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Lowering your emissions through innovation in transport and energy infrastructure

Transport

Energy Infrastructure

Knowledge & Enterprise

Predicting On-Street EV Charging Demand:

A Case Study using the City of Worcester

EVEREST

July 2021

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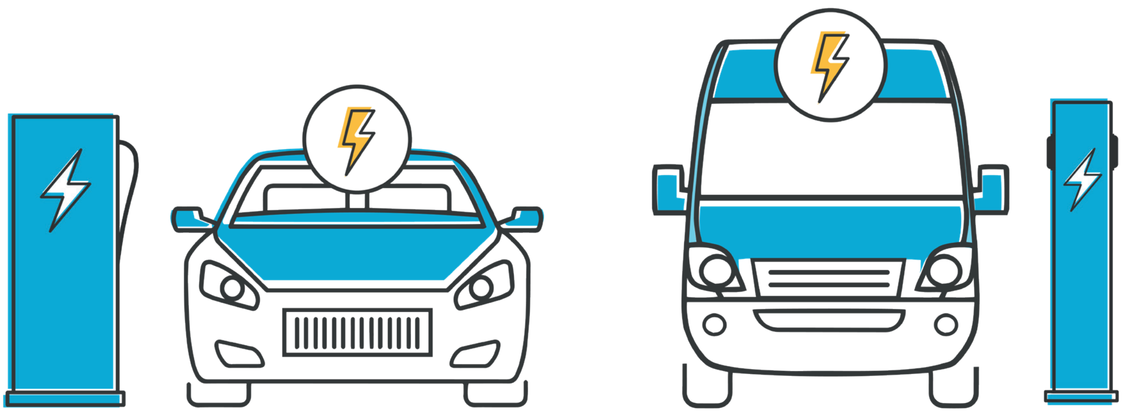


Introduction to Cenex

Cenex was established in 2005 as the UK's Centre of Excellence for Low Carbon and Fuel Cell technologies.

Today, Cenex focuses on low emission transport & associated energy infrastructure and operates as an independent, not-for-profit research technology organisation (RTO) and consultancy, specialising in the project delivery, innovation support and market development.

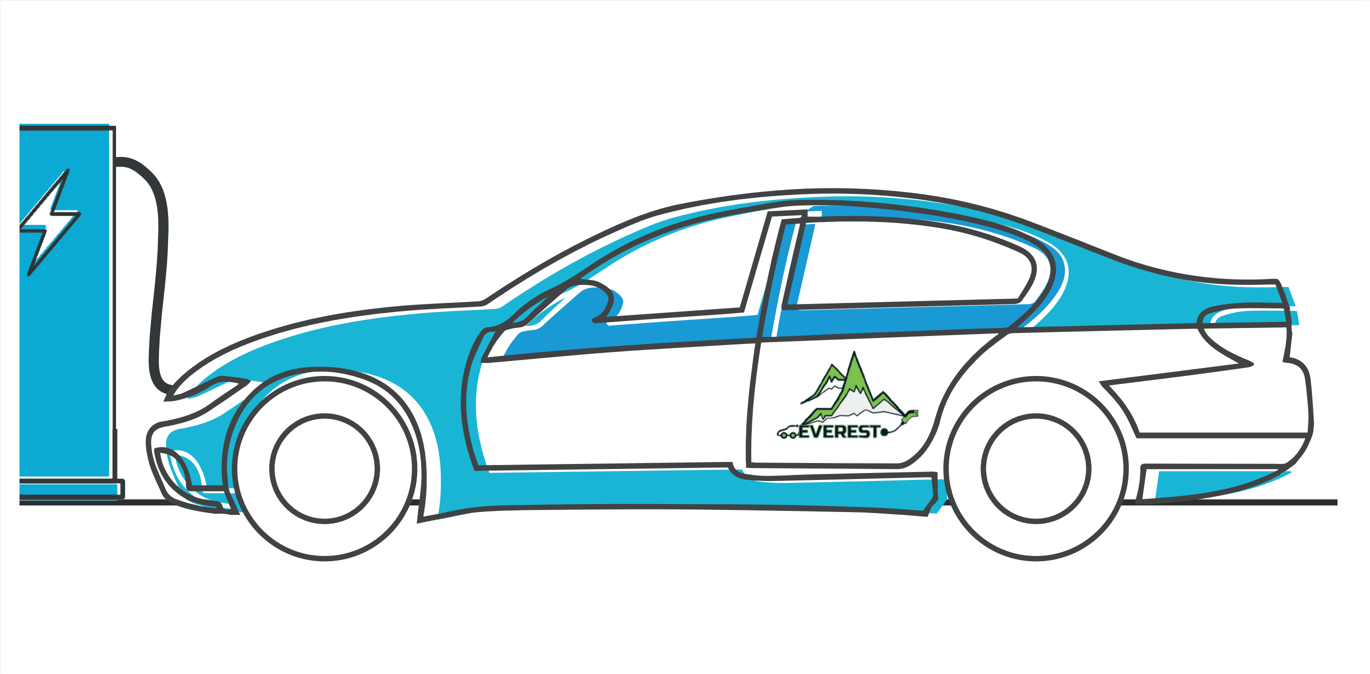
Our independence ensures impartial, trustworthy advice, and, as a not-for-profit, we are driven by the outcomes that are right for you, your industry and your environment, not by the work which pays the most or favours one technology.

