School of Architecture Technology and Engineering

Installation of Electric Vehicle Charge Points in Brighton & Hove

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XE636 Final Year Project

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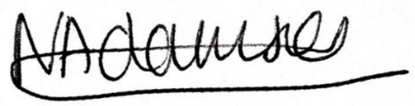
Final year report submitted in partial fulfilment of the requirements for the degree of BEng (Hons) Mechanical Engineering

DISCLAIMER

I hereby certify that the attached report is my own work except where otherwise indicated. I have identified my sources of information; in particular, I have put in quotation marks any passages that have been quoted word-for-word and identified their origins.

Signed: 

Date: 11/05/2022

Abstract

This report provides the details on the project ‘Installation of Electric Vehicle Charge Points in Brighton & Hove’, completed in partnership with the Brighton Energy Cooperative.

The aim of the project is to provide 3-5 suggestions of suitable locations for a solar photovoltaic array and a 7kW electric vehicle charge point installation. The locations must be within an area of low-income, technically suitable, and commercially viable.

The project followed an Engineering Systems approach, which breaks down the process into sub-systems and components to ensure successful project management.

Key methods include research within several key areas, data mapping, decision matrix and evaluative methods.

The project successfully suggests 3 locations, all within the West Blatchington area.

Technical and accuracy limitations are evaluated throughout, and suggestions for further work are provided, concentrating on methods of communication with businesses and residents.

Acknowledgements

I would like to show my deepest appreciation to Steven Begg for his continued support, constructive feedback, and guidance on this project.

I would also like to thank Brighton Energy Cooperative, Damian Tow and Noeleen Keen, as this project wouldn't be possible without their support.

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Abbreviations

B.E.C. – Brighton Energy Cooperative

B.E.V. – Battery Electric Vehicle

DG – Distributed Generation

D.N.O. – Distribution Network Operator

E.S.V.E. – Electric Vehicle Supply Equipment

E.V. – Electric Vehicle

E.V.C.P. – Electric Vehicle Charge Point

IoD – Indices of Multiple Deprivation

LSOA – Lower layer Super Output Areas

N.C.R. – National ChargePoint Registry UK

MILP – Multi Integer Linear Programming

OZEV – Office for Zero Emission Vehicles

PEV – Plug-in Electriv Vehicle (BEV + PHEV)

P.H.E.V. – Plug-In Hybrid Electric Vehicle

P.V. – PhotoVoltaic, best known as solar panels

REVUP – Regional Electric Vehicle Unified Plan

U.L.E.V. – Ultra-Low Emission Vehicles

ULEZ – Ultra Low Emission Zone

V2G – Vehicle to Grid: Smart grid capability to share charge

V.E.D. – Vehicle Excise Duty

1.0 Introduction

The UK government's "Ten Point Plan for a Green Industrial Revolution aims to accelerate the country's path to net-zero emissions". Point 4 is accelerating the shift to zero-emission vehicles, and with this new focus, the electric vehicle (E.V.) has emerged as the solution for decarbonising the passenger car industry (The Ten Point Plan for a Green Industrial Revolution, 2020).

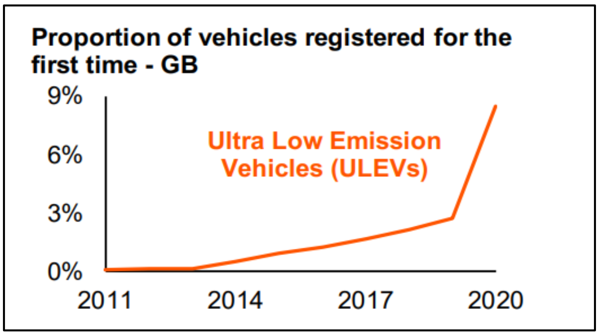


Figure 1: Proportion of new ULEV vehicles registered in the UK from 2011 to 2020. (Vehicle Licensing Statistics: Annual 2020, 2021)

Figure 2: Electric Vehicle on Charge ((O'Brien publishes new regulations that will see number of electric vehicle charging points increase across the country, n.d.)

Figure 1 shows that since 2011, Ultra-Low Emission Vehicles (ULEV) made up 8.5% of new registered cars in 2020 (Vehicle Licensing Statistics: Annual 2020, 2021). As of Quarter 3 of 2021, there are 621,564 plug-in vehicles (both plug-in hybrid electric (P.H.E.V.) and battery electric vehicles (B.E.V.) (Table VEH0131, n.d.).

To continue to grow the E.V. market, the required charging infrastructure must be developed. Unlike internal combustion engines, E.V.s rely on electric vehicle charge points (E.V.C.P.s) to recharge the battery, as shown in figure 2.

The Brighton Energy Cooperative (B.E.C.) is a community-funded organisation operating in Sussex with a focus on photovoltaic solar electricity generation.

Figure 3: The Brighton Energy Cooperative logo (Brighton Energy Coop - Community Energy in Brighton and Beyond!, 2016)

In 2019 the cooperative was awarded funding by Power to Change 'Next Generation Community Energy Programme' to install electric vehicle charge points (E.V.C.P.) along with solar photovoltaic (P.V.) arrays. (Electric Vehicle Charge Point Project, 2020). The first electric vehicle charge point (E.V.C.P.) The first E.V.C.P. went live in April 2021 at the Bolney Wine Estate, Haywards Heath (Keane, 2021a), system seen in figures 4 and 5.

Figure 4: E.V.C.P. at Bolney Wine Estate (Keane, 2021b)

Figure 5: 60kW of P.V. Array at Bolney Wine Estate (Community Solar Energy Projects, 2019)

B.E.C. hold a contract with PodPoint, a charge point provider, to install a total of 10 7kW charge points within Sussex. The electricity generated by the P.V. array feeds directly into the charge point, but the units are sold to the grid if not used. Currently, 8 successful PodPoint charge points have been installed in Sussex (Electric Vehicle Charge Point Project, 2020), as seen in figure 6.

Figure 6: Map and information per site of EVCS installed through BEC, information from (Electric Vehicle Charge Point Project, 2020)

The first meeting with B.E.C. was held on Friday, 28th January 2022, to understand the organisation and scope of the project for the remaining 2 installations. It was agreed that the installations of the E.V.C.P.s should be in areas which will enable the local community to own an E.V., with a unique selling point that users can 'fuel' their E.V.s with locally sourced renewable energy.

2.0 Problem Statement

The co-operative would like to continue to expand within the electric vehicle charge point market, hence the need to assess the Brighton & Hove area for further potential charge point installations. A method is required to suggest 3-5 areas which are commercially viable in areas of low income to enable EV ownership within these communities. Ideal locations should have access to an area suitable for PV array installation that can be fed through to the charge station.

3.0 Project Aims & Objectives

3.1 Aim

Determine 3-5 locations within the Brighton & Hove area that are suitable for E.V.C.P. deployment alongside PV solar arrays using an Engineering Systems approach.

3.2 Systems Engineering Approach

To ensure that this project has suitable structure, the V-model was developed and applied. This systematic approach ensures stakeholder requirements are met, and milestones to be determined and met prior to progressing to the next stage (Systems Engineering for ITS Handbook - Section 3 What is Systems Engineering?, n.d.).

Validation is limited as successful validation requires contact with the operators of the potential location, and due to the time limitation of this project this is deemed not achievable.

Figure 7 shows the project structure using the V-model diagram and Engineering Systems concepts.

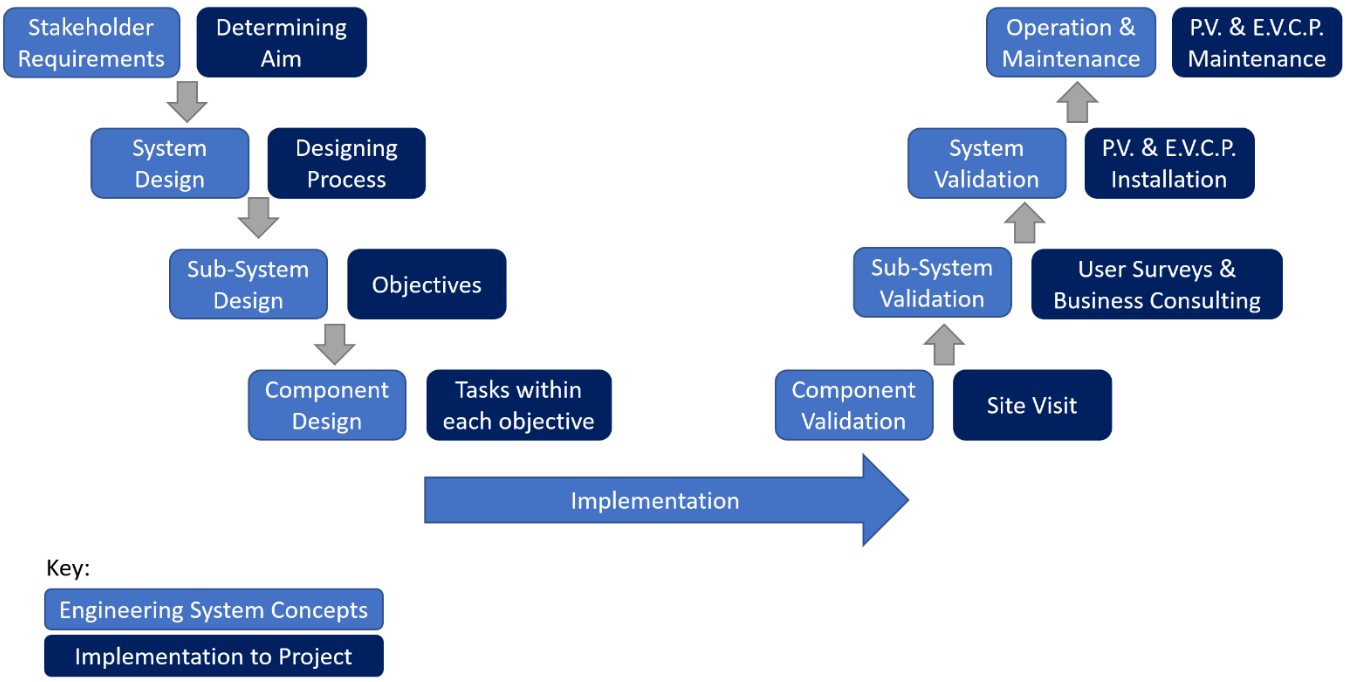


Figure 7: Engineering Systems Project Structure

3.3 Objectives

1. Create a map of areas that lack E.V.C.P.s and fall within lower-income categories.
2. Determine criteria that assess potential locations to ensure suitability.
3. Determine the method for commercial assessment of each location.

3.4 Work Package

The objectives were split into work packages, as seen in figure 8.

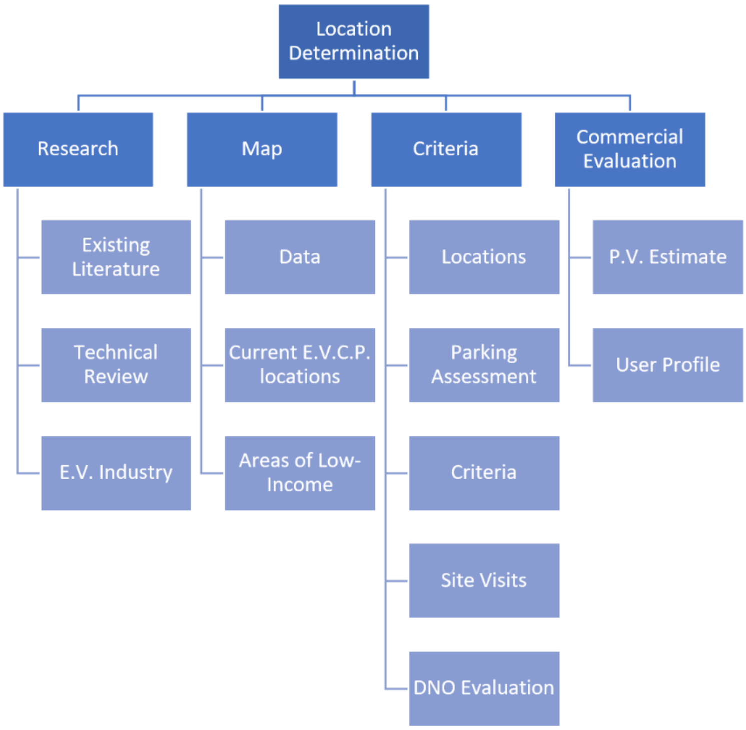


Figure 8: Project work package breakdown

3.5 Limitations

Limitations were constantly assessed through the progress of this project against to the criteria in table 1.

Table 1: Criteria for accuracy limitation evaluation

Score	Definition
1	Credible data available from a referenced source.
2	The information given is accurate, credible, however incomplete.
3	The information might be accurate and credible and/or incomplete.
4	The information is inaccurate, not credible, and incomplete.
5	The information required does not exist.

4.0 Research

A rich picture, figure 9, was created to understand the problem and establish appropriate research areas. It includes the system's main components and annotations of essential details within these areas that may be considered.

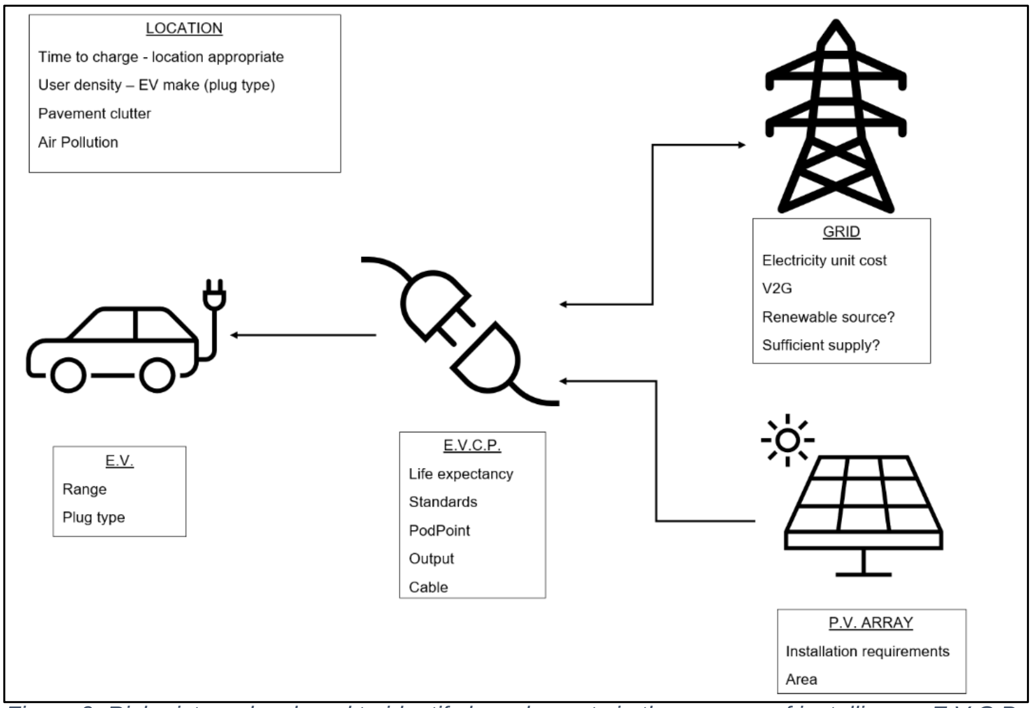


Figure 9: Rich picture developed to identify key elements in the process of installing an E.V.C.P.

The research can be split into three parts: existing literature, technical review, and current market.

4.1 Existing Literature

The existing literature within relevant areas falls within three categories: charge point location, commercial and legal.

4.1.1. Charge Point Locations

A study by Lam *et al.* (2014) developed four mathematical models for optimising placement and concluded that the use of MILP, mixed-integer linear programming, was most successful. MILP relies on a problem being expressed as a linear function and can capture discrete choices by limiting the numbers a variable can take (Mixed-Integer Programming (MIP) - A Primer on the Basics, n.d.). Although MILP was most helpful, it will not be considered for this project due to time and knowledge constraints.

