3 = 26 km). As previously stated, this method of estimatingthe range is cautious and only serves as an approximation because therange is influenced bymore thanjustthebatterypack'scapacity.

Figure3.16:Battery packlocalization

A battery,forexample,has the freedom tobe installed practically whereveron thebicycle when it comes to how the electrical components are distributed throughout the vehicle.Even so,certain parts,such asthethrottle,LCDdisplay,andmotor,mustbeattachedinparticularlocations in order to function. We considered a number of aspects while decidingwhere to attach the battery pack, including its impact on the mass centre, its ease of removal andmounting, its proximity to the motor, and the simplicity of the electrical connections. Since thebattery is a relatively heavy component, its location along the framewill have a significantimpactonthemasscentreofthebicycleand,consequently,onitshandlingcharacteristics.Thisis the factor that we have deemed to be of the greatest importance. The grid behind the seat orabovetherearwheel,theseattubeandinthetoptube,infrontofthehingethatfoldstheframewere the other options for where to place the battery. The seat tube was deemed to be theoptimum option when taking into account the aforementioned factors. Compared to the otheroptions, it can be put at a lower position, which results in a lower mass centre for the assembly.Due to its proximity to the motor, the wire needs to be shorter, creating a safer connection andsimplifying the installation. In any of the possible orientations, removing the battery from theholder would be a simple operation because the holder allows the battery to be removed bysimplyslidingittothe side.

Handlebar

The handlebar in the previous design could be retrieved into the head tube but it wasn'tcollapsible. As a result, we will employ a handlebar with a hinge that moves the handlebar to theside of the front tyre in order to obtain a more compact form when folded. This resulted in afoldable configuration that was much more portable and easy to store. The handlebar can befolded quickly and effectively since the folding system is locked with a quick release skewer. Inan effort to maintain the bicycle's original and timeless aesthetic, we searched for a handle barthat would seem similar to the original but be superior and could enhance the bicycle's capacityforfolding.

Through a conical wedge boltsimilar to the one in the figure, the stem (the bottomportion of the handlebar set) is fastened to the headset. In the folded position, it is pressed upinside the hinge, pushing the wedge up and up against the interior of the headset to create a tightfix.

ModelDescription

The handlebar set is made of prated steel, while the majority of the bicycle's parts aremade of an alloy of steel. The frame alone weighs about 10 kg, as shown in the image below, butnotincludingthewheelsortheseatandseat-post.Theweightoftheentirebicycleassembly shouldberoughly20kilogrammes,withthebatteryalonebeing2.8kgandthemotorweighing 3.8 kg. However, certain components, most notably the battery pack and the motor, are stillmissing. The handlebaris the component that determines this dimension, which is roughly 1,40mlong,1.06mhigh,and56cmwidewhenitisinstalled.

Figure3.19: Assemblyofthemodel

Costs

We will outline the costs associated with producing the prototype in this section. Incontrast to the predicted expenses for the imagined model, the costs of producing the prototypecan be reduced to the cost of the individual components because the thesis author handled thebuildingprocedures andlabour.

Table3.3: Component costs

Component	**Price**
Motor	600e
Batterypack	350e
Bicycle	100e
Foldingpedals	15e
Brakingsystem	35e

Wheelsandrims	15e
Seat	20e
Chain	10e
Paintjob	75e
TOTAL	1900e

Thereby, thetotalcostfor buildingandassemblingtheprototypewas1305e.

3.4COMPARISONBETWEENTHETWODESIGNS

In this section, we'll evaluate the two models' compliance with our project's requirements,compare them,anddiscusstheirkeysimilaritiesanddifferences.

First, we'll evaluate and contrast both models' compliance with the project's requirementsfor weight, autonomy, portability, foldability, and safety. The prototype model weighs 20 kg,which is significantly heavier than the anticipated 15 kg weight of the designed model. Theprimary cause of this discrepancy is the difference in mass density between the raw materialsused tomake theframes, steel and aluminium.Despite this, the weightof the aluminium andsteel frames is fairly considerable, and it is not possible to greatly reduce this weight by usingmaterials that are so widespread and generally simple to work with. In terms of the models'autonomy,bothbatteries'capacities—321.9Whforthedesignedmodel—arerelativelycomparable. As a result, their range should be similar, but since the aluminium frame is 5 kglighter, this model should have a wider range. Because the first model enables it to be transportedsimilarly to a trolley, it should be simpler to transport the bicycle when it is folded. It can becarried similarly to the prototype, although it is more difficult and less convenient for the rider.Regarding the capacity for folding, both models offer easy and quickfolding techniques toproduce a compactshape. Both models can befolded and unfolded quickly and easily with alittlepractise.Theprototypemodel'sfoldedassemblymeasures77x29x86cm,whilethedesigned model's folded assembly is 75x40x77 cm. Therefore, there aren't any big differencesbetween the two. Both frames were structurally analysed using the finite element method, whichis why their structures are regarded as safe to use in terms of the models' usability. The prototypemodel's wheel base is 90 cm while the conceptual model's is 1 m. This reduces the size of theprototype model slightly when it is installed, enabling easier transportation of the model in thisstate.