Finally, as trusted advisors with expert knowledge, we are the go-to source of guidance and support for public and private sector organisations along their transition to a zero-carbon future and will always provide you with the insights and solutions that reduce pollution, increase efficiency and lower costs.

To find out more about us and the work that we do, visit our website: **www.cenex.co.uk**

Lowering your emissions through innovation in transport and energy infrastructure

Executive Summary



The EVEREST model (Electric Vehicle Energy Resource ESTimator), developed by Cenex as part of the Virgin Park And CHarge (VPACH2) project, predicts the amount of public charging infrastructure that needs to be deployed to support and facilitate the expected uptake rates for privately used Electric Vehicles (EVs) as the road transport industry electrifies.

EVEREST enhances the precision and scale of Cenex's advice to local authorities and chargepoint network operators (CPNO) as to where and when **on-street EV charging** is going to be required, based on real data and configurable assumptions.

This report demonstrates the capabilities of **EVEREST** and how the results fit into a wider strategy; using the city of Worcester – part of Worcestershire County Council, who are a partner within the VPACH2 consortium – as a case study.

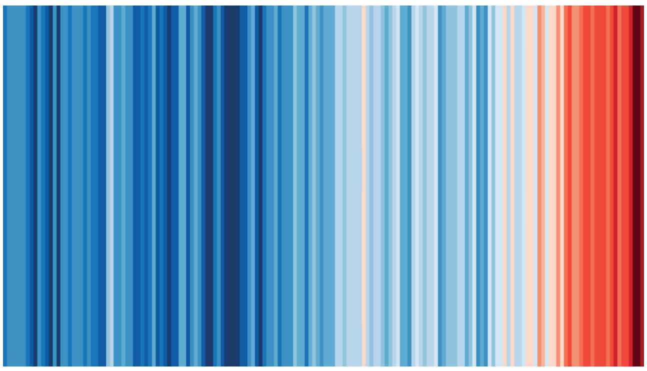
Electric Vehicles and Environmental Policy

The UK has a legally-binding commitment to reach net-zero carbon emissions by 2050 and EVs are a key part of the plan to achieve this.

On 18th November 2020 the UK Government published a 10-point action plan for a "Green Industrial Revolution"; the fourth point of which includes:

> **"transforming our national infrastructure to better support electric vehicles".[1]**

In the accompanying documentation, the UK confirmed it would end the sale of new petrol and diesel cars and vans by 2030, ten years earlier than the UK's previous Industrial Strategy as laid-out in the Road to Zero publication. Furthermore, the sale of hybrid cars and vans that can drive a significant distance with no carbon dioxide coming from the tailpipe would be prevented from 2035 onwards.



Warming Stripes: Annual global temperatures from 1850-2017 [8]

This action is being implemented to tackle two environmental issues:

1. Environment and Climate Change

The UK's ten warmest years all occurred since 2002[2], reflecting a global heating which is considered "extremely likely" to have been caused by the increasing levels of carbon dioxide (CO_2) being emitted into the atmosphere[3].

The latest Committee on Climate Change report shows that transportation is now the worst-performing sector in the country and emissions have risen in four of the five most recent years[4].

According to the Decarbonising Transport report, "there is no plausible path to net-zero without major transport emissions reductions".

2. Society and Public Health

Poor air quality is now the largest environmental risk to UK public health[5]. The enquiry into the death of Ella Kissi Debrah listed air pollution as an official cause of death for the first time in the UK[6] and a recent study highlighted that a child living within 50 m of a major road could have their lung growth stunted by up to 8% due to air pollution[7].

The transition to electric vehicles is key to improving air quality in urban areas and avoiding all of the direct and indirect health issues it can cause.

Electric Vehicle Charging and the On-Street Challenge

EVs are fundamentally different to the internal combustion engine (ICE) vehicles that they are replacing in terms of how they are "refuelled". While safety requirements around handling of petrol and diesel means that ICE vehicles refuelling is limited to 'forecourt' locations, electric vehicles can be recharged almost anywhere that an electrical supply is available.

Current battery technology means that the range of an EV is often lower than the ICE equivalent, meaning that the vehicle needs to be recharged more frequently. However, the infrastructure required for recharging is simpler than that needed for petrol or diesel refuelling and therefore there is much greater flexibility in where and when an EV is recharged.