Additionally, He *et al.,* (2013) developed an equilibrium modelling framework for PHEVs, which depend on routes driven by the users. The framework is developed by using a set of formulas to capture to simulate changes to the economy, and gauge behaviour response (Computable General Equilibrium modelling: introduction, n.d.). This study was considered valuable, as confirmed by its use in the State of California's strategy for charge point infrastructure (PlumX, n.d.).

Jia *et al.* (2012) developed a mathematical model based on variables within the road network, capacity, and road dimensions, whilst considering demand in an area,

calculated as the 'vehicle-hour' value which multiplies the number of vehicles by the time in which they stay.
A more recent study by Shepero *et al.* (2018) focused on the viability of using solar photovoltaic energy to charge electric vehicles. The conclusion was optimistic, however, outlined limitations; lack of user charging profiles and the combination of P.V. produced energy to feed E.V.C.P.s and the modelling of this on a city-wide scale.
Although a generic approach is a good starting point for charge point locations, an analysis of the local area must be performed for optimal positioning. Baouche *et al.,* (2014) completed a study assessing charge point locations based on the user's typical route, within the Lyon metropolitan area. Another study, for Tunis, by Bouguerra *et al*. (2018), used ILP (integer linear programming), to develop 5 models of possible networks of charging stations by considering existing infrastructure and operational costs.

4.1.2. Commercial

Tushar *et al.* (2012) studied the result between the grid energy prices and vehicle charging strategies in a smart grid situation, formulated by a Stackelberg game. The result of several iterations concluded that the grid would maximise the price, whilst PEVs (plug-in electric vehicle) energy suppliers would purchase units strategically. This result forms a Stackelberg equilibrium; a leader firm setting prices, with the competitor firms as followers.

4.1.3. Legal

H.S.Das (2020), a review of current E.V. technology, provides an overview of the standards required within E.V. grid integration. The study concludes with the suggestion that unified standards are a key to E.V. market popularity. This point may influence future legislation and the structure of E.V.C.P.s, highlighting the importance of futureproofing.

A paper written by Chen *et al.* (2020) has provided an insight into the UK's charging infrastructure; British standards required for EV chargers, government strategy and incentives. The paper concludes that EVCPs require renewable energy sources, and in the development of EVCPs, the customer, components, cost, network, social and environmental influences must be considered.

4.1.4. Summary

The areas of importance across mentioned studies include:

- Routes driven have a large influence on charge point location.
- A mathematical model maybe useful to determine suitable charge point locations, however this requires surrounding factors to be quantified.
- Commercial awareness of potential areas must be understood, and pricing structure and competitor hierarchy would be valuable to ensure commercial viability. This is limited as it does not predict instances of other installations thereafter.
- Legislation must be reviewed to ensure locations meet requirements.

The gaps within this knowledge are:

- No journals for case studies for UK cities.
- No studies have touched on potential locations based on socioeconomic factors and the effects of this divide on E.V. density and use.
- Studies using existing data for a P.V. scheme to charge E.V.s.

Limitations outlined in table 2.

Table 2: Accuracy limitation evaluation for existing literature findings

Limitation	Score	Mitigation
Data for common routes taken by E.V.s may not be recorded.	5	Other data will be considered.
Quantifying factors may not be possible due to the complexity of the problem	2	A structured process must be developed to consider the required details.
Futureproofing: E.V.C.P. lifespan is not considered against possible change in regulations, as speculated in an announcement late last year (Government funding targeted at more affordable zero-emission vehicles, 2021). The commercial effect due to required changes is not yet measured.	5	The project will assume that the charge points will adhere to potential changes in regulation, or that the E.V.C.P. provider will ensure any works required are completed

4.2 Technical Review

To understand the scope of the project better, the technical details regarding E.V.C.P. installation must be understood. Although the installation will be completed by a third party, it is essential that the location chosen is suitable.

4.2.1. Electric Vehicle Charge Stations

Due to the lack of standardisation in the industry, each E.V.C.P. will differ in components due to different requirements (The Essential Guide to Designing Your EV Charging System, 2021). The makeup of a charge point simplifies down to 3 components:

- Casing: the shell of the charge point, with the following considerations: IP rating (due to water ingress), shape, placement, aesthetic, and size (The Essential Guide to Designing Your EV Charging System, 2021).
- Cabling: to carry current to charge, but also for charge point communications. Tethered cables if a specific plug is to be used or untethered to keep it flexible (The Essential Guide to Designing Your EV Charging System, 2021).
- Electronics: Electric Vehicle Supply Equipment (ESVE) includes all electrical components required to control the charge point, as seen in figure 10.

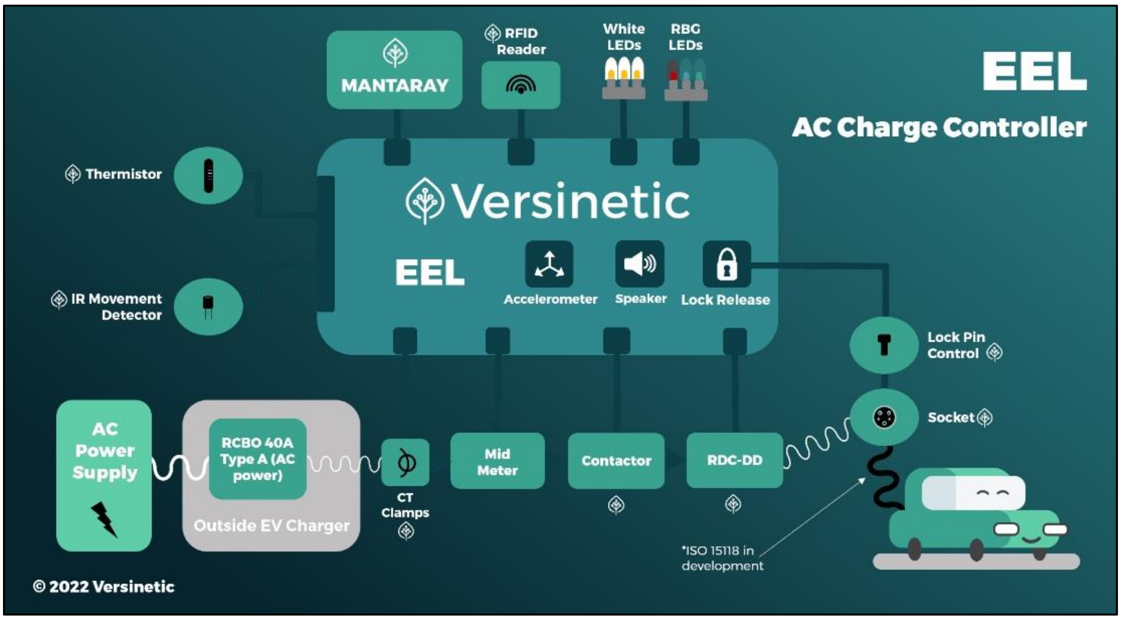


Figure 10: A Diagram of ESVE Components (Charging Points | EVSE & Smart Charge Point Solutions, n.d.)

Figure 11 shows the variety of different plug types within the E.V. market, Mennekes type 2 plug is considered the European standard, and hence the most common plug in the UK charge points for AC charging.

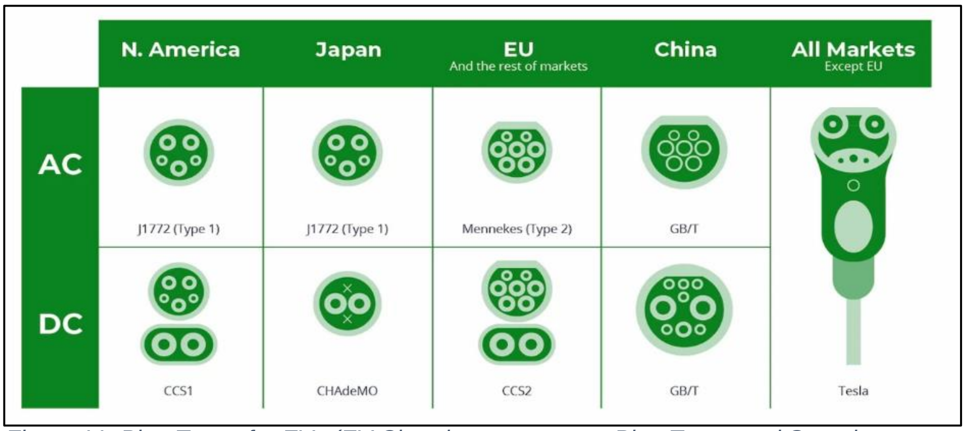


Figure 11: Plug Types for EVs (EV Charging connectors: Plug Types and Speeds Explained | OVO Energy, n.d.)

Charger rating is an important detail as this defines the amount of time an E.V. will need to charge for, hence dictating the amount of time the owner will need to stay in the vicinity for. Figure 12 shows the average charge time for each charger type; slow is a 3-pin plug, fast is between 7 and 22kW, and rapid is above 22kW (What is fast charging? What is rapid charging? What is ultra-rapid charging? EV charging speeds explained, n.d.).

Figure 12: Charge Times per Charger Type. (How do electric cars work?, n.d.)

Local electrical load capacity must be considered at the site of installation to ensure no additional charges may incur due to additional works being required. Capacity is calculated as the difference between load used and maximum available (EV Charger Installation on Business Premises, 2021).

4.2.2. Standards & Regulations

Standards are a relevant basis for charge station installation, and a basic understanding of these may be valuable when determining suitable locations.

Table 3 includes information on relevant standards. As the sector is still developing, standards are being produced within the industry, for example, Technical Committee (TC) 69 is in current development (IEC - TC 69 Dashboard> Scope, n.d.).

Table 3: Information on relevant standards [1] (Standards, n.d.) [2] (Understanding OCPP: Why Interoperability Matters | EVBox, n.d.) [3] (14:00-17:00, n.d.) [4](IEC - TC 69 Dashboard> Scope, n.d.).

Standard	Description
BS EN 62196	Conductive charging of electric vehicles, applicable to plugs, socket-outlets, vehicle connectors and cable assemblies. [1]
Open Charge Point Protocol	Open-source communication standard to ensure interoperability and supports changes in software. [2]
ISO 15118	Standard dedicated to communication between the E.V. and charging components, E.V.S.E. [3]
TC 69	Energy transfer systems for electrically propelled road vehicles. Standards include: IEC 63382, IEC 63110.[4]

The charge point regulation, known as the Electric Vehicles Regulations 2021, has been released and is due to be in force on the 30th of June 2022 (The Electric Vehicles (Smart Charge Points) Regulations 2021, n.d.), its functions are detailed in table 4.

Table 4: Brief Summary of Electric Vehicles (Smart Charge Point) Regulations (Complying with the Electric Vehicles (Smart Charge Points) Regulations 2021, 2022)

Function	Description
Smart Functionality	User interface and network capabilities.
Electricity Supplier Interoperability	Functionality remains after electricity supplier change.
Loss of Communications	Must be able to charge a vehicle even when disconnected from the network.
Safety	User must not have access to change settings or any other operation which may endanger themselves or anyone else.
Measurement System	Must be able to measure or calculate electrical power supplied.
Off-Peak Charging	Must be stated when off-peak charging occurs and to allow user to accept or decline change of rate.
Randomised Delay	Must have a randomised delay function to allow for delayed charge start.
Security	Must meet cyber-security standard ETSI EN 303 645.
Assurance	Must provide assurance that requirements are met.

4.2.3. Photovoltaic Array

To install P.V. panels, the surrounding environment and roof conditions must be considered.

Firstly, to ensure that P.V. installation is suitable, solar irradiance – the measure of light energy received from the Sun (NASA - SOLAR IRRADIANCE, n.d.) – should be checked to ensure optimal placement. Figure 13 shows the area of Brighton and Hove to fall within the highest P.V. power potential bracket of specific yield of 3kWh/kWp per day, 1095kWg/kWp annually.

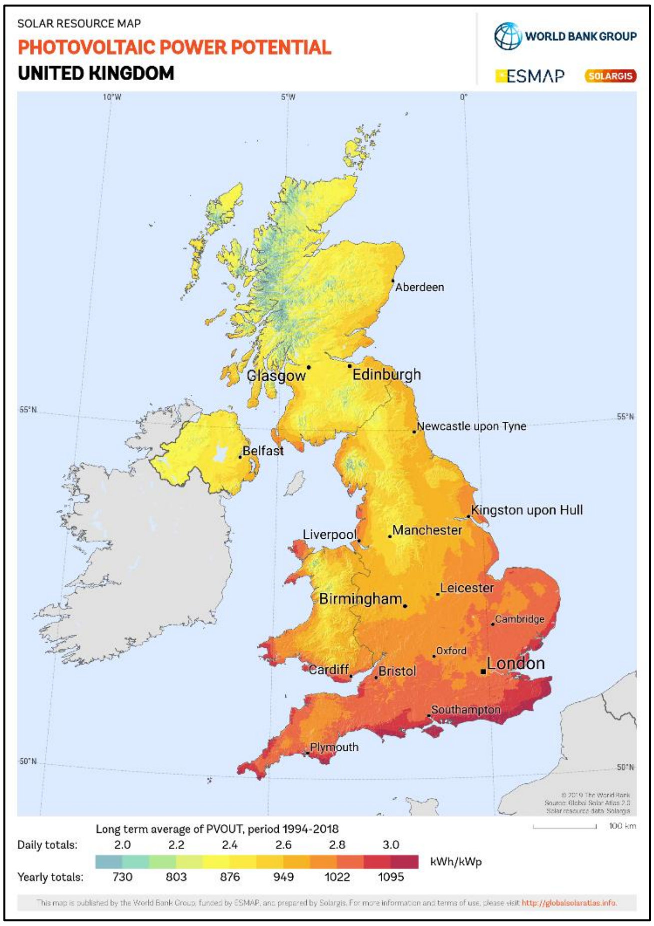


Figure 11: P.V. power potential across the UK (What's a good value for kWh/kWp? An overview of specific yield, 2017)

To ensure panel longevity the installation site must not experience any shading as this causes additional load on the P.V. system, reducing overall output by 30-40% if only 1 out of the 60 cells experiences shading (THE IMPACT OF SHADING ON SOLAR PANELS, n.d.).

The roof quality and material should also be considered, as thatched, glass and roofs containing asbestos are unsuitable for P.V. array installation (Solar panels: Is your roof suitable?, n.d.).

4.2.4. Summary

Important technical aspects:

- Charger rating will affect how long users need to be in the area, hence appropriate locations should be considered based on time.
- The desired location must have the electrical capacity for installation, otherwise, the project must fund capacity upgrades which is costly.
- The type 2 plug should be used.
- Mobile data strength in the area should be considered to enable communication to the charge point interface and call for support if required.
- P.V. installation area must be inspected to avoid shading and roofs should be made from suitable material.

Limitations:

- Regulations and standards are updated quickly, and the technology used may become outdated sooner than expected.

Table 5: Accuracy limitations within technical review

Limitation	Score	Mitigation
A heat map of available capacity does not exist.	2	The location must be determined first, then capacity checked.

4.3 E.V. Industry

It is important to be aware of what is going on within the industry as this may affect the location's suitability.

4.3.1. Government Incentives

Electric vehicles are a huge step towards decarbonisation, where the sale of new petrol and diesel cars is set to end in 2030 (Government takes historic step towards net-zero with the end of the sale of new petrol and diesel cars by 2030, 2020). The government has provided incentives to encourage the sale of electric vehicles and support the development of charging infrastructure, as seen in table 6:

Table 6: UK Government incentives to support E.V. charging infrastructure development. [1] (Low-emission vehicles eligible for a plug-in grant, n.d.).[2] (Electric Vehicle Homecharge Scheme: guidance for customers, n.d.) [3] (Workplace Charging Scheme: guidance

Incentive	Description
Plug-In Vehicle Grant	This grant offers a maximum discount of £1,500 for one of the electric vehicles mentioned within the grant conditions and must be less than £32,000 in retail value.[1]
Electric Vehicle Homecharge Scheme (EVHS)	A grant which provides a 75% contribution to the cost of one charge point and its installation. Applicant must have a qualifying vehicle in possession and dedicated off-street parking. Installation must be completed by an EVHS installer which applies on the customer's behalf. [2]
Workplace Charging Scheme (WCS)	Voucher based scheme for businesses, charities, and public sector organisations. For eligible applicants, 75% of the cost of installation of EV charge points is covered, capped at a maximum of £350 per socket, 40 sockets maximum. It must be installed by an OZEV-authorised (Office for Zero-Emission Vehicles) WCS installer. [3]

Vehicles registered since March 2001 pay Vehicle Excise Duty (V.E.D.) based on tailpipe CO_2 emissions, which means Battery Electric Vehicles (B.E.V.) are exempt from charges, whilst P.H.E.V.s have a reduced rate (How Much Does It Cost To Tax An Electric Car? (2022 Update), n.d.). This also means E.V. owners enjoy exemption from London's Ultra Low Emission Zone (ULEZ) and other congestion charges (Congestion charge and electric vehicles: Everything you need to know | Guides, n.d.). As the government has not yet put anything in place to transition to, this is seen as an incentive for buying an E.V.