CHAPTER - 04

PROTOTYPECONSTRUCTION

The primary challenges we encountered, themodifications or adjustments we had tomake to the components, and the procedures we utilised to do it will all be presented in thissectionaswe describe the constructionstagesthatleadtothe finalprototype.

MAJORDIFFICULTIES

Weencountered various challenges as we werebuilding andmounting. Theframe wasthesourceofthemajorityoftheissuesbecauseitwasanoldframewithnon-standardmeasurementsthatneededto be adjustedinordertomake thecomponentsworktogether.

Finding parts that could be adjusted to the dimensions and fastening locations of thebicyclewasamajorchallenge.Componentslikebrakecalliperswere difficulttocomeby,andthe original bicycle and frame mountings were made to use a horseshoe-shaped braking system,which is no longer in use. Nevertheless, after a thorough search across numerous dealerships, weare able to locate the exact calliper model for which the frame was designed and which wasutilised by factory default. The handlebar was particularly difficult to get because there aren'tmanyvintagebicycleswithusable,foldinghandlebars.

A specific washer is needed in the rear hub's internal gear system to lock the hub axle andpreventit from spinning. This washerjoins the rear hub axle to the rear dropout; the washer'stwo parallel faces perfectly fit the axle's two parallel faces, keeping the washer from spinning.Two grooves that fit in the rear dropout must also be present on the washer's outer surface. Thesewashers are essential parts because the gear system wouldn't function without them. The washersthat came with the bicycle (the originals from the manufacturer) were extremely worn out anddeformed and couldn't fulfil their purpose, so they had to be replaced. Even after a thoroughsearch,wewereunabletolocatethesepartsbecausetheyarenolongerbeingproduced.Additionally, because they are a very worn-out part, we were also unable to find them on anyusedbicycles.Inorderforthegearsystemtofunctionproperly,wethereforehadtoconstructtwo of these washers. All of the challenges relating to the construction process and componentadjustmentswereultimatelyovercome.

COMPONENTALTERATIONS/ADAPTATIONSANDPROCESSESUSED

Even so, there was a very slight fit issue with the handlebar stem and wedge nut withinthe headset. The headset didn't have the usual diameter, but the handlebar did because it was apart of a more modern model. We chose to use a lathe and remove a small portion of materialfrom the bottom half of the stem and from the wedge nut because it didn't fit by a tiny amount.Less than or equal to one millimetre of material was removed. By carefully and incrementallyremoving the material, we were able to create a strong and secure connection between thehandlebarandtheheadset.

Due to the non-standard size of the bottom bracket, the motor could not fit. The motor'schainring and the rear sprocket were noticeably out of line when it was assembled in the bottombracket at its original length. So, to shorten the bottom bracket, we used an electric grinder. Toretain the bottom bracket in the middle of the bicycle, the material was taken from both sides. Bydoing so, we successfully decreased the chain's misalignment and decreased the risk of the chainjumping off.Several supports that were welded to the frame were alsoremoved using thegrinder.

We employed a chemical procedure to remove the old paint and rust from the frame.Pickleliquor is used repeatedly until all of the rustand ink has been eliminated, leaving theframe clean and ready for painting. The paint work was completed in three stages. The first stepinvolved spraying a primer layer using the appropriate ink for this type of application. It shieldsthe metal from rust and provides an appropriate rough surface for the ink to adhere to. The finaloutcome wasthenachievedbyprayingtwo layers ofblackink. The handlebar, stem, hubs, spokes, and some embellishments on top of the fork andheadsetare justa few of the chrome-plated parts of the bicycle. Wefirstsanded and cleanedthese with steel wool before treating them. After that, and to get the desired outcome, we used"Duraglit,"ametalpolishermade to eliminate tarnishandprovide a glossysheen.

We began with a solid piece of steel to make the unique washers that prevented the rearaxle hub from spinning. We utilised a lathe to giveitits rounded external shape, a manualmilling machine to make the grooves that fit into the frame dropout, and a borer to make thefitting for the axle. A small square-shaped file was used for the last adjustments and to ensure aflawless fit between the washer, axle, and frame. The washer was constructed, then painted usingthe sametechniqueasthebicycleframe.