The transition to electric vehicles is still in the early adopter phase and there are a number of challenges to address to ensure that a robust charging infrastructure network is in place to support a transport system where EVs are mainstream. One of these challenges is ensuring that charging a vehicle is available and equitable for all drivers. This problem was not as pronounced for ICE vehicles – regional price variations were reasonably small other than at premium motorway prices and even in the extremely rural areas fuel stations are accessible, although they may be slightly more expensive.

For EV charging the difference is more visible. In effect, the divide is between those with access to off-street parking at home and those without. Those with off-street parking – which accounts for the majority of early adopters – can deploy their own EV chargepoint to charge their vehicle at home using their home energy tariff. By contrast, those without access to off-street parking are purely reliant on using the public charging network.

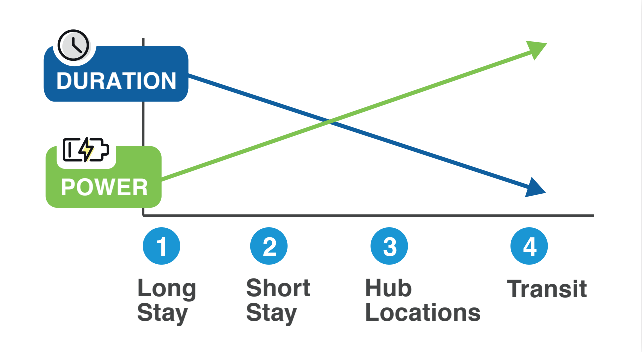
Historically, public charging has focused on providing high powered ('Rapid') charging. As electricity is taxed at different rates dependent on whether it is used domestically (5%) or commercially (20%), using public charging is inherently more expensive than recharging at home. However, taking into account that high powered public charging also requires more expensive technology, as well as typically needing some amount of civil works, the costs of public charging infrastructure can be anywhere from 60% to 300% more expensive than charging at home. Those without access to off-street parking are therefore the ones most exposed to this price discrepancy.

It is estimated that approximately 40% of UK households do not have access to off-street parking at home, most of whom are in urban areas with air quality issues where EVs are most needed.

As the EV charging industry develops, a wider range of public charging technologies have become available, enabling more options to be provided to support the recharging needs of those without access to off-street parking. Each technology has its own advantages and disadvantages, which means that the technology selection is dependent on the location and duration that a vehicle is at that location.

Electric Vehicle Charging and the On-Street Challenge

EV public charging location types can be split into four categories of decreasing charging duration and increasing power requirement:



1. **Long-stay:** This location type includes residential areas, workplace locations, park and rides, travel hubs; fleet depots; and hotels; all locations where the vehicle is parked for a number of hours (Typically 6+ hours).

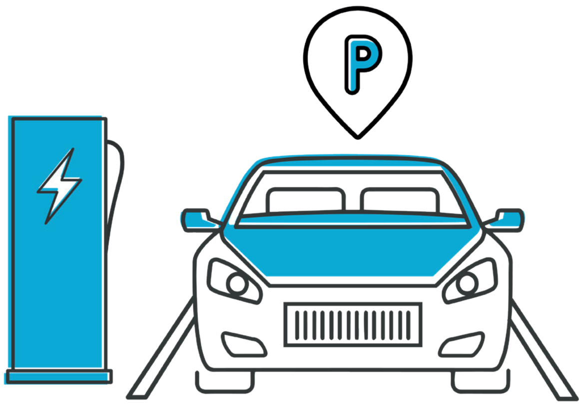
2. **Short-stay:** This type includes locations where the EV will be parked for a small number of hours and includes retail parks and shopping centres, leisure facilities, tourist attractions and workplace visitor parking where vehicles are likely to be parked up for between 0.5 - 3 hours.

3. **Hub Locations:** These are locations where the primary reason to visit is for recharging of the vehicle. Therefore, high powered charging is required to limit the time spent waiting by the driver. These locations may also include some facilities for the driver, or be located in close proximity to destinations. The pre-eminent example is the first bespoke EV charging hub in the UK; the Gridserve Electric Forecourt in Braintree, Essex[9].

4. **Transit:** These are locations where the vehicle requires a charge to complete their journey. Typically, the parking duration for transit locations is shortest and therefore the highest power charging is required. Locations include existing fuel stations near to major roads and motorway services.

Residential on-street charging is a type of long-stay charging that can enable those without off-street parking to transition to electric vehicles. It can also be highly convenient and the most similar to off-street charging – the user simply plugs in the vehicle when parked outside their home and the vehicle is recharged whilst it is parked and not used. However, current EV adoption in urban areas without off-street parking, which often coincide with less affluent demographics, is typically low and therefore the case for on-street charging is not always commercially attractive. Nevertheless, many local authorities have recognised the social need for charging infrastructure to encourage the electric transition in these regions.