To support the industry, the government is making data available as often as every 3 months for electric vehicle charging device grant scheme statistics, (Electric vehicle charging infrastructure statistics, n.d.), and has also developed the National Chargepoint Registry (Find and use data on public electric vehicle chargepoints, n.d.), a database on all public charge points. This is particularly valuable as the data given is considered reliable, given that the government is the source, and encourages clarity on the evolution of the industry.

4.3.2. Market Limitations

There are several limitations within the market which has caused a level of disorganisation which may affect E.V.C.P. roll out.

Parking restrictions often do not accommodate for extended parking due to EV charging, and result in owners receiving parking fines, as reported in the Lancashire Post (EV drivers hit with £120 parking fines for using public chargers, 2022). Future E.V.C.P. installations could benefit from being outside of parking restrictions.

Figure 14: E.V. charging with issued parking ticket (Bradley, 2022)

The South East network of E.V.C.P.s was shut down in March 2017 due to lack of funding. Most of the network was distributed to other partners, whilst legacy chargers which were considered outdated were left up to the landowner to decide (Lilly, 2017). This has left EV drivers frustrated, as seen in this thread in July 2017 with abandoned chargers still showing as available on respective E.V.C.P. maps (Abandoned Charge Points, n.d.). Contingency for this possibility should be kept in mind.

Unforeseen events like the 2021 UK fuel supply crisis can influence the E.V. market. This event inadvertently encouraged E.V. sale, with EVA England, an organisation for EV drivers, reported a spike in interest of EVs at dealerships during this event (Bryant, 2021). Carwow, a vehicle selling platform, also recorded a 550% year-on-year increase during September 2021 for BEV and PHEV enquiries (Semiconductor shortage masking true extent of EV demand, 2022).

However, due to the semi-conductor shortage, the production of E.V.s has been severely affected, as seen by Ford which had to delay the release of the Mustang Mach-E, their flagship E.V., and saw General Motors close the Detroit factory which makes the Bolt E.V (News, 2021). This sudden pull-push of the E.V. market is not sustainable and will likely increase the strain of semi-conductor demand.

4.3.3. UK Case Study: Charge My Street

Charge my street is a community charge point organisation, like B.E.C., which has been awarded a grant from Innovate UK to install E.V.C.P.s across Cumbria and Lancashire (chargemystreet.co.uk | EV charge point community benefit society, n.d.). Figure 15 shows the map of charge point locations, including those which are currently being considered, and those that have been declined in Cumbria.

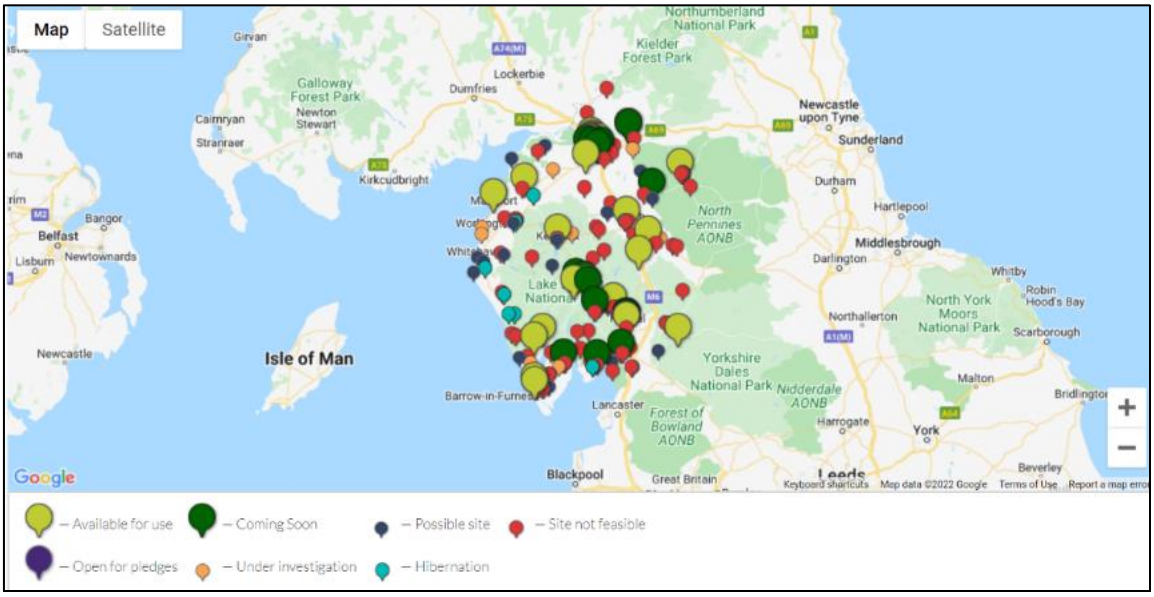


Figure 15: Map of locations accepted, considered, and rejected by Charge My Street in Cumbria (Cumbria | chargemystreet.co.uk, n.d.)

Figure 16, below, shows the breakdown of sites determined unsuitable due to the criteria shown. The set of criteria falls within 3 areas: Commercial (55%), Technical (31%) and Managerial (14%).

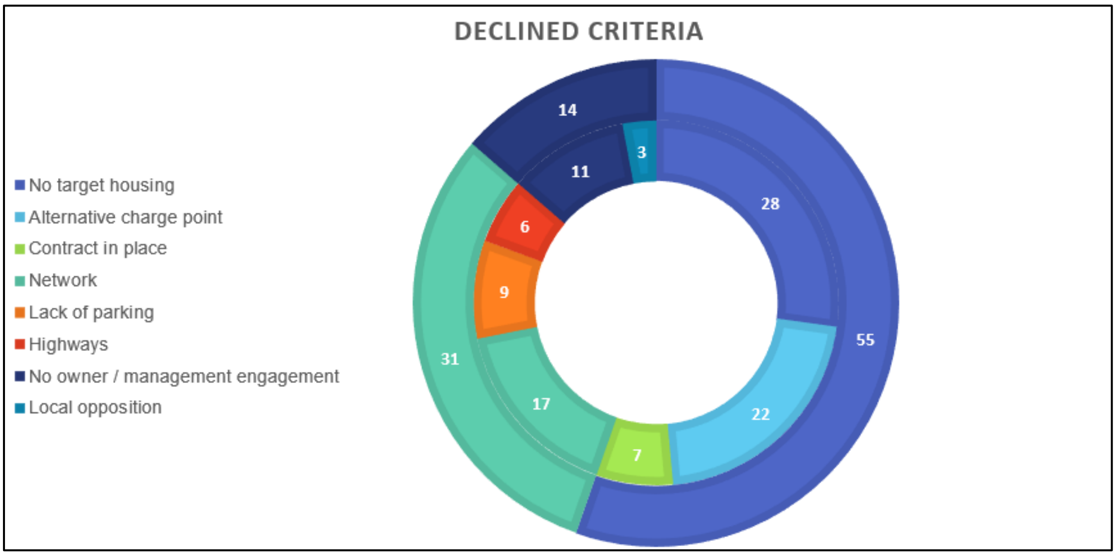


Figure 16: Declined criteria for EVCS location in Cumbria. (chargemystreet.co.uk | EV charge point community benefit society, n.d.)

This research has given a good starting point for the set of criteria that will need to be implemented for locations within Brighton & Hove, with additional consideration required for P.V. integration.

4.3.4. REVUP North

The Regional Electric Vehicle Unified Plan (REVUP) North conference attended at Durham town hall on Tuesday 22nd March was an opportunity to further understand the E.V.C.P. industry.

The notable findings include:

Andrew Larkham, a representative from the Office for Zero Emission Vehicles (OZEV), highlighted that the current rate of installation of E.V.C.P. is not meeting requirements for the 2030 ban.

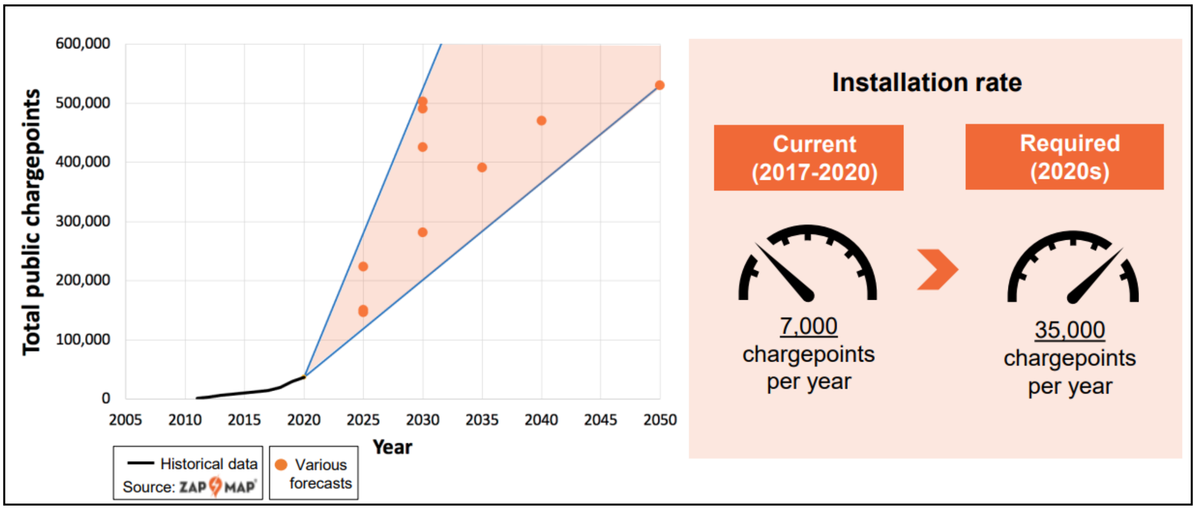


Figure 17: Installation rates of E.V.C.P. requirements (Charging Up, n.d.)

Andrew was also able to provide a summary of the UK's roll out of EV charging infrastructure which helped understand the government's response to further work needed – through further study and further funding awarded to projects addressing this issue (Taking charge: the electric vehicle infrastructure strategy, n.d.).

Tracy Millmore, UK's first E.V. council officer, stated that E.V.C.P. installation is a 'complex problem which doesn't follow an easy formula. Each location has its own set of considerations and must be evaluated accordingly'. Tracy has taken a key role in developing a toolkit to enable local authorities to facilitate the installation of E.V.C.P.s. (Homepage, n.d.). Tracy was also able to confirm based on her involvement in E.V.C.P. installation projects that a reasonable E.V.C.P. catchment area from the owner's house is a 5-minute walk (Homepage, n.d.).

4.3.5. Summary

Government incentives address the major problems within E.V. ownership, the additional cost of E.V.C.P. installation, or the possibility of installation is not considered fully, and therefore limits the potential E.V. owners to those who can afford these additional costs.

Based on the findings from the Charge My Street case study, the following criteria will be used to refine possible locations:

Table 7: Criteria for location assessment

Area	Description
Technical	No/inadequate parking
	Local electrical load capacity
	Area for PV installation
Commercial	Target housing
	Average time spent at facility

Due to time constraints, this project will not assess managerial criteria; contact with site managers and assessing local opposition, and hence results from this study will only act as a recommendation for BEC to consider and contact on their accord.

Additionally, supermarkets will not be considered due to parking restrictions limiting E.V. owners to charge their cars within a small window of time, and the contracts for E.V.C.P. provider have already been established.

The REVUP event confirmed that the project's proposed process is suitable for the problem and taking time to understand each location is important. Implementation of site visitation to ensure the correct conclusion has been made is critical.

Limitations:

Table 8: Accuracy limitations for findings in E.V. Industry research

Limitation	Score	Mitigation
Data for E.V. location does not exist.	5	Usage will need to be modelled based on existing usage data.

5.0 Methodology

The process, outlined in figure 18, defines the system, split into sub-systems and components. This approach ensures all aims and objectives can be met.

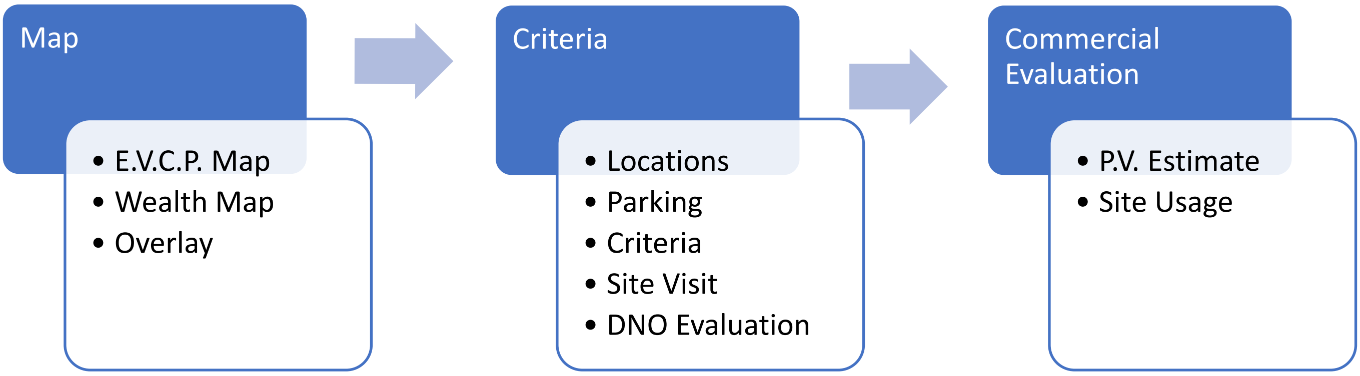


Figure 18: Sub-system and component process

5.1 Map Creation

A map was used to easily identify areas of low-income and a lack E.V.C.P. density. As the combination of this data does not exist, its development was required to begin the project.

Overall, the aim is to have these two maps as two layers within one map to illustrate areas which do not have access to E.V.C.P and those of low income. Within these areas, community shared facilities, i.e. libraries, leisure centres, and town halls will be identified as the next step to refine location recommendations.

5.1.1. E.V.C.P. Map

To find the current E.V.C.P. locations, data from the National Charge point Registry (NCR) was used. The source is considered credible as the department for transport developed the registry, and only shows publicly accessible chargepoints (NCR - National Chargepoint Registry, n.d.). Given in a .CSV format, it was easy to refine to the Brighton and Hove area. The refined data includes data from east and west Sussex to ensure all charge points were captured. A limitation to this data set is that the registration of new charge point locations rely on the charge point owner or network operator to upload data on the charge point, and as that is not required by law, it may not happen (National Chargepoint Registry (NCR), n.d.).

Ideally, data from ZapMap, a well-known E.V.C.P. location site, and often used by the UK government, would be used however access to data on charge point location was limited as it relied on payment. Additionally, ZapMap includes 'ZapHome' and 'Zap-Work', peer-to-peer charge points, if included in the data set may cause inaccuracies as the availability of these charge points may be inconsistent. (Lilly, 2018).

To map the locations, MapBox, a software available to use in browser, was used. The lack of a user-friendly interface and the requirement of further knowledge of data handling and use of code rendered the software inappropriate for this project. Figure 19 shows the E.V.C.P. location data mapped within this program.

Figure 19: MapBox map of EVCS in Brighton & Hove.

ArcGIS, another mapping software, was used as the software was available through the University's license. The same data set was uploaded and shown in figure 20.