Figure4.1: Concluded prototype

Figure 4.2:Assembly of Parts

CHAPTER5
GLOBALPOSITIONINGSYSTEM(GPS)

Due to the fact that they include a power source, e-bikes have special options for trackingusage patterns and understanding how they interact with the urban environment, which could beadvantageous for both e-cyclists and traditional cyclists. Understanding how e-bikes are used inparticular geographic and cultural situations might assist to comprehend and communicate theirpotentialadvantagesforsustainabletransportationandbeyond.

In this paper, the term "e-bike" refers to bicycles with a small motor and battery whereriders always have to pedal but can engage electric assistance (often with a choice of low,medium, or high settings) if they so choose. When the peddling stops or a speed of 15 m/h (25km/h) is reached, the assistance stops. These electric bicycles, often known as pedelecs, are usedin several European nations. There are other e-bike models available, such as ones that allowassistance to be utilised without pedalling; they are very common in several Asian nations, butare outside the scope of this study. The models used in this study represent two of the mostcommon motor and battery configurations available for e-bikes: (i) a front-hub motor with arack-mountedbattery;and(ii)a crank-drivenmotorwitha centralbattery.

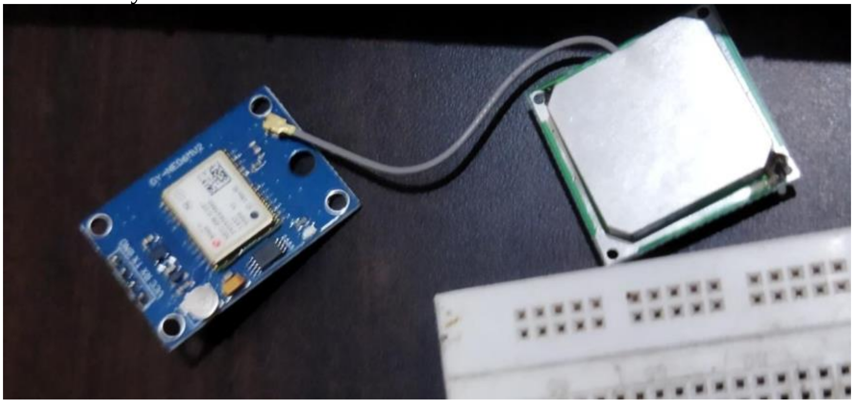


Figure 5: GPS

Since tracking moving objects requires battery power, this technology has primarily beenapplied to moving objects that already have batteries, which are typically motorised vehicles likecars, lorries, boats, or trains. A moving object without a battery, such as a regular bicycle, makesmonitoring more difficult because devices cannot draw power from an existing source. As aresult, many methods of monitoring bike use have concentrated on the rider's own gadgets (suchas their mobile phone) or on mounting long-lasting devices to bikes (such as GPS trackers). Bothstrategies, while useful in the absence of other options, have drawbacks because they demandcompromisesin terms of data quality and/or reliability.

Theformer relies on people carryingtheir phone on every trip they take (with the relevantapplication running), while the latterrequires a second device to be charged, turned on, and attached to the bike (plus, selecting asetting that increases the device's battery life results in less data being retransmitted). E-bikesinclude an on-board battery thatmay be connected to a monitoring system,which records thebike instead of the rider via their phone while maintaining data quality (as is frequently the caseincyclingresearch).

Numerous projects show how to collect sensor data from cyclists. Cycling enthusiastswere requested by Dill and Gliebe [6] to put a GPS device on their bikes and turn it on beforeeach journey. After a period (of at least 7 days), the data was collected from the device. In their2007study,164individualsroderegularbicyclesequippedwithGPStrackersfor(atleast)7days each. In order to evaluate the impact of various types of infrastructure, such as bicycle lanesor trails, on bicycling, the research sought to map where cyclists were riding their bicycles inPortland, Oregon. The researchers used a GPS personal digital assistant called the Garmin iQue,which was set to gather extra data from trial participants regarding the route and the associatedweather that had to be manually entered for each trip. For each journey the trial participants took,the device had to be mounted on the bike (different mounting for each type of bike). The device'smemory card was used tostore the data. Following the device's collection,the researchersanalysed and visualised the data. Then, trial participants accessed maps of all their trips throughan online interface and were asked to provide more details for each trip. Trial participants had toputina significantamountofefforttodothis.