Cenex has created the **EVEREST** model to calculate the amount of on-street charging infrastructure that is required to support the mass-market adoption of electric vehicles. This document shows the current capability of the model using the case study of the city of Worcester. In future, the EVEREST model will be updated to optimise the deployment of rapid charging in hub locations in conjunction with on-street residential charging.



Methodology

The EVEREST model takes in multiple inputs to predict the demand for, and optimise the deployment of, public EV charging infrastructure. These inputs can be simplified into three groups which are listed below, with a description of how they are each used.

1 Publicly available datasets:

- Locations of **existing chargepoints** taken from the **National Chargepoint Registry**[10] (NCR), which is managed by Cenex. This input is vitally important in order to account for existing on-street chargepoints that will already cater for a certain amount of EV charging demand. Additional data is taken from **Google Places**. The use of two datasets enables the data source to be checked for completeness, as well as providing redundancy in the situation where one source is not available. The inputs are pre-processed to ensure that no chargepoint is accounted for twice.
- Driving behaviour taken from the **National Travel Survey (NTS)** from the Department for Transport, supplied via the UK Data Service under a Special Licence for the development of EVEREST. The NTS is conducted annually and the most recent dataset is from 2019; the model uses years 2016-2019 to give a comprehensive dataset which is used to understand driving behaviour, and therefore charging demand, for different vehicle classifications.
- **Output Area** geography and the social demographics of the population within them, taken from the 2011 **UK Census**. The output areas bound the scope of the problem for the area being modelled – e.g. Worcester – and the demographic gives information on level and type of vehicle ownership.

2 Other datasets:

- An **EV uptake prediction**, devised by Cenex, taking into account the impact of the latest UK legislation such as the 2030 sales ban of new petrol and diesel cars and vans. The uptake curve is tailored to the local social demographic and gives predictions by vehicle type until 2040.
- Number of **households** with access to **off-street parking**. This dataset is processed from Ordnance Survey maps by mapping specialists Field Dynamics, appointed by Cenex. This is especially important as these households will not be reliant on the public network for their day to day charging needs.

3 User inputs and assumptions:

- Other **planned, on-street chargepoints** in the area. When working with a local authority, there may be planned chargepoints that won't be accounted for by the standardised model inputs. These can be input at this point.
- The model takes an assumed amount of charging done at **leisure and workplace** sites and removes this from the total on-street charging demand. This input is configurable.
- Any constraints on the amount of on-street infrastructure that can physically be deployed in an area can be set. This may be useful for very small Output Areas such as large apartment blocks or high-rise flats.
- The maximum distance can be set to determine how far someone can be expected to go from their home to use an on-street chargepoint.
- Settings on driver recharging behaviour and vehicle driving efficiency.