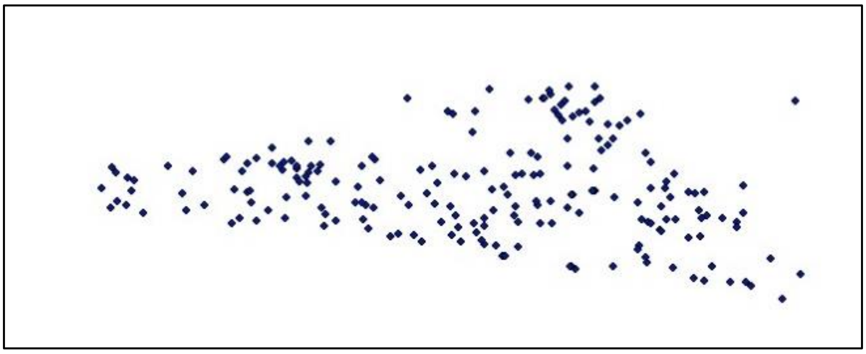


Figure 20: E.V.C.P. locations in Brighton & Hove

A 500m radius was given to each charge point to illustrate the assumed catchment area which falls within a 5-minute walk from the E.V. owner's house, shown in figure 21.

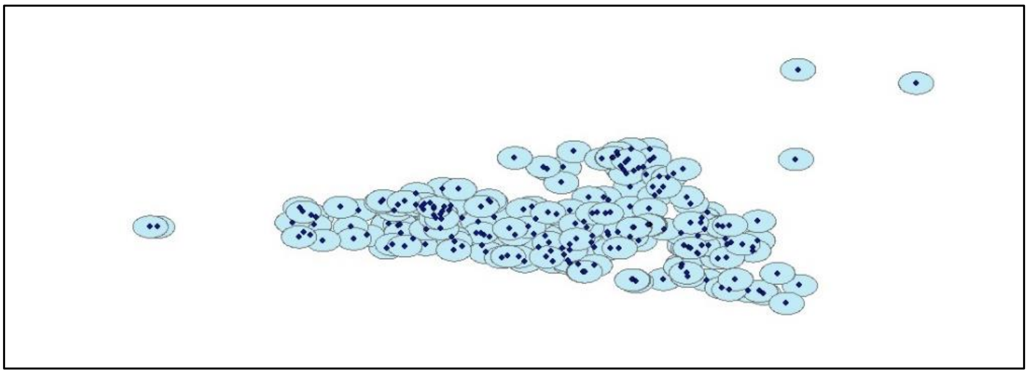


Figure 21: E.V.C.P. Locations in Brighton & Hove with catchment area implemented.

5.1.2. Wealth map

To illustrate and identify areas of low income, data from the Indices of Multiple Deprivation (IoD) 2019 was used as it included income data with geographic coordinates. Within this data, IncDec, the income decile, is a score based on ranking areas from most to least income and dividing them into 10 equal groups. Decile 1 is most icome, whilst decile 10 is least income nationally (NCDR Reference Library, n.d.). This was chosen as it allows easy identification and illustration of lower-income areas graphically with the use of a key.

No other data was considered for the creation of this this map as IoD data is supplied by the Office for National Statistics, which is the recognised national statistical institute of the UK (Home - Office for National Statistics, n.d.).

The biggest challenge working with this data is the file type .geoJSON which the data was supplied in. Refining the information is not easy and requires the use of spatial mapping software. Alternatively, .CSV file types are preferred as refinement to local area is simple, however latitude and longitude coordinates must be included. Unfortunately, the IoD data within .CSV format gives geolocation as postcode which cannot be read by arcGIS.

Additionally, the area was divided into Lower layer Super Output Areas (LSOAs) which were developed to improve statistical reporting in small areas within England and Wales (Census geography - Office for National Statistics, n.d.). Figure 22 shows the requirements for LSOA definition.

Population and household minimum and maximum thresholds for SOAs in England and Wales

Geography	Minimum population	Maximum population	Minimum number of houseolds	Maximum number of households
LSOA	1,000	3,000	400	1,200
MSOA	5,000	15,000	2,000	6,000

Figure 22: LSOA requirements (Census geography - Office for National Statistics, n.d.)

The data was imported into arcGIS, as seen below, regions colour-coded by wealth indicator.

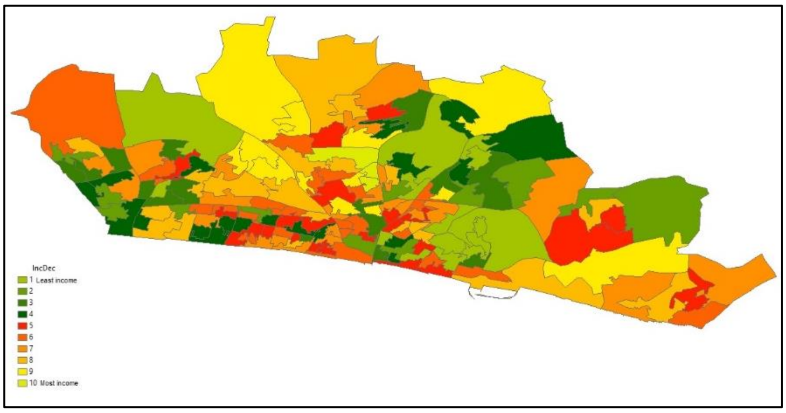


Figure 23: Income ratings per LSOA

5.1.3. Overlay

To identify target areas that meet both conditions, the two maps were combined within ArcGIS, shown in figure 24. Areas which are investigated further are highlighted in blue.

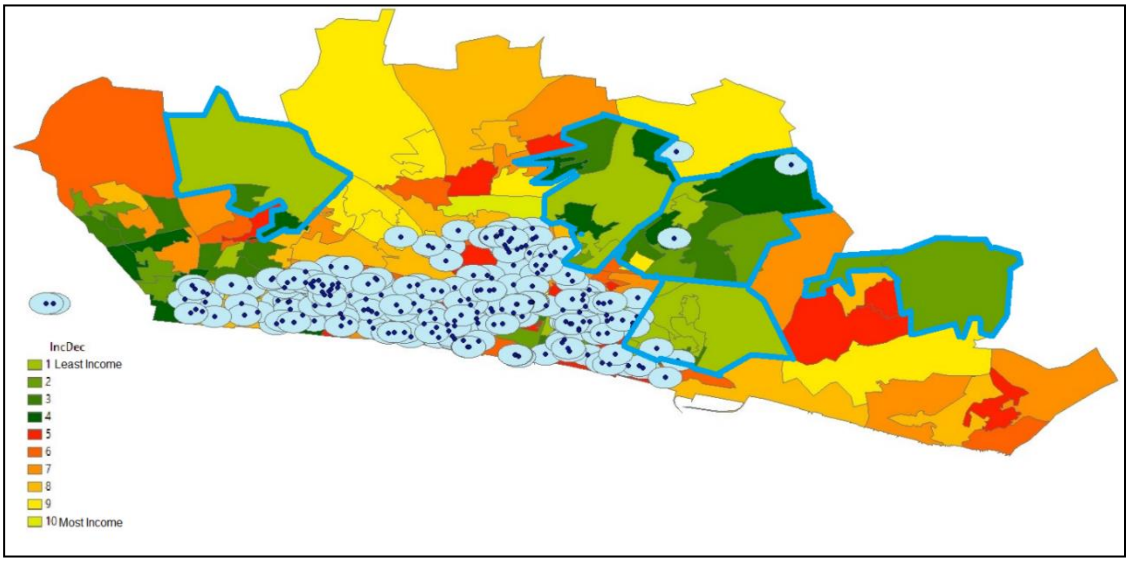


Figure 24: Map of Brighton & Hove with E.V.C.P. location and catchment area, and income key applied.

Apart from technical challenges within file types and software, a limitation to this method is that the data does not automatically update as EVCPs are built, or when different postal areas change income indicators. Manual re-uploading and potential formatting will be required if this method was to be implemented, which may be too time-consuming.

The limitation to using LSOAs is that they do not take into consideration the interaction within the neighbourhood, therefore we have boundaries in places which might be deemed inappropriate for E.V.C.P. installation consideration. The area of Woodingdean is an example of this, where we have the LSOA boundary dividing the area in an unnatural way, as the amenities are likely shared across these boundaries, as seen in figure 25.

Figure 25 Woodingdean low-income LSOA

5.2 Criteria

To find suitable locations, the process in figure 26 is used to determine locations, assess their suitability and rank.

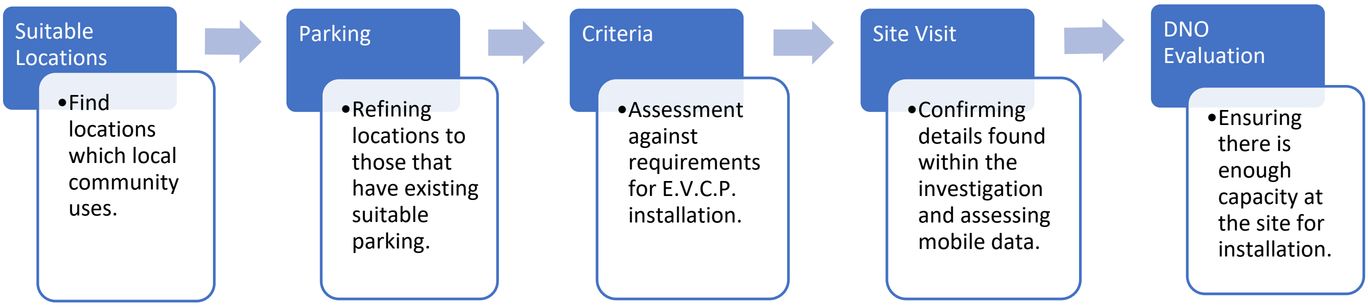


Figure 26 Process for location evaluation

5.2.1. Locations

ArcGIS isn't compatible with google maps, which meant that the drawing tools within google maps' my maps had to be used. This allowed the LSOA boundaries to be traced over google maps, and possible locations were then identified in each area.

A total of 85 locations were identified, as seen in Figure 27 as blue markers.

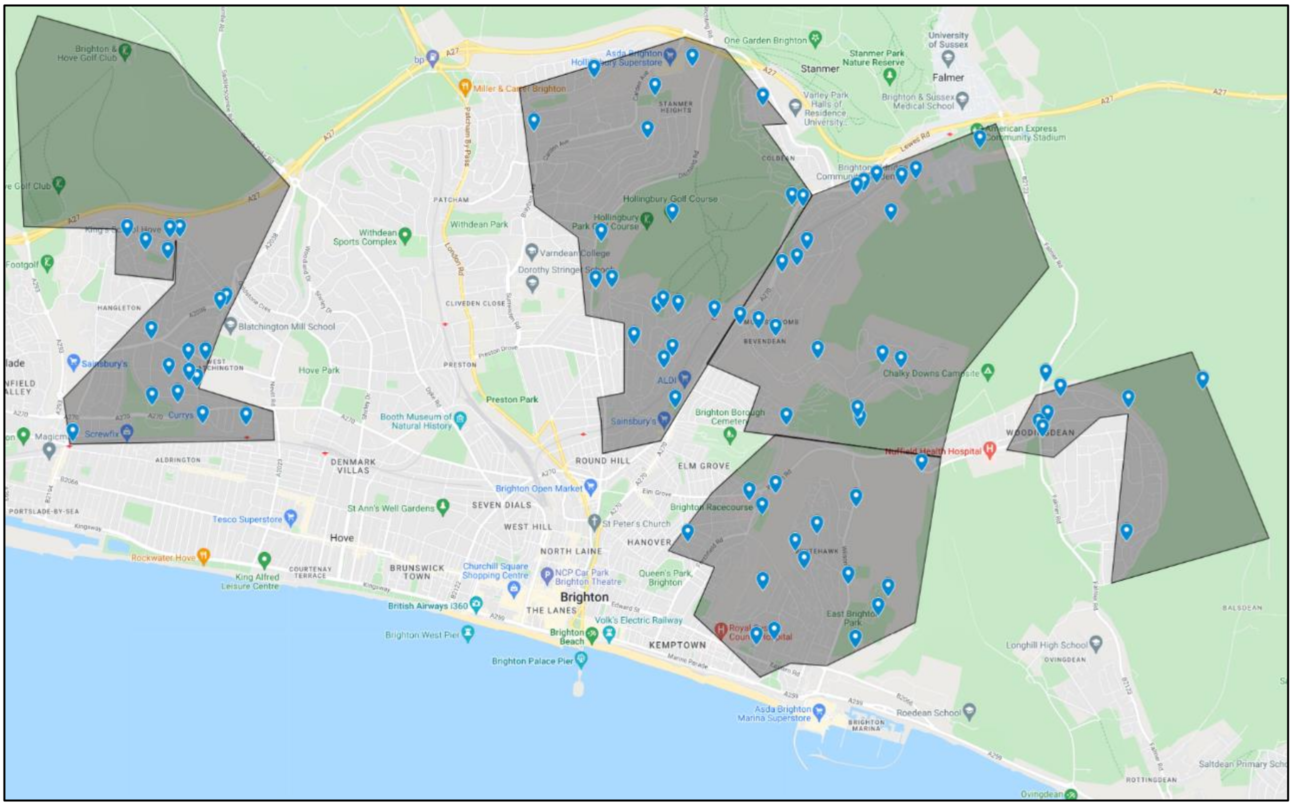


Figure 27 Map of low-income LSOAs including markers for community shared locations.

To improve accuracy, the government map was referenced which included a map underlay as seen in figure 28, however due to the nature of the boundaries, the result LSOA shapes are simplified.

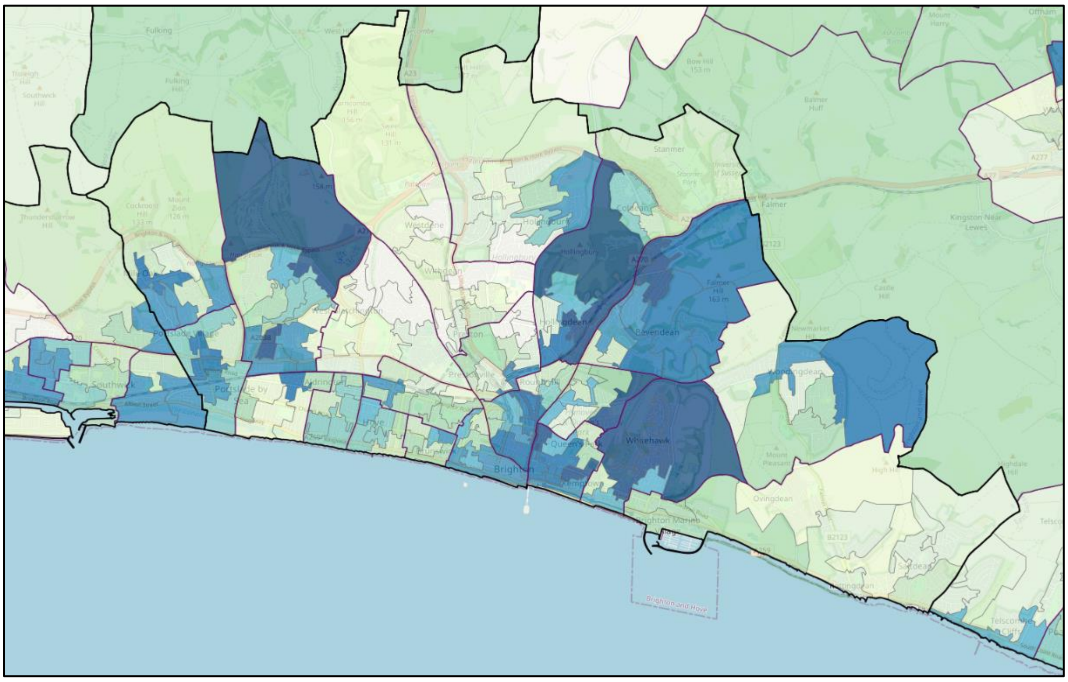


Figure 28: IoD 2019 map of LSOA with map underlay. (Indices of Deprivation 2015 and 2019, n.d.)