Both the Biketastic and UbiActive experiments solely used the phone's built-in sensorsand employed Android programmes that were installed and running on the participants' ownphones. The Copenhagen Wheel went a step further by using Bluetooth sensors mounted on thebiketoconnectriders'phones.PaefgenandMichahellestrackede-bikesusingtheTelexPicotrackGPSmonitorandgeneralpacketradioservice.TheBikeNetprojectusedacellphoneto monitor several sensors, including as video and pollution monitors, and communicated dataovermobilenetworks andWiFi. The Picotrackmonitorfrom Paefgen demonstrates howamonitor can operate independently utilising electricity from the e-bike battery, although thesemodules are only capable of GPSsensing.A niceillustration of how touse a mobile device asthe focal point of a monitoring system is the BikeNet project.

The Campus Mobility initiativealsokept track of e-bike usage on a college campus. They made use of a GPSmoduleinstalledonthebikeandasmallAndroidtouchscreencomputer.

There are a number of public bike programmes that track utilisation data in real-time,however they depend on parking and charging facilities. E-bike rental programmes existincountries like Germany and the Netherlands, as well as in the San Francisco Bay Area, theUniversity of Tennessee-Knoxville, and a future pilot programme that will integrate with a car-sharingcompany.Whilemosthireschemesdonotcollectdataontheactualjourneybetween stations, many do record data when bikes enter and exit parking stations. Instead of GPS data ofthe actual path travelled, the trip data used when analysing the movement of bikes in public hireschemesusesthelocationandtime ofthe stationatthe startandconclusionofeachtrip.

Figure 5.1:Smart E -Bike

HARDWAREDESIGN

An Android phone, an open hardware interface board, and a custom power board toconnect the system to the e-bike battery make up the three primary parts of the SEMS hardware.The circuit diagrams for the unique power board for the Dover bicycle and the Velo-cité areshown in Fig. 4. Behind the bike rack, all components are kept in a small water and dust-proofbox.

a description of the hardware in the monitor system. SEMS is built around an IOIO boardand an Android phone. The IOIO is a cheap interface board that attaches to the phone using theUSBport.Itsupportsavarietyofdigitalinput/outputprotocolsandanalogueinputsforconnectivity with a wide range of sensors. Communication between a board and a phone is madepossibleviaanAndroidsoftwarelibrary.TheadvantagesoftheAndroidapplicationprogramminginterface(API)andphonesensors,suchastheGPSandaccelerometer,areprovided by this combination, which also makes it possible to customise the hardware in a veryflexible way using the IOIO. Importantly, the system can operate continuously without humanintervention thanks to the IOIO's ability to be powered by the bike battery, which can thenrecharge thephone.

Figure5.2GPSInstalledBox

PHONESELECTION

Several Android phones were evaluated in order to determine which one would serve asthe central hub of each monitoring system. Low cost, boot-on-charge capability, GPS signalquality, third generation (3G) connectivity, and long battery life were the main requirements. Tomeet the design objective of autonomous operation for SEMS, a phone needed to be able to bootup automatically (without user assistance) in a situation where it had run out of battery (for anyamount of time). Restoring the power source was necessary to restart the phone and start theSEMS app in addition to automatically starting the phone to recharge (i.e. attaching a chargedbike battery to the e-bike). This was done to account for scenarios where the participant woulddrain the bike's battery or take the phone off the bike, which would result in the phone runningout of battery.When trial participants weren'tusing the e-bikefor prolonged periods of time—for example, due to holidays or sick days—problems arose from an initial design thatusedmobile phones that don't reboot. As a result, this functionality became the main criterion forchoosing a gadget. Finding a cheap Android phone with boot-on-charge functionality was tough,but after some trial and error, a phone was discovered that, after rooting and tweaks to low-leveloperatingsystemfunctions,woulddothisconsistently.

CHAPTER-06

CONCLUSIONSANDFUTUREWORK

The goal of this project was to design and construct an electrically assisted bicycle thatwas suitable for urban environments. The idea is to develop a more superior and adaptable modeoftransportationforusageinurbansettings.Itshouldofferadvantagesandsuperiorcharacteristics above the standard options, such as public transportation, private automobiles, orregular bicycles. The project was designed to streamline and facilitate movement in large urbanareas generally, but it was primarily intended to be used in the "Last mile" idea. A study on theelectrical bicycle market was conducted, and the results showed that sales of these vehicles haveincreased significantly and exponentially over the past several years. It shown that electricalbicycles will undoubtedly be used in the future for a variety of applications, not just in urbansettings. Growing environmental concerns and technological advancements were two of the keyfactorsthatcontributedtothe market's currentlevelofprominence.