Methodology

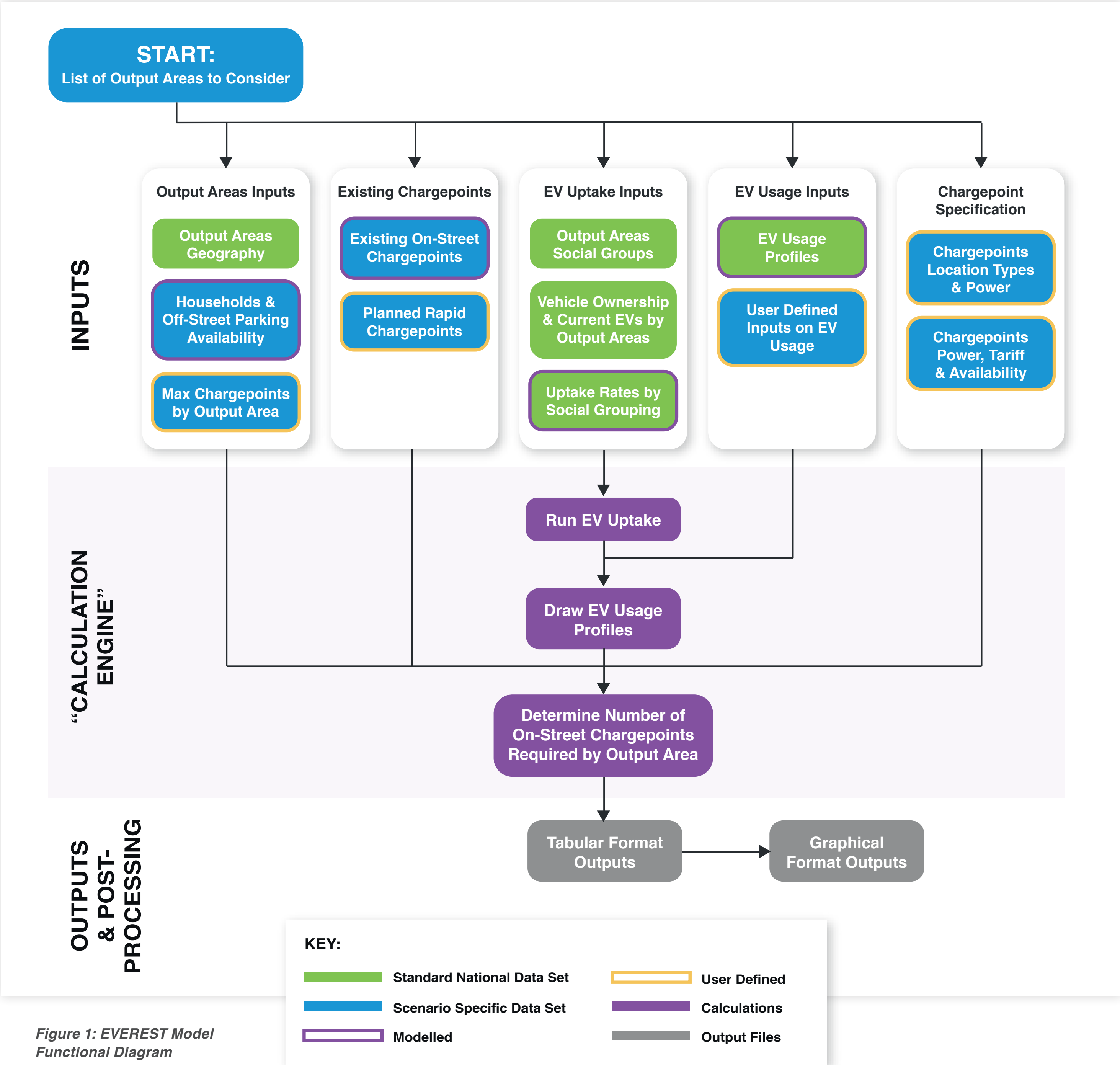


Figure 1: EVEREST Model Functional Diagram

These inputs are then used by the EVEREST calculation engine to calculate the number and location of on-street chargepoints required for the entire study area and for each year the model is run. The overall process is shown above in ***Figure 1***.

EVEREST will attempt to deploy chargepoints in the EV's "home" Output Area as required. However, if this is not possible, it will attempt to deploy chargepoints in neighbouring Output Areas.

The model will also issue warnings to the user if there are any predicted EVs that are not served by the required chargepoints or any unmet demand due to the constraints input.

Results

All of the results shown in this section are given for the city of Worcester, selected for the EVEREST demonstration as Worcestershire County Council is a partner in the VPACH2 project. This is evidenced, actionable information that can then be used by the local authority or chargepoint network operator to inform decisions on EV charging deployment and strategy.

The city of Worcester comprises 322 Output Areas over approximately 33 km^2 with a population of 102,158 in 2020[11].

The main output from the EVEREST model is the number of on-street chargepoints required for each Output Area. The model can deliver results for each year up until 2040; ***Figure 2*** shows 2020 to 2035 in five-year increments:

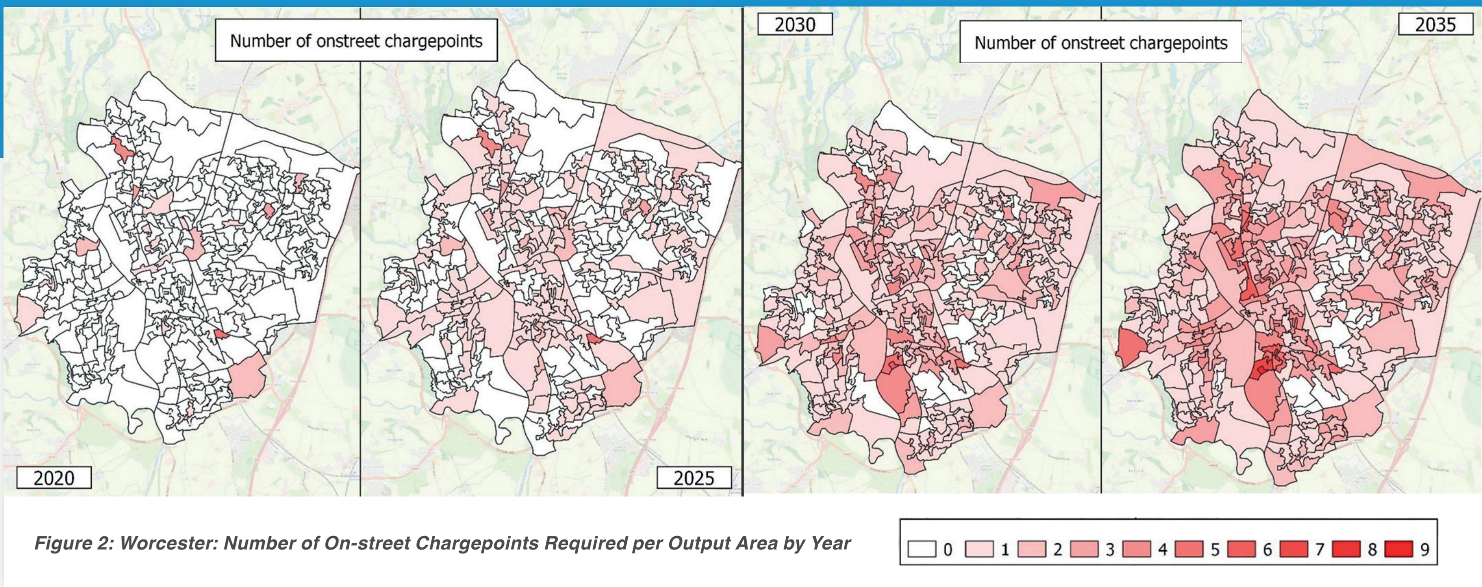


Figure 2: Worcester: Number of On-street Chargepoints Required per Output Area by Year

This output is immediately useful as it identifies areas that require immediate action to enable greater early EV adoption, as well as hotspots that can be planned for in the longer term. The data is also provided in a tabular format, such as the example given in ***Table 1***, for easy post-processing:

On-street chargepoints required				
	2020	2025	2030	2035
Output Area 1	1	3	6	8
Output Area 2	0	0	1	2
Output Area 3	0	1	3	5
...	...	...	...	...

Table 1: Example tabular chargepoint requirement per output area

Results

Whilst the number of chargepoints required to meet demand is the key output, intermediate results can also be of interest, including the following results per Output Area shown by ***Figure 3***:

- The locations of existing public chargepoints in the city;
- The current level of EV ownership;
- The percentage of homes with off-street parking;
- The walking time from existing public chargepoints.