Determining suitable locations within these areas was time-consuming as there is no map data of current council owned/managed facilities, which also runs the risk of potentially suitable locations being missed.

5.2.2. Parking

The fundamental detail to assess a location is whether suitable parking exists. It is expensive, and time-consuming, to attempt to provide planning for currently non-existent parking spaces. Due to the volume of potential areas, it is more time-efficient to determine parking quality through google maps street view.

Locations were assessed according to parking availability criteria in table 9 and accepted and rejected locations are shown in figure 27.

Table 9: Parking assessment criteria

Parking Type	Description	Accepted?
Publicly accessible	A car park or parking bays exist and are accessible to the public with no parking restrictions.	Yes
On-Street	Suitable on-street parking is available.	Yes
Private	A car park exists, however, is inaccessible through a gate or parking restrictions	No
None	No suitable parking exists for the location.	No

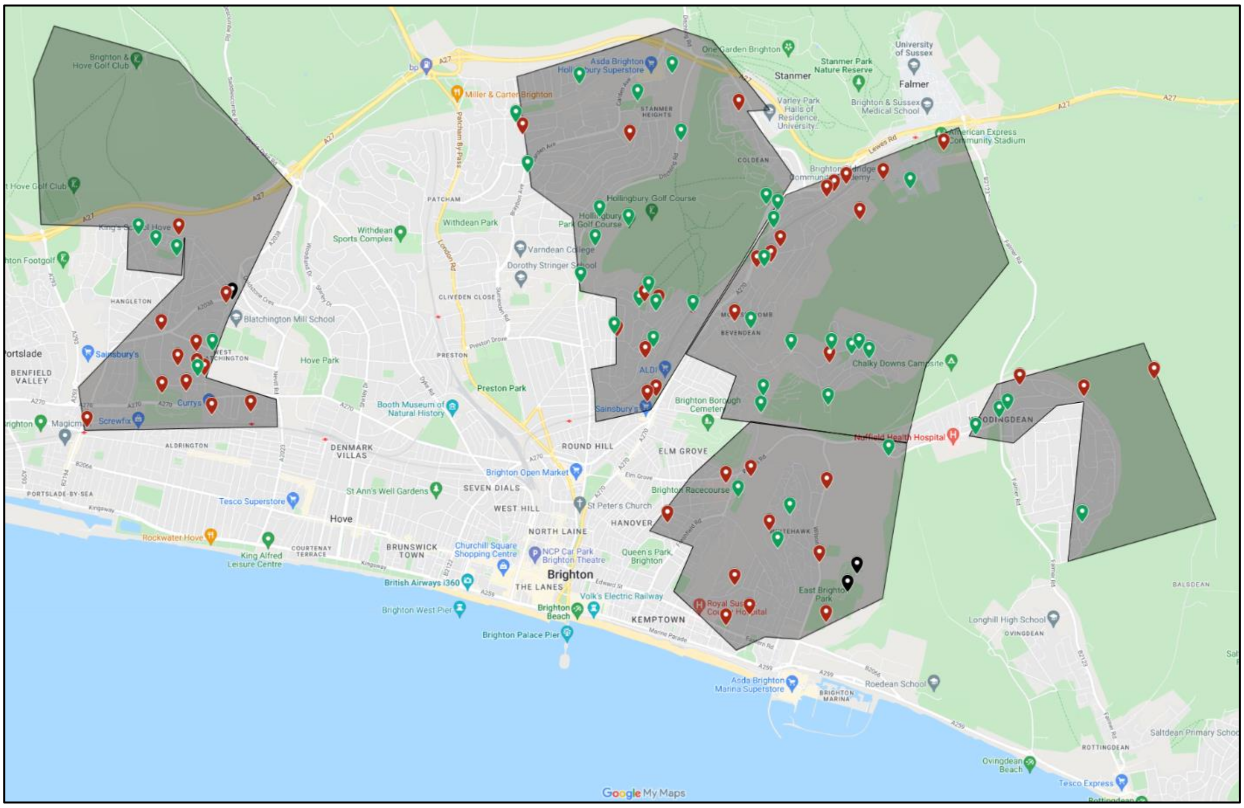


Figure 29: Map of parking assessment results

Table 10: Key for parking assessment map

Colour	Status
	Accepted
	Rejected
	Rejected: information not available

The full list of assessed locations is found in Appendix A.

Possible inaccuracies could show due to the time between google uploading the street view data and the time of assessment, hence a site visit is used further in the process to confirm these details. Due to the time constraints of this project, it is not possible to assess all 85 locations to confirm parking details. A total of 43 locations were accepted for further assessment.

5.2.3. Decision Matrix

To refine what areas are most suitable for the installations, the following criteria were determined important:

1. Potential P.V. Area

Important to ensure that PV installation is possible, with the highest prediction is preferred.

The method of estimation involved using google maps measure tool as seen in figure 28. The perimeter of the building was measured, and sides multiplied for the area. This assumes that the full roof area is suitable for P.V. array installation, hence should be regarded as the maximum potential P.V. area.

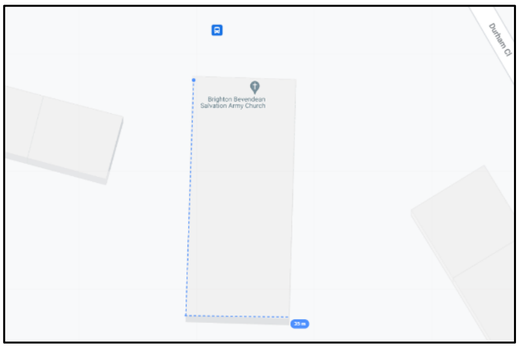


Figure 30: Google maps measuring tool measuring the perimeter of a building

2. Dwell Time

This must be suitable for the type of charger, as for 7kW it takes on average 4 hours to charge a vehicle to 100%. The longer the stay, the higher the likelihood of a full charge, and therefore maximises the potential earnings of the E.V.C.P.

Table 11: Dwell time definitions

Location Type	Estimated hours
Car park	4-8
Community Centre	3-4
Park	1
Church	1-2
Gym/Sports	1-2
Vet	1-2
Education	6
Nature Walks	4
Café	1-2
Ammentities	1-2
B&B	8
Business Park	4-8

Time spent at a location is a large uncertainty due to lack of data, and hence an approximation is made based on reasonable time spent at the location. To improve this, data from businesses may be able to provide a more accurate dwell time.

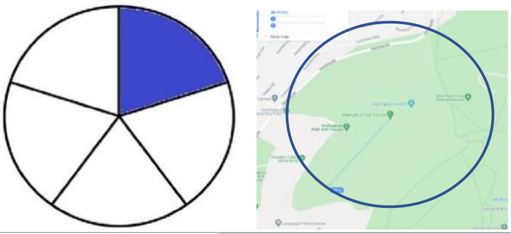
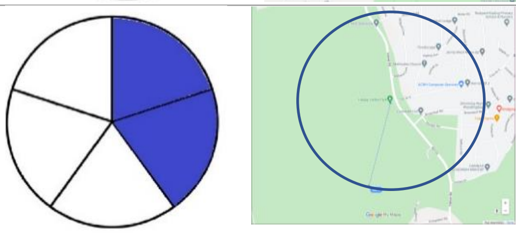
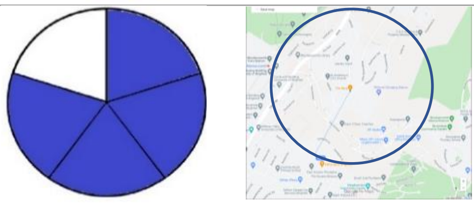
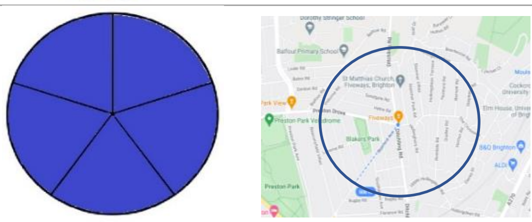
3. Surrounding Neighbourhood

The denser the surrounding neighbourhood is, the more potential customers the E.V.C.P. will have, which will in turn maximise earnings.

This is assessed by drawing a circle of 500m radius around the location and estimating the housing density within this area. Table 12 includes the different densities and the equivalent scale.

This method is limited as it does not consider the type of housing it is, as properties that are semi-detached and have a driveway may have taken advantage of the Electric Vehicle Homecharge Scheme (EVHS). This may have an impact on the number of potential customers as those who live in apartments are more likely to require the use of a commercial E.V.C.P. rather than be able to install their own.

Table 12: Criteria definitions

Scale	P.V. Estimate [m^2]	Housing Density	Dwell Time [hours]
1	0=<x<200		0=<x<2
2	200=<x<300		2=<x<3
3	300=<x<400		3=<x<4
4	400=<x<500		4=<x<6
5	500=<x		6=<x

The top 10 scoring locations are taken forward for further evaluation, the locations shown in figure 29.

Figure 31: Map of top 10 scoring locations

Table 13: Location names in reference to map location

Map Number	Location	Map Number	Location
1	Hangleton Community Centre	6	Central Hub Brighton & Cedar Centre
2	Bishop Hannington Memorial Church	7	Hazelgrove Nursing Home
3	Wayfield Avenue Resource Centre	8	Partridge House
4	Patcham Community Centre & Library	9	The Hyde Business Park
5	Hollingdean Children's Centre	10	St. Cuthmans & Valley Social Club

The full table of results can be found in Appendix B.

5.2.4. Site Visit

To verify that each location is suitable, a site visit was arranged. This allowed confirmation of findings from google maps and assess mobile data strength which is important for customer communication to the user interface and reporting E.V.C.P. problems.

A risk assessment was carried out prior to commencing site visits, please refer to Appendix C.

The following aspects were verified:

- Parking quality
- Parking restrictions
- Ease of accessibility
- Shadowing of roof
- Quality of roof
- Equipment on the pavement which might suggest cable capacity exists
- Council ownership/management
- Mobile data strength
  Mobile data strength is only a subject of 4G, as 5G was not available at any of the locations.

Locations which were accepted are:

- Hangleton Community Centre
- Central Hub Brighton & Cedar Centre
- The Hyde Business Park
- Wayfield Avenue Resource Centre
- Bishop Hannington Memorial Church

The remaining 5 locations were rejected due to not meeting P.V. installation requirements, parking restrictions and inconsistent site management.

This process is limited largely due to lack of contact with the businesses that operate at the location.

5.2.4. DNO Evaluation

The local Distribution Network Operator (DNO) is UK Power Network. To see if the shortlisted locations have available capacity, the UK Power Network's Distributed Generation (DG) Mapping Tool is used. The E.V. charging capacity

This shows the capacity of substations across the DNO's catchment area for E.V. charging.

The key shows the 3 different power availabilities, green showing available capacity, and red as no capacity available, as shown in figure 29.

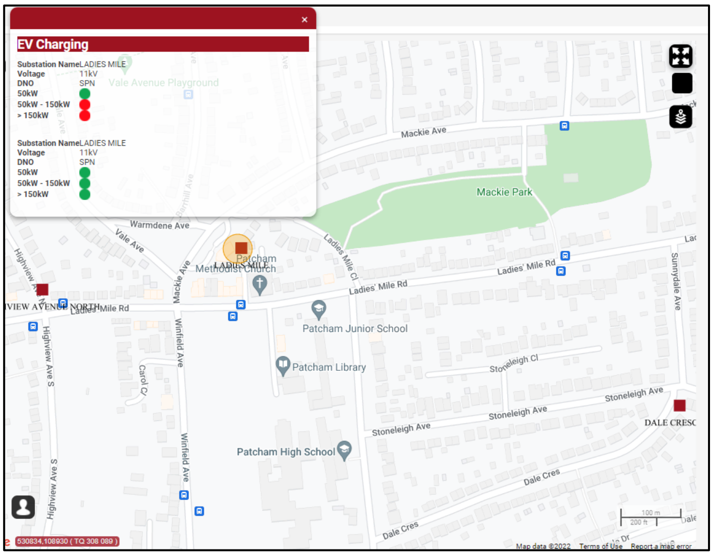


Figure 32: UK Power Network E.V. Charging capacity tool

Unfortunately, the tool does not show the substation catchment area, which has left some locations at risk of rejection as the capacity cannot be confirmed due to several options available at different ratings. Table 14 shows each location's capacity availability. Appendix D includes details of substations per location.

Table 14: DNO evaluation results

Location	Capacity
Hangleton Community Centre	>150kW
Central Hub Brighton & Cedar Centre	50kW
The Hyde Business Park	50kW
Wayfield Avenue Resource Centre	>150kW
Bishop Hannington Memorial Church	50-150kW Minimum

Ratings of 50kW have been rejected as they indicate limited capacity, which may require network reinforcement to complete the installation of a E.V.C.P. and P.V. array and may require additional funding.

5.2.5. Summary

The 3 locations which are going to be commercially evaluated are as follows:

- Hangleton Community Centre
- Wayfield Avenue Resource Centre
- Bishop Hannington Memorial Church

Table 15: Accuracy limitations within the criteria process

Limitation	Score	Mitigation
Businesses are not contacted.	5	This process has attempted to ensure that all aspects are considered outside of this requirement.
Lack of capacity understanding: wiring.	3	Assumption that if local substation has capacity, that required wiring exists at the location.

5.3. Commercial Evaluation

Commercial evaluation is required to ensure that the funding required for installation is recouped. A charge point which won't be used will not be serving the community, and therefore may be considered as pavement clutter instead.

The values for P.V. generation and number of customers are used within B.E.C.'s commercial viability tool which generates profit and loss estimates for an assumed 25 years of E.V.C.P. and P.V. system project, please refer to Appendix E for more information.

5.3.1. P.V. Electricity Generation Estimate

To calculate an accurate estimation for P.V. generated electricity within the Brighton & Hove area, data from the University of Brighton's P.V. project is used.

The data was supplied per site for 19 sites, however due to lack of historic readings 18 were rejected, hence the Cockroft P.V. meter readings were used. This system is rated at 44kW: made of 132 333W rated panels.

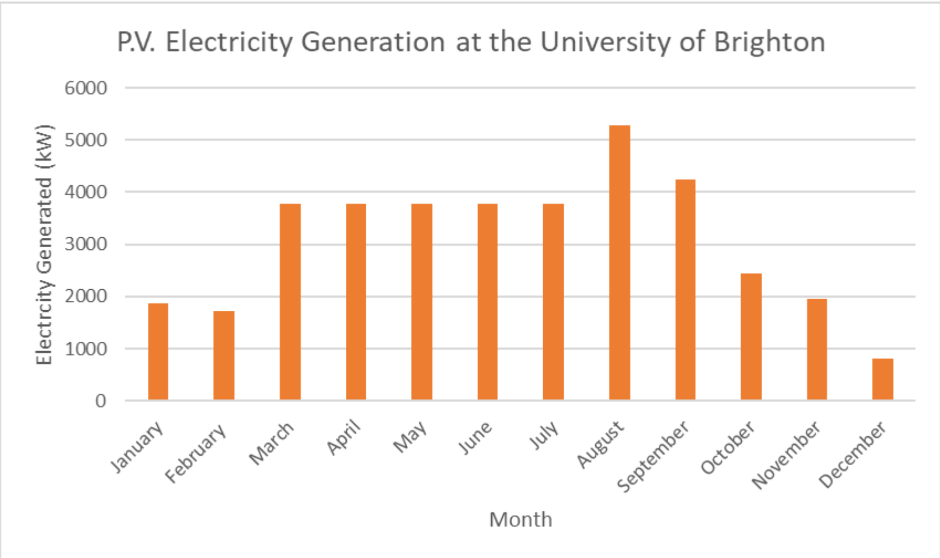


Figure 33: P.V. Generation from University of Brighton Cockroft building

Generated electricity (kW) per meter squared of P.V. panel was calculated as this value can be multiplied by each site's estimated P.V. area to generate an annual estimate for the location:

$$Annual\ P.V.Generation(kW) * \frac{1}{132 * 1.668} = Annual\ P.V.Generation\ per\ meter$$

The value 1.668m^2 was used as this is the area of a 330W P.V. panel (330W Black Plus Mono Solar Panel, n.d.).