A survey was conducted with the goal of defining the primary needs in order to create aproduct that represents a workable option as a mode of transportation and is primarily focused onthe "last mile" idea. These specifications, which were taken into consideration, are essentialqualitiesandaspectsthatthebicycleshouldhave.Theyare:autonomy,weight,easeoftransportation, practicability, and safety. We might then move on to project and construct afeasible solution from these fundamental components. A bicycle, or an electrical bicycle, is madeup of a number of parts, all of which must be carefully picked in order for them to work togetherharmoniouslyandproduceaworkableandviablesolution.Beinganancientmodeoftransportation,bicycles and the components thatmake them uphave undergonesignificantevolution. Consequently, there are numerous options available for the various parts that make upa bicycle.On thisbasis,we evaluated themany componentpossibilitiesin order toselectsystemsthatwouldserve ourneeds andbe able toproduce aworkable set.

Due to the project's restrictions, as previously said, we created two distinct designs: onethat was created from scratch without much consideration for the limitations set forth, and theother that was created to be built and serve as a fully functional prototype for the project. UsingCAD software, the structural validity of both models was verified. The construction procedurecould start after the structural validity and component selections. The finished product displays acompletelyfunctionalprototypethatcanserveasarealistictransitoptioninacitysetting.Theprototypewasconstructedusingrecycledbicycleparts,andasaresult,wewereabletoproducea product that bridges the gap between the past and the present by combining a traditional-lookingbicyclewithmodernimprovements.

Improvement and reinforcement of the design, as well as consideration of other optionsthat may be more suited, to hold the bicycle in the folded position, would be future work anddevelopment of this project. Regarding the raw material used, there are various alternatives thatcanbeconsidered,includinglighter andmoresuitablematerialslikecarbonfibre.

With the help of this research, it was feasible to draw the conclusion that bicycles, andmore specifically electrically assistedbicycles,have playedan essential role as amode oftransportation and will likely continue to do so because they are constantly improving. Electricalbicyclesareanotion thatisintendedtoexpandandtendtobroadenitsfieldofusesastechnology improves and breakthroughs. With the help of this effort, we were also able to drawthe conclusion that although the technology that supports the notion has advanced greatly, it stillhas significant limitations. This largely pertains to the batteries because they are an essential partthat reduces the bicycle's range and increases its weight, which are two needs taken into accountfortheproject.Asbatteriescontinuetobeupdated,itisanticipatedthatthesesignificantdrawbacks will be resolved in the near future thanks to technological advancement. Additionally,new andmore effectivemotors are beginning to be developed,along with retroactive systemsthatenable batteryrechargingwhilethe bicycleisbeingused.

REFERENCES:

[1] A. Hrennikoff. Solution of problems of elasticity by the framework method. Journal of applied mechanics,1941.
[2] R. Courant. Variational methods for the solution of problems of equilibrium and vibrations.
[3] J. H. Argyris. Recent advances in matrix methods of structural analysis. Pergamon Press, 1964.
[4] M. J. Turner. Stiffness and deflection analysis of complex structures. J. Aeronautical Society, 1956.
[5] H. C. Martin. Plane elasticity problems and the direct stiffness method. Trend in Engineering, 1961.
[6] Y. K. C. O. C.Zienkiewicz. The Finite Element Method: Its Basis and Fundamentals. Butterworth-Heinemann,1967.
[7] S. Pugh. Creating Innovative Products Using Total Design: The Living Legacy of Stuart Pugh. Addison-WesleyPublishingCompany,1996.
[8] Bicycles produced in the world - worldometers. http://www.worldometers.info/bicycles/. Accessed:2016-08-08.
[9] O. Bolton. Electrical bicycle, 9 1895. URL http://www.google.com/patents/US552271.
[10] C. Tirelyc. theryc, 11 1896. URL https://www.google.com/patents/US572036.
[11] H. W. Libbey. Electric bicycle, 12 1897. URL http://www.google.com/patents/US596272.
[12] E. Parliament. Directive 2002/24/ec relating to the type-approval of two or three-wheel motor vehicles and repealing council directive 92/61/eec. Official Journal of the European Communities, 18March2002.
[13] E. C. for Standardization. Cycles. electrically power assisted cycles. epac bicycles. Technical Report EN 15194:2009,European Committee for Standardization, January 2009.
[14] E. Parliament. Directive 2001/95/ec on general product safety. Official Journal of the EuropeanCommunities,3December2001.
[15] E. C. for Standardization. City and trekking bicycles - safety requirements and test methods. Technical Report EN 14764:2005, European Committee for Standardization, September 2005.