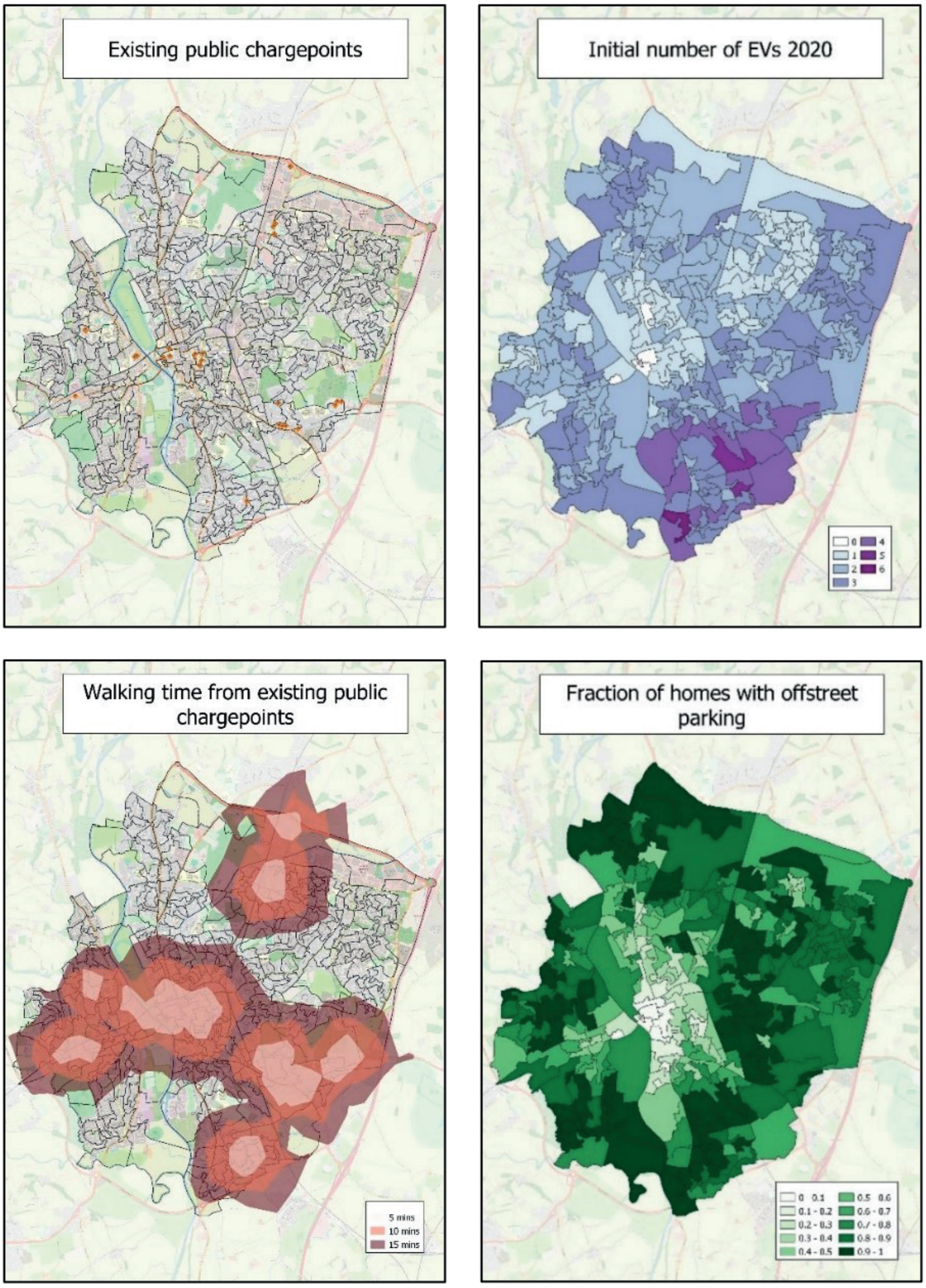


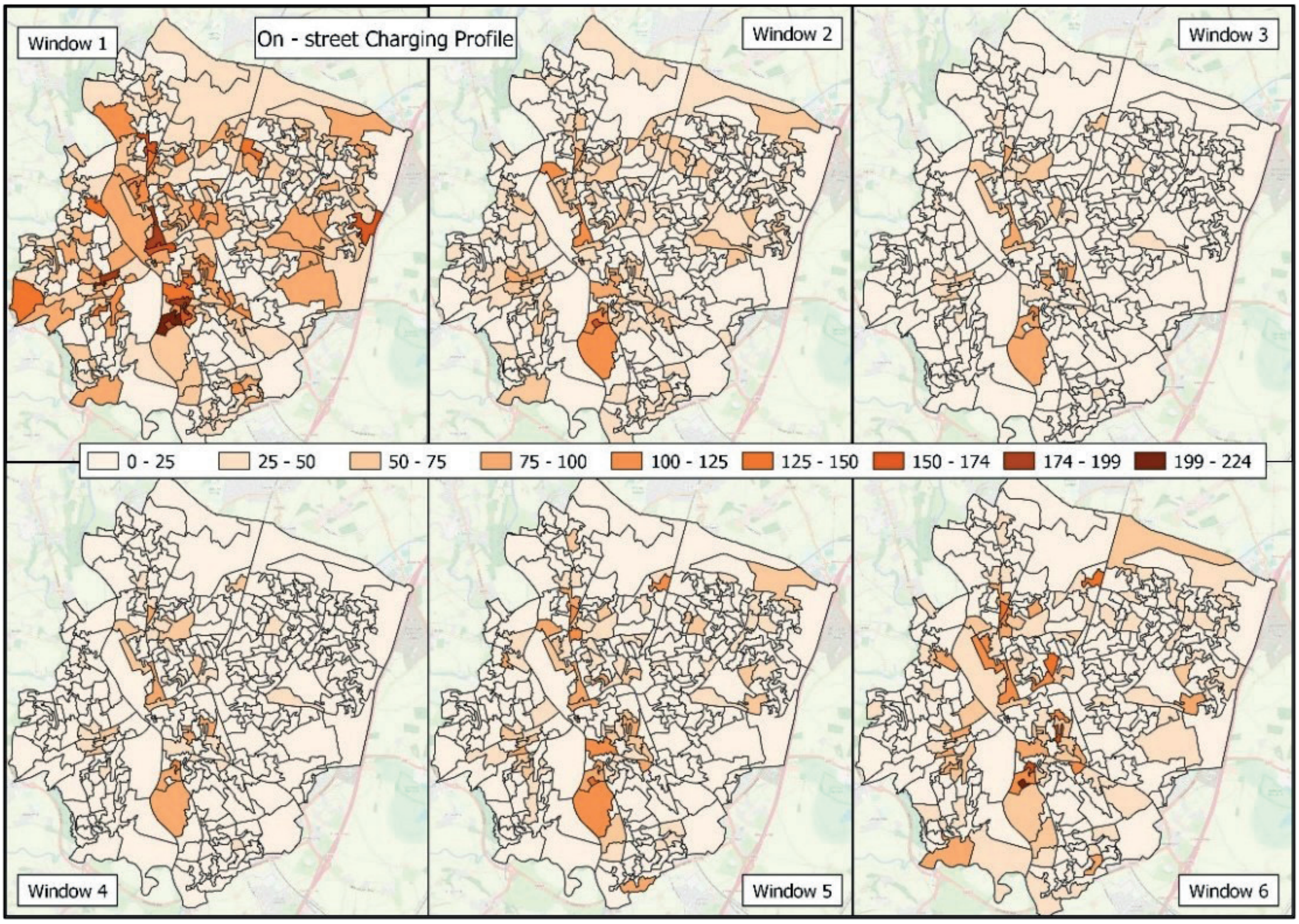
Figure 3: Worcester: Existing Chargepoints, Number of EVs, Fractions of Homes with Off-street Parking and Walking Time from Existing Chargepoints 2020

Results

This can demonstrate whether the areas where EVs are currently located are where on-street charging is needed. In fact, in many cases, this highlights the need to enable those without off-street parking to transition to electric by providing them with public charging infrastructure. In the case of Worcester, this highlights the concentration of homes without access to off-street parking are centrally within the city and demonstrates how this may be limiting the transition to electric vehicles for residents in these areas.