For the full set of results, please refer to Appendix F.

5.3.2. Site Usage

An approximation for E.V.C.P. usage would be valuable as it may estimate the number of usual customers the charge point may have. This information can then be used to approximate income from the E.V.C.P. and create a robust commercial estimate for suggested location.

At the start of the project, it was expected that a process could be developed to provide an approximation for potential E.V.C.P. usage, however proved not possible due to several reasons:

- Existing data on E.V.C.P. usage is not widely shared and very difficult to obtain. If such data sets were accessible, it may be possible to develop usage profiles for locations which meet the same criteria as suggested locations were assessed in this project.
- The University of Brighton records data on the charge points installed on the campus, however due to technical difficulties with access to the PodPoint dashboard it was not possible. Additionally, this data would be limited as access to these charge points requires a University parking permit, deeming it inaccessible to the public and local residents.
- No simulation currently exists for E.V.C.P. use in a place which doesn't have an E.V.C.P. installed.
- Surrounding housing type should be considered also as this will greatly change the number of potential customers which will depend on the E.V.C.P.

Due to experienced difficulties, the site usage will take default values as set out by B.E.C. as seen in table 16.

Table 16: Default variables for E.V.C.P. usage

Variable	Value
No of new users per charge point in year 1	10
Assumed increase / decrease in new user volume per year	0.0%
No of days used per year (site occupancy)	250
Charge point usage per day (Peak rate)	4
Charge point usage per day (Off-Peak rate)	0
Assumed increase in use of the chargers (frequency) per year (Peak Rate)	0.0%
Assumed increase in use of the chargers (frequency) per year (Off peak)	0.0%

5.3.3. Summary

No sites are rejected through this method as all sites produce profit, as seen in table 17.

Table 17: Net profit per location

Location	Profit (Unrestricted)	
Hangleton Community Centre	£	10,478.00
Bishop Hannington Memorial Church	£	15,945.00
Wayfield Avenue Resource Centre	£	4,188.00

5.4 Validation

Validation is an essential part of the engineering systems approach to real world engineering problems and would have been very valuable to include in this project.

5.4.1. Current UK Network

The initial attempt at validation was requesting data from a UK case study, in this case Charge My Street, and assess like-for-like E.V.C.P. locations on their existing network. The E.V.C.P. use on the closest scoring locations could then determine whether the charge point will be as commercially viable as first estimated. As many criteria were considered during this process, only local housing density, dwell time and location type were concluded as valid like-for-like attributes and applying further criteria may render this process unsuitable.

This approach is heavily limited as P.V. generated electricity is not considered, leaving the assessment to be user based only. Additionally, the E.V. density between Brighton & Hove and Cumbria may differ significantly, and with no data source on the location of E.V.s it is difficult to assess the accuracy of this method.

Although contact with Charge My Street was established, requested data was not available to be provided within the required timeframe. Hence due to the limited time between location determination and the closing of the project, the possibility of completing this process was deemed unattainable.

5.4.2. Simulation Software

In the early stages of the project, it was thought that arcGIS has the capabilities to simulate E.V.C.P. use using the forest-based classification & regression tool. A project uses this tool to model and estimate house values in California (Nieto, 2019), of which the process was hoped to be transferable to finding suitable locations for E.V.C.P.s. However, after consulting an arcGIS specialist, it was determined that this method was not transferrable to this project.

Additionally, Ampcontrol.io, an AI based software for E.V.C.P. use simulation within the user's defined parameters (Ampcontrol | Smart Charging Simulation Tool, n.d.), was also considered. The software was announced in March 2022, and a demonstration request was made, however due to lack of response, the implementation of this software within this project was not possible.

6.0 Results

The following 3 locations are suggested to B.E.C. for further investigation as potential E.V.C.P. and P.V. array installation sites.

6.1 Hangleton Community Centre

14 Harmsworth Crescent, Hove BN3 8BW

The community centre has a car park which is accessible to the public with 7 unrestricted bays and surrounded by dense apartment housing. The local area depends heavily on on-street parking.

Figure 34: Photo of housing surrounding the Hangleton Community Centre

Figure 35: Car park and building of the Hangleton Community Centre

This location has a large roof area for P.V. array installation, and local capacity is available for installation.

Popular Times, a feature by google that provides times which a location is busy, shown in figure 36, shows a trend which may be beneficial for a 7kW E.V.C.P. as dwell time is suggested in 4 hour shifts during the day. Additionally, the availability of this data shows that this location is somewhat popular as this feature is not available for all locations.

Figure 36: Hangleton Community Centre popular times (hangleton community centre - Google Search, n.d.)

This location has a high estimated P.V. area, hence providing a high net profit.

Table 18: Results for Hangleton Community Centre

Hangleton Community Centre	
P.V. Area Estimate	$900m^2$
Annual P.V. Generation	152219 kWh
Net Profit	£ 10,478.00

6.2 Bishop Hannington Memorial Church

Nevill Avenue, Hove BN3 7NH

The church is situated in an area of high footfall which is attractive for marketing of the E.V.C.P. The car park does not have designated bays as its laid with gravel, it is undetermined whether this may reduce or increase the installation costs. The surrounding housing is a mixture of terraced and semi-terraced, which means the spread between on street and off-street parking is even.

Figure 37: Bishop Hannington Memorial Church car park

Figure 38: Photo of the Bishop Hannington Memorial Church

The 'Popular Times' feature shows that this location is not usually very busy, however the dwell times are consistent, starting at 9am til approximately 2pm each day Monday - Friday.

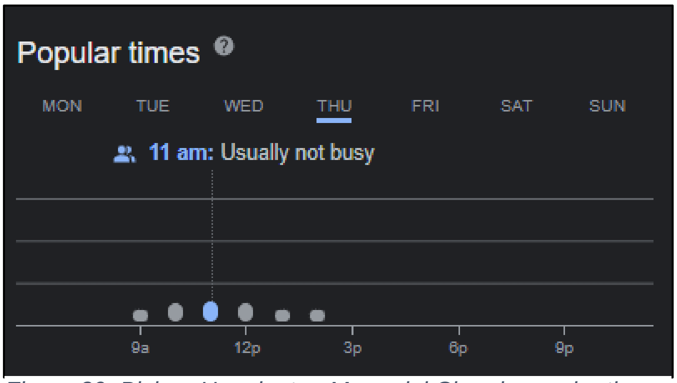


Figure 39: Bishop Hannington Memorial Church popular times (bishop hannington memorial church - Google Search, n.d.)

This location has the largest estimated P.V. area, and therefore predicted the highest net profit.

Table 19:Results for Bishop Hannington Memorial Church

Bishop Hannington Memorial Church	
P.V. Area Estimate	1250m^2
Annual P.V. Generation	211416 kWh
Net Profit	£ 15,945.00

6.3 Wayfield Avenue Resource Centre

2 Wayfield Avenue, Hove BN3 7LW

This location shares the same catchment as the Bishop Hannington Memorial Church. The car park has 12 unrestricted bays. The surrounding housing is mostly semi-detached with driveways, however on-street parking is also used heavily.

Figure 40: Photo of the Wayfield Avenue Resource Centre car park

Figure 41: Photo of the Wayfield Avenue Resource Centre building

Popular times data is not available at this location.

The P.V. estimate is the lowest, which in turn provides a smaller net profit.

Table 20: Results for the Wayfield Avenue Resource Centre

Wayfield Avenue Resource Centre	
P.V. Area Estimate	500m^2
Annual P.V. Generation	84566 kWh
Net Profit	£ 4,188.00

7.0 Discussion & Analysis

This project's aim is to suggest 3-5 locations for E.V.C.P. and P.V. array installation within the Brighton & Hove area. To achieve a result which meets the requirements outlined by B.E.C. and the industry, research in relevant areas was conducted, locations assessed through multiple criteria, and a commercial evaluation completed.

This process resulted in 3 areas which are deemed suitable for further investigation:

1. Hangleton Community Centre
2. Bishop Hannington Memorial Church
3. Wayfield Avenue Resource Centre

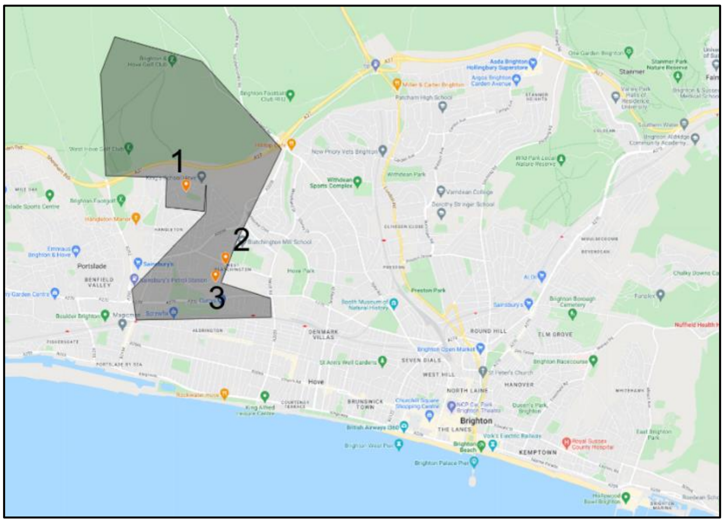


Figure 42: Position of final 3 locations on google maps

The results are promising, and as although the usage wasn't possible to predict, the locations are situated in a densely populated area which ensures maximum possible use.

The limitations which this process is restricted by are described:

- Housing type: determining the housing density composition would be very valuable as it allows locations which serve areas which rely on on-street parking entirely as a priority. Due to the data not being easily available, and requires each location to be investigated further, this is difficult to implement however not impossible.
- Managerial criteria: whether the operating business would like to have an E.V.C.P. and P.V. array installation is an essential consideration and impossible to determine without communication. A survey of local businesses may complete this requirement effectively.
- Usage: it may be more effective to survey residents to ask if they would consider the purchase of an E.V. if the infrastructure was built within their catchment. A survey may aid in estimating possible usage, however may limit operation to one area rather than across the city due to resource required to complete this successfully.

8.0 Project Management

Project planning is important as it defines aims and their deadlines, which enables a project to be completed within the desired timeframe. There are many tools which exist and can be created to tailor a specific project and team better to ensure time management can be kept. This project made use of GANTT charts, risk assessments, health and safety review, tailored weekly progress reports and spreadsheets for report completion.

8.1 Time Management

Figure 43 shows a GANTT chart which includes all required phases of the project, as defined in the work packages in Figure 8, page 12. This includes all required deadlines which were set to complete the module.

Overall planning went well, once the general process was established it was easy to plan how long each phase should last for and approximating how much time it will take.

The project was split into 5 phases which did overlap with each other to ensure good progress.

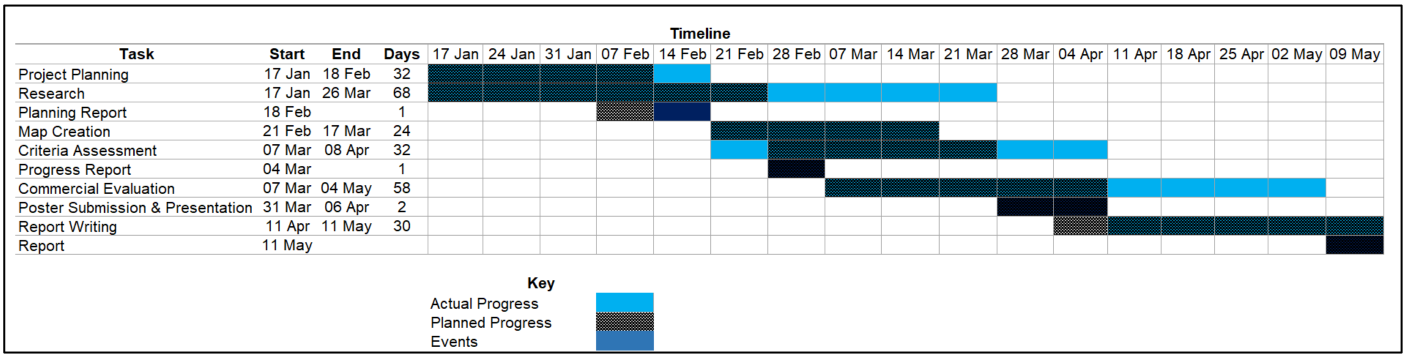


Figure 43: Whole project GANTT chart

8.1.1. Planning

The planning phase was important to be able to understand the scope of the project, create the required time management tools and produce the planning report. As seen in figure 44, this phase saw one major delay of 1 week, which was due to COVID. Therefore, an extension was approved for planning report submission for Friday 18th February.

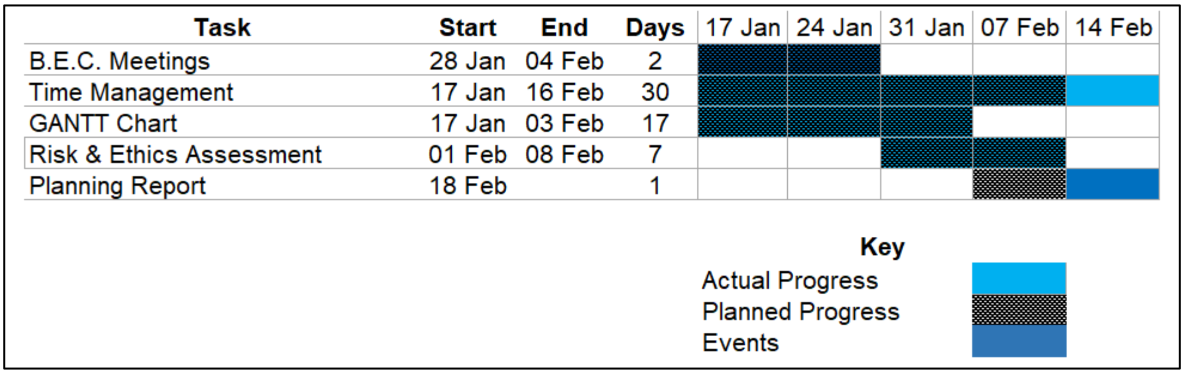


Figure 44: Planning phase GANTT chart

8.1.2. Research

The research phase was originally easy to plan, however upon learning more within the industry it was understood that further research was required. Additionally, the chance to attend the REVUP North conference on Tuesday 22nd March was not foreseen until contact with Charge My Street representatives was established.

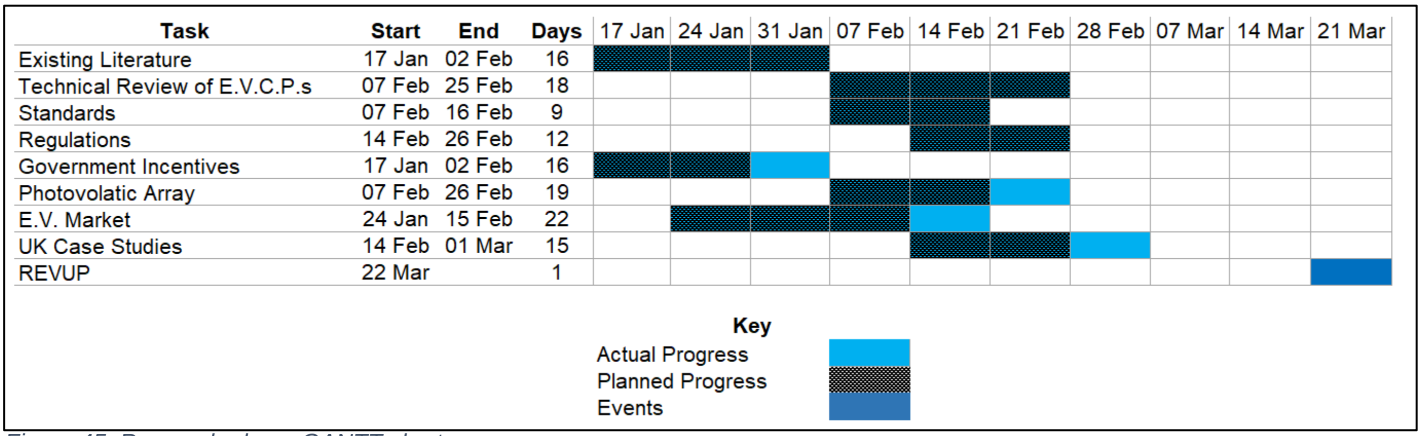


Figure 45: Research phase GANTT chart

8.1.3. Map Creation

The map creation phase surprisingly suffered no delays even though the use of software was changed during the phase. As the data was provided in a format that spatial software can read, it was easy to change software providing a user-friendly interface and no additional prerequisites were required to operate the software.

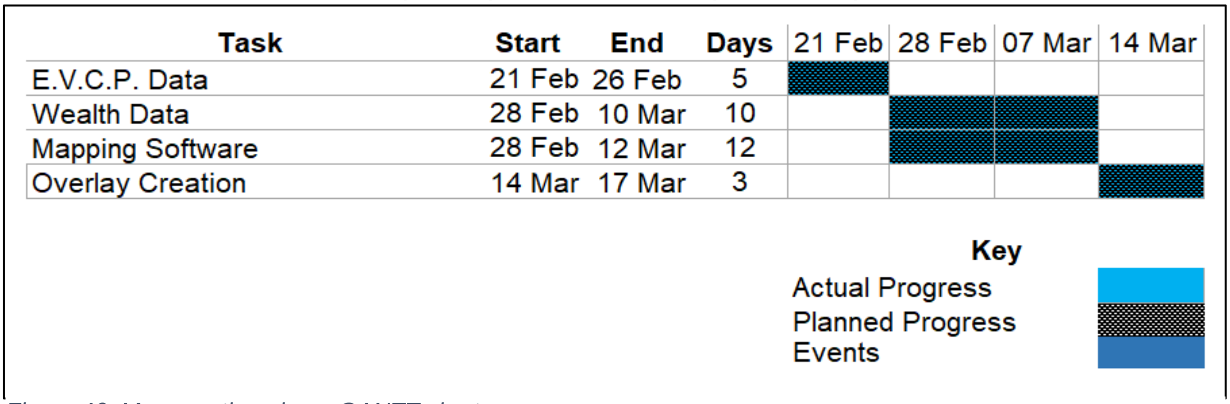


Figure 46: Map creation phase GANTT chart

8.1.4. Criteria

The criteria phase was difficult to stay on schedule due to the process not being completely developed in time, as seen in figure 47.

The major setback was learning about electrical load capacity, and how that can be determined for local areas. The DG mapping tool from UK Power Network was originally difficult to find, and access to the E.V. capacity is not integrated within the tool dashboard itself, hence finding it through navigating through the website was laborious.

Additionally, the formative progress report took longer than expected to produce as all information required was not in report form, and although the report was formative, the feedback gained from both supervisor and internal examiner was invaluable.

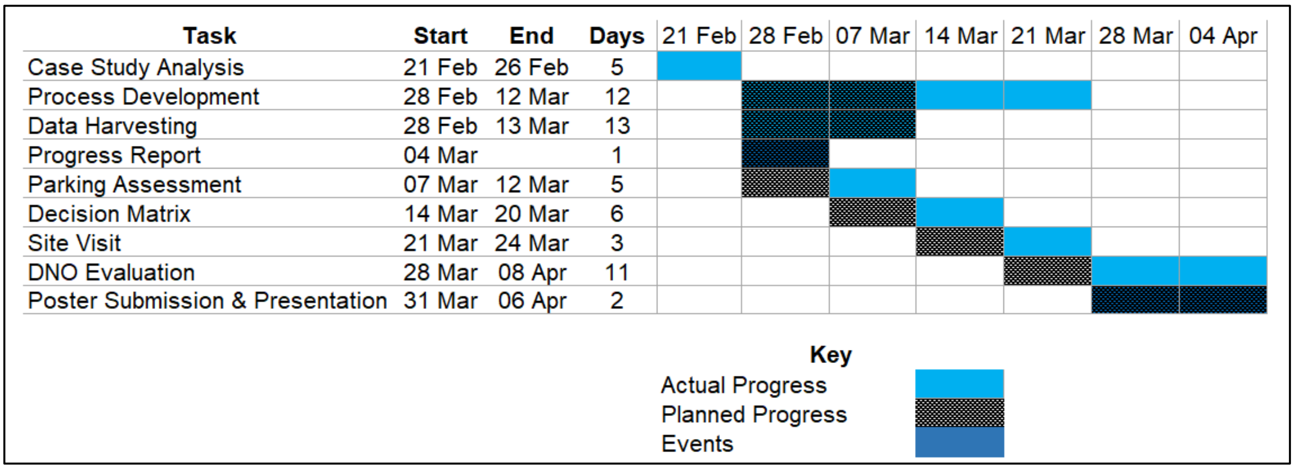


Figure 3: Criteria phase GANTT chart

8.1.5. Commercial Evaluation

The commercial evaluation was difficult to plan at the start of the project as the details of evaluation were yet to be confirmed, however overall was completed within reasonable timing.

Ideally a validation step would be valuable to the project, however due to time limitations and incompletion due to access to data and simulation software required to complete the commercial evaluation as planned, it was removed from the plan.

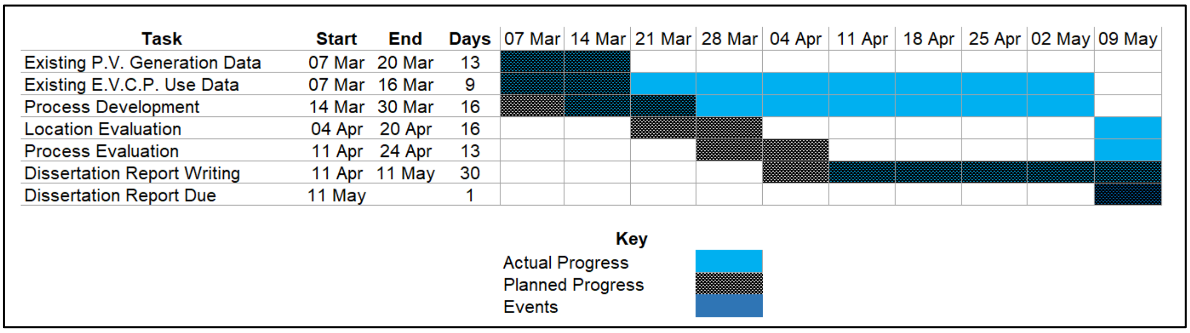


Figure 4: Commercial evaluation phase GANTT chart

8.2 Weekly Diary

A weekly diary was made within Excel to keep track of weekly aims and whether the project is experiencing any delays, as seen in Figure 49. This made it easy to understand where the project was suffering due lack of time and to respond by altering the plan in good time.

To improve, a counter could be added to ensure awareness of the deadline of the next deliverable. Additionally, a dissertation section could be added to encourage work to begin at an earlier stage.

XE636: FINAL YEAR PROJECT NAT ADAMSON

Week 3, Methodology

Progress

Week 1	Week 2
On Track	**On Track**

Aims

1	Gather Data
2	Methodolgy
3	

Tasks

Task Title	Description	Issues?	Done?
Map	Map current BEC; chargers and pv		Yes
Standards	Standards applicable to EVCS & PV		EVCS
Data	Find open source data from reliable source		Yes
Data	Request data from BEC		No- email pending
Criteria	Create critieria strategy	Requires further development	Started

Notes

From meeting with Steven:
- Look into council services; this is where people spend time plus usually has parking.
- Charge my street; has info + criteria for location choice
- Create heat map of possible locations.
- Demographic data would be useful; council could provide
- Pollution index; Kevin/Kirsty Smallbone - Moulsecoombe air pollution

Updates:
Using GIS to create a map may be possible.
Mapbox is also a useful tool - getting file type to cooperate is tricky (JSON).
Government data on charge point location is out of date/ incomplete.

Review

All tasks completed?
If not, why?
Data acquisition; ensuring that data I request is needed and relevan

Ammendments required to project plan?
No

Project progress:
On track

Figure 45: Progress sheet - week 3

8.3 Report Spreadsheet

A spreadsheet, appendix G, was created to understand report progress down to each subsection. The colour-coded progress key was useful as it allowed instant illustration of overall progress and what section requires further work. This enabled an efficient working method as it avoided spending too much time on one area, which may be likely during the production of a large report. To further improve this tool, it would be useful to order the contents by completeness to encourage work on sections which require the most work.

8.4 Risk Assessment

Assessing risk to the project is important as it enables planning to consider likely delays.

The 2 areas assessed in risk assessment matrix, appendix H:

- Software risk.
  Software concerns depend largely on the health of the machine being used. To mitigate risk, a physical and cloud drives are to be used to ensure continuity of the project should a failure arise.
- General factors.
  General factors have the most risk associated with them, as this project relies on secondary data, it is imperative that the data can be obtained within a reasonable time frame. Failure to do so will have a certain effect of the project's success.

Overall, the project was planned to ensure limited liability due to uncertainties around government response to further COVID-19 measures.

8.4.1. Health & Safety

A health and safety review, Appendix I, was conducted to ensure that throughout the progress of this project there was no risk to human life. If risk to human life was prevalent, the conditions surrounding this possibility must be known and understood prior to further progression.

8.5 Summary

Overall, time management was well kept, and project progress was successful even when experiencing severe delays which indicates that project management tools were appropriate for this project.

To improve, a soft project management course could have been taken prior to project start, to further understand project management concepts and theories. An evaluation of techniques could be useful not only for this project, but those in the future also.

9.0 Conclusion

This project has successfully suggested 3 locations for further investigation for an E.V.C.P. and P.V. array installation, with several accuracy and technical limitations.

Overall, this project has been challenging yet enjoyable to complete, and comprehensive research has allowed to develop a process for solving a real-world problem. Additionally, the opportunity to attend the REVUP North conference allowed full immersion into the industry and to learn from experts in the field.

10.0 Suggestion for Further Work

To further improve this process the following actions are recommended:

- Surveys can be used to gauge local interest from both businesses and residents.
- Ensure housing type is considered when evaluating local housing density.
- Dwell time could be recorded by potential businesses and whether they have E.V. owner customers which charging needs are currently unmet.
- Development of a spreadsheet: it may be possible to create a similar tool to that of the B.E.C.'s commercial modelling tool to assess potential locations. Score limitations can be implemented which ensures that a location that does not meet the required criteria is rejected.
- On a larger scale, it may be beneficial to communicate with other charge point installers to ensure that a location is not being considered by another party as this may have a detrimental effect on commercial viability for both parties.

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Appendices

Appendix A: Parking Assessment Results

Area	Site	Parking
1 - West Hove/Blatchington	Dyke Railway Trail Car Park	Yes - public access
	King's School Hove (inc. Primary)	Yes - private
	Hangleton Community Centre	Yes (unsure if public)
	Hangleton Park East Enterance	No
	West Blatchington Windmill	Undetermined
	St. Peter's West Blatchington	No
	The Grenadier	Yes - private
	Bishop Hannington Memorial Church	Yes - public access
	Sussex Education Centre	Yes - private
	Lindridge Care Home	Yes - private*
	Martlets Hospice	Yes - private
	Bishop Hannington Youth & Community Centre	No
	Wayfield Avenue Resource Centre	Yes - public access
	Hove Cemetery	Yes - private
	Hove Community Fire Station	Yes - private
	Hove Jobcentre	Yes - private
	Hove Recycling Centre	No
2 - Hollingbury	PHX GYM Brighton	Yes - public access
	Old Boat Corner; Community Centre	Yes - on-street
	Top Cat Veterinary Centre	Yes - public access
	Patcham High School	Yes - private
	Patcham Community Centre & Library	Yes - public access
	County Oak Medical Centre	Yes - private
	Brighton Elim Church	Yes - on-street
	Coldean Primary School	Yes - private
	Hollingbury Golf Course	Yes - public access
	Hollingbury Recycling Point	Yes - public access
	Hollingbury Park, Woods & Allotments	Yes - public access
	Hollingbury Park: Sports	Yes - on-street
	South entrance to Wild Park	Yes - public access
	Hollingdean Skate Park	No
	Hollingdean Children's Centre	Yes - on-street
	Central Hub Brighton & Cedar Centre	Yes - public access
	Hertford Junior School	Yes - private
	Hertford Infant School	No
	Allied Medical Centre	Yes - on-street
	Hollingdean Community Centre	Yes - public access
	St Joseph's Primary School	No
	Saunders Community Garden	No
	Saunders Park	No
	Moulsecoomb Train Station	Yes - on-street
	Wild Park Main Entrance	Yes - public access
	Ditchling Road Wild Park Entrance	Yes - public access

3 - Moulsecoomb	Amex Stadium	Yes - private
	Brighton Aldridge Community Academy	No/Private
	Bridge Car Park	Yes - public access
	The Keep	Yes - private
	Woollards Orchard	No
	St George's Hall	Yes - on-street
	Moulsecoomb: Hairdressers & Amenities	Yes - on-street
	Ashurst Rd: Access to fields	No
	Moulsecoomb Industrial Park	Yes - private
	Moulsecoomb Leisure Centre	Yes - private
	Moulsecoomb Primary School	Yes - private
	Moulsecoomb North Hub & Boxing	Yes - on-street
	St Andrews Church	No
	The Bevy	Yes - public access
	Hazelgrove Nursing Home	Yes - public access
	Bevendean Primary School	Yes - private
	Bevendean: Green Space & Amenities	Yes - on-street
	Great Overcomers Parish	Yes - on-street
	Partridge House	Yes - on-street
	Bevendean Salvation Army	Yes - on-street
	Bevendean Industrial Park & Funplex	Yes - public access
	Meadowview Community Centre	Yes - public access
	Cemetery	Yes - public access
4 - Whitehawk	Sheepcote Valley Car Park (Warren Road) FREE	Yes - public access
	Recycling Site	No
	Dobbies Garden Centre Brighton	Yes - private
	Brighton General Hospital	Yes - private
	Brighton Racecourse	Yes - public access
	St Cuthmans & Valley Social Club	Yes - on-street
	City Academy Whitehawk	Yes - private
	Roundabout Children's Centre	Yes - public access
	Allotments	No - permit
	The Manor Gym	No - permit
	Brighton College Nursery & Pre-Prep School & Swim School	No
	Stanley Deason Leisure Centre	Yes - private
	East Brighton Café	No - COVID site
5 - Woodingdean	Hairdresser & Local Amenities	Yes - on-street
	Woodingdean Skate Park	No
	Woodingdean Industrial Park	Yes - private
	Coop Warren Way	Yes - on-street
	The Downs B&B	Yes - public access
	Woodingdean Youth Centre	Yes - public access

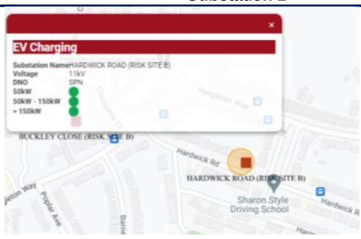
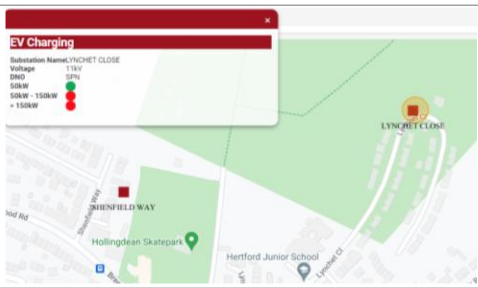
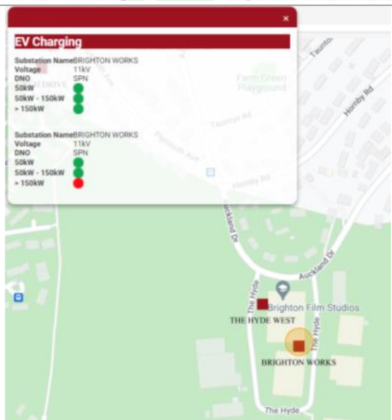
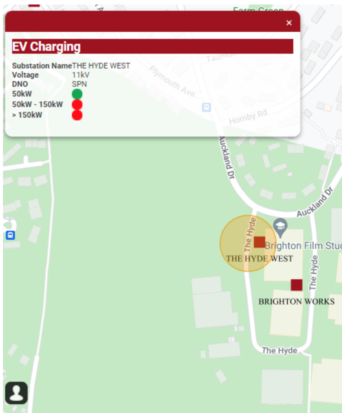
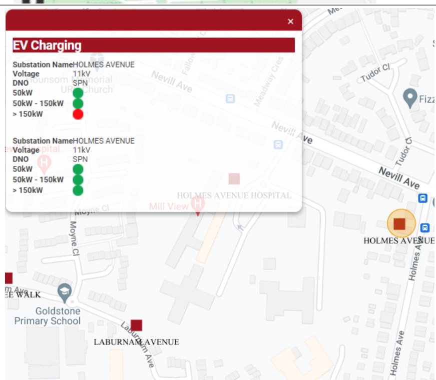
Appendix B: Criteria Assessment Results

Site	PV Score	Time Score	Surrounding Houses	TOTAL
Dyke Railway Trail Car Park	1	5	5	11
Hangleton Community Centre	5	3	5	13
Hangleton Park East Enterance	1	1	5	7
Bishop Hannington Memorial Church	5	1	4	10
Wayfield Avenue Resource Centre	5	3	3	11
PHX GYM Brighton	0	1	1	2
Old Boat Corner; Community Centre	5	3	2	10
Top Cat Veterinary Centre	0	1	4	5
Patcham Community Centre & Library	5	3	5	13
Brighton Elim Church	3	2	5	10
Hollingbury Golf Course	3	4	1	8
Hollingbury Recycling Point	1	1	3	5
Hollingbury Park, Woods & Allotments	1	3	1	5
Hollingbury Park: Playground	1	1	3	5
South entrance to Wild Park	1	4	2	7
Hollingdean Children's Centre	4	5	3	12
Central Hub Brighton & Cedar Centre	5	5	3	13
Allied Medical Centre	0	1	5	6
Hollingdean Community Centre	1	3	5	9
Moulsecoomb Train Station	1	1	3	5
Wild Park Main Entrance	1	4	2	7
Ditchling Road Wild Park Entrance	1	4	2	7
Bridge Car Park	1	2	1	4
St George's Hall	2	3	2	7
Moulsecoomb: Hairdressers & Amenities	1	1	2	4
Moulsecoomb 67 Centre & Boxing				0
The Bevy	1	1	5	7
Hazelgrove Nursing Home	5	5	2	12
Bevendean: Green Space & Amenities	5	1	4	10
Great Overcomers Parish	4	2	2	8
Partridge House	4	5	3	12
Bevendean Salvation Army	3	3	3	9
The Hyde Business Park	5	5	2	12
Meadowview Community Centre	2	3	3	8
Cemetery				0
Sheepcote Valley Car Park (Warren Road) FREE	1	4	1	6
Brighton Racecourse	5		2	7
St Cuthmans & Valley Social Club	5	3	4	12
Roundabout Children's Centre	2	1	3	6
Rosalyn's Hairdressers & Local Amenities	5	1	4	10
Coop Warren Way	1	1	5	7
The Downs B&B	1	5	4	10
Woodingdean Youth Centre	5	3	2	10

Appendix C: Site Visit Results

Location	Details	Mobile Data	Accepted?
Hangleton Community Centre	Car parking is open to public, 6 unrestricted bays. Surrounding housing is apartments. Location likely council owned.	4	Yes
Patcham Community Centre & Library	Car parking open to public however soft restrictions in place. Surrounding housing is apartments. Building is council owned.	5	No: soft restrictions on parking
Central Hub Brighton & Cedar Centre	Car parking open to public, 12 unrestricted bays. Surrounding housing is semi-detached. Building owned by council. EV parked in car park.	4	Yes
Hollingdead Children's Centre	P.V. potential likely to be significantly smaller than approximated. On-street parking available but may not be suitable. No capacity clues. Local housing is apartments.	4	No: Parking does not meet requirements.
Hazelgrove Nursing Home	Car parking open to public but may appear closed off - must drive around the building. Surrounding housing is semi-detached. Slight concern for future shadowing of PV. Private owner.	5	No: P.V. requirements not met.
Partridge House	Car parking open to public but may appear closed off. PV space - concern over surrounding trees. Housing is semi-detached and not as populated close to the location as might be prefered.	5	No: P.V. requirements not met.
The Hyde Business Park	Car parking open to public, large amount of unrestricted bays (>10). Large P.V. area, corregated roof ideal for installation. Surrounding housing terraced.	4	Yes
St. Cuthmans & Valley Social Club	Valley social club car park not available - on-street bay looks suitable. Capacity likely. Surrounding housing mixture of terraced and apartments.	4	No: Management differs across both of the locations.
Wayfield Avenue Resource Centre	Car parking open to public, 12 unrestricted bays. Surrounding housing is semi-detached. Building owned by council.	3	Yes
Bishop Hannington Memorial Church	Car parking open to public, gravel bays. Surrounding housing is a mixture of semi-detached & terrace.	3	Yes

Appendix D: DNO Evaluation Results

<table>
<tr><th>Area</th><th>Location</th><th>Substation 1</th><th>Substation 2</th></tr>
<tr><td>1 - West Hove</td><td>Hangleton Community Centre</td><td>
</td><td>N/A</td></tr>
<tr><td>2 - Hollingbury</td><td>Central Hub Brighton & Cedar Centre</td><td>
</td><td>N/A</td></tr>
<tr><td>3 - Moulsecoomb</td><td>The Hyde Business Park</td><td>
</td><td>
</td></tr>
<tr><td>1 - West Hove</td><td>Wayfield Avenue Resource Centre</td><td>
</td><td>N/A</td></tr>
<tr><td>1 - West Hove</td><td>Bishop Hannington Memorial Church</td><td>
</td><td>N/A</td></tr>
</table>

Appendix E: B.E.C. E.V. Modelling Tool

E.V. Modelling Tool

	Input	Calculated		Estimated	
No of years to model over	25		**Income from Solar PV**		
			FiT available	n	Y/N
The Site			Fit Generation rate	£ 0.037	£/kWh
Solar PV on site	y	Y/N	Deemed Export available	n	Y/N
% Solar generation used on site	80.0%		PPA unit rate	£ 0.11	£/kWh
Volume exported	20.0%		PPA (annual increase)	2.5%	
			Export rate	£ 0.05	£/kWh
Solar PV System			Export annual increase	2.5%	
PV system size		kWp			
Expected generation		kWh	**Solar PV System costs**		
No of inverters on site	1		Capital cost of Solar PV per kWh inc installation	750	£/kWh
Electricity costs			**Solar Array performance / maintenance**		
Solar generated on site cost PPA	£ 0.11	£/kWh	PV array performance reduction / year	1.0%	
Grid Electricity cost (import)	£ 0.13	£/kWh			
			No of years before inverter(s) needs replacement	10	
			No of years before inverter(s) needs 2nd replacement	20	years
General operating costs			Cost of new inverter inc installation	£ 6,798	
Administration hours per year	40				
Administration cost per hour	£25.00		Metering & monitoring per year	£ 50	
Marketing			Insurance EV alone	£ 225	one quote
Cost per acqusition (advertising etc)	£ -		Insurance PV + EV	£ 420	
Price promotion discount	0%		General Ops & Maintenance as % of Capital	1.0%	
No of months p.a. that promo applies	0				
			Whole System (PV & EVCP) financing		
			Project development cost (% of PV Capital cost)	10.0%	
			Bridging loan - cost of capital	5.0%	not used
			Bridging loan term	0	
			Community finance cost of capital (share interest)	3.5%	
			Share payback period	25	
			how long you have to own shares before earning interest	2	full years
			first year that shares can be withdrawn	2	
			Inflation assumption	2.50%	
			Capital Depreciation period	25	
			Rate of Depreciation	4%	
			NPV Rate (assumed to equal interest on debt)	3.5%	
			Do you want to build up cash for replacement equipment?	y	Y/N

EV Charge points		
number of charge point units installed on site	1	
number of sockets per charge point (ie single or dual)	2	
Charge point capacity	7	kWh
No of new users per charge point in year 1	10	
Assumed increase / decrease in new user volume per year	0.0%	
No of days used per year (site occupancy)	250	days
Charge point usage per day (Peak rate)	4	hours per day
Charge point usage per day (Off-Peak rate)	0	hours per day
Assumed increase in use of the chargers (frequency) per year (Peak Rate)	0.0%	
Assumed increase in use of the chargers (frequency) per year (Off peak)	0.0%	
EV Charging customer price (Peak)	£ 0.25	£/kWh
EV Charging customer price (Off-Peak)	£ 0.10	£/kWh
EV Charging customer price (Peak) EX VAT	£ 0.21	£/kWh. VAT Charged at 20% on EV Charging
EV Charging customer price (Off-Peak) EX VAT	£ 0.08	£/kWh. VAT Charged at 20% on EV Charging
Assumed increase / decrease in charging price per year (Peak Rate)	0.0%	
Assumed increase / decrease in charging price per year (off peak)	0.0%	
Volume of Energy used by EV charger (Peak)	7,000	kWh
Volume of Energy used by EV charger (Off-Peak)	-	kWh
Total Volume of energy used to charge	7,000	
percentage of EV charges carried out when solar is generating	60%	averaged across the year
Percentage of EV Charges from grid	40%	
Charge point costs		
Charge point unit cost	£1,650	
Initial installation cost (include civils, electrical upgrades etc)	£1,500	per chargepoint installation
Grid connection cost	£ -	
Total installation cost	£3,150	
Charge point performance / maintenance		years
No of years warranty	3	
Performance reduction / year	0.0%	
No of years before charge point(s) needs replacement	10	
No of years before charge point(s) needs 2nd replacement	20	
No of years before charge point(s) needs 3rd replacement	0	
Cost of new Charge point	£1,650	
Installation costs for replacement	£ 100	
Total replacement costs	£1,750	
Data charges post warranty period	£ 120	
Extended warranty costs	£ 300	
General Ops & Maintenance as % of Capital	1%	£/kWh
EV operator charge	£ 0.01	

Appendix F: P.V. Generation Estimate Data

Month	Value	kW per panel	kW per m2	Hangleton Community Centre (kW)	Bishop Hannington Memorial Church (kW)	Wayfield Avenue Resource Centre (kW)
January	1860	14.0909091	8.447787225	7603	10559	4223
February	1725	13.0681818	7.834641378	7051	9793	3917
March	3787	28.6893939	17.19987646	15479	21499	8599
April	3787	28.6893939	17.19987646	15479	21499	8599
May	3787	28.6893939	17.19987646	15479	21499	8599
June	3787	28.6893939	17.19987646	15479	21499	8599
July	3787	28.6893939	17.19987646	15479	21499	8599
August	5280	40	23.98081535	21582	29976	11990
September	4241	32.1287879	19.26186324	17335	24077	9630
October	2437	18.4621212	11.06841799	9961	13835	5534
November	1944	14.7272727	8.829300196	7946	11036	4414
December	817	6.18939394	3.710667829	3339	4638	1855
TOTAL	37239	282.113636	169.1328755	152219	211416	84566

Note:
Adjustment made for August:
(3066/18)*31=5280
For full month figure

Appendix G: Report Progress Spreadsheet

REPORT PROGRESS

		CONTENTS	KEY	COMMENTS	COMPLETE?	Page count	
0		Title Page	1	DONE		1	
1		Disclaimer	1	DONE		1	
2		Abstract		not completed until EOR			
3		Acknowledgements	6	not completed until EOR		1	
4		Contents	6	not completed until EOR		1	
6		Table of Figures	6	not completed until EOR		1	
7		Table of Tables?	6	not completed until EOR		1	6
8		Abbreviations	6	not completed until EOR			
	1	**Introduction**	**1**	DONE - POSSIBLE REVIEW		1	
	2	**Problem Statement**	**1**	DONE		1	
	3	**Project Aims & Objectives**	**1**	DONE		0	
		3.3Work packages		DONE			
	4	**Research**	**1**	DONE			10
		4.1: Existing Literature	**1**	DONE		3	
		4.1.1: Charge Point Locations	*1*	DONE			
		4.1.2: Commercial	*1*	DONE			
		4.1.3: Legal	*1*	DONE			
		4.1.4: Summary	*1*	DONE: LIMITATIONS			
		4.2 Technical Review	*1*	DONE		3	
		4.2.1. EVCS	*1*	Capacity write up			
		4.2.2. Standards	*3*	Table of standards needs descriptions+reference			
		4.2.3. P.V. Array	*3*	Neatening required			
		4.2.4. Summary	*2*	Wording, neaten up			
		4.3 E.V. Industry	*1*	DONE		4	
		4.3.1. Government Incentives	*1*	DONE			
		4.3.2. Limitations	*3*	Potentially too much - need to revisit on Monday			
		4.3.3. Case Study: Charge My Street	*1*	DONE			
		4.3.4. REV Up North	*4*	Writing up			
		4.3.5. Summary	*4*	ideas are there, just requires formulating			
	5	**Methodology**	**3**	V diagram required.			15
		5.1: Map	*1*	DONE		4	
		5.1.1: EVCS Map	*1*	DONE			
		5.1.2: Low income Map	*2*	data			
		5.1.3: Overlay	*2*	DONE - Limitations			
		5.2 Criteria	*1*	DONE		8	
		5.2.1: Locations	*2*	number of locations			
		5.2.2: Parking	*2*	number of locations			
		5.2.3: Decision Matrix	*3*	Dwell time info			
		5.2.4. Site Visit	*3*	wording			
		5.2.5. DNO Evaluation	*2*	limitation			
		5.2.6: Results?	*3*	limitations to think of			
		5.3: Commercial Evaluation	*2*			3	
		5.3.1: P.V. Generation	*5*				
		5.3.2: EVCS Usage Profile	*4*				
		5.3.3: Application to Locations	*5*				
		5.4 Validation					
	6	**Results**					
	7	**Discussion & Analysis**					
	8	**Conclusion**					
	9	**Suggestion for Further Work**					
	10	**Planning**					
		6.1 GANTT Chart					
		6.2 Workbreakdown Structure					
		6.3 Weekly Diary					
		6.4 Spreadsheet					
		6.5 Risk Assessment?					
		6.4.1: H&S Review					
	10	**References**					
	11	**Appendices**					

Key
100% done
completed - requires review
somewhat
started
none

Appendix H: Risk Assessment

Type	Risk	Description	Severity (1-3)	Liklihood (1-3)	Risk Factor (1-9)	Risk Level	Mitigation
SOFTWARE	Personal P.C. breakdown	Loss of access to software: excel, arcGIS	1	1	1	Low	Access to an alternative machine which is powerful enough to operate the software.
		Loss of work	3	1	3	Low	Ensure work is uploaded to a cloud-based service which continuously saves files.
GENERAL FACTORS	Project Incompletion	Time management	3	2	6	Medium	Plan week-to-week schedules to ensure organisation is kept. This will also serve as an indicator for when my time management is failing; not meeting self-dictated deadlines.
		Data from third parties	3	2	6	Medium	Ensure to prioritise data gathering to commence at the earliest opportunity to lessen severity. Evaluate required data by its relevance to the project and place priority on critical data. Produce a mitigation plan should critical data not be delivered to ensure project outcomes can be reached.
		Breakdown of communication with supervisor(s).	3	1	3	Low	Organise a weekly session check in to ensure communication between myself and my supervisor is sufficient.

Appendix I: Health & Safety Review

Hazard	Affected	Current Controls	Risk (H/M/L)	Mitigation
Strain to eyes	Myself, colleagues working on data	Ensuring awareness of the health implications and appropriate actions.	L	To keep this low, a timer on the screencan be used as a reminder. Additionally, any over-the-counter medications to help keep the eyes moist.
Bodily harm - Whilst assessing charging stations, risk of being hit by a car	Myself,colleagues also if supervised.	Being aware of my surroundings and highway code when working on a public road.	M	To lower risk, going on the road could be avoided, or only step on the road if accompanied by another person to ensure safety.
Risk of electrocution	Users of damaged/compromised electric charge points	To report any damage or risk to the owner of the charge point.	H	To stay by the charge point until a qualified member of staff arrives so no member of the public gets hurt.