Additionally, the model predicts at what time of day vehicles will plug in to the deployed charging infrastructure. The 24-hour day is divided into six windows, and ***Figure 4*** shows the number of plug-ins per window predicted for 2035. In the case of Worcester, the EVEREST model predicts the most popular plug-in periods are the evening and overnight windows.

Figure 4: Number of on-street plug-ins by charging window.



Window 1 **22:00 - 06:00**	**Window 2** **06:00 - 08:30**	**Window 3** **08:30 - 12:00**
Window 4 **12:00 - 14:00**	**Window 5** **14:00 - 17:30**	**Window 6** **17:30 - 22:00**

Results

Finally, the total amount of energy delivered by all modelled chargepoints – including off-street domestic charging – is calculated, as shown by ***Figure 5***. This can be useful for utilities to understand the total energy demand of certain regions.

An extension of this will be to analyse the impact of the deployed charging on the network – many Distribution Network Operators (DNOs) are improving access to their data as part of digitalisation initiatives, and although this is not standardised, a future model development is planned to highlight where charging deployment could encounter energy network constraints. This will be particularly important when EVEREST is updated to optimise the deployment of both on-street and rapid charging.

Heat maps have been used to display results here, however all outputs can also be given in tabular or graphical format as required by the client.

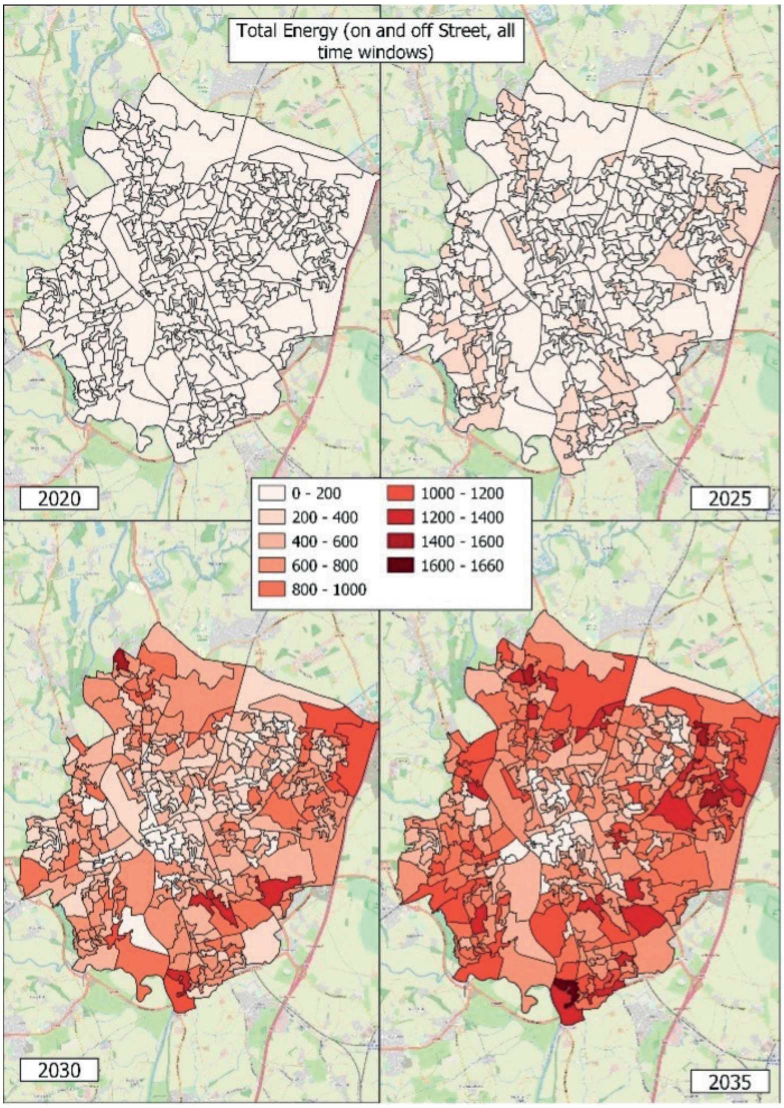


Figure 5: Worcester: Total Charging Energy Requirement

Further Work

The EVEREST model is fully functional and can be used by Cenex staff to reliably predict the demand for on-street charging.

However, predicting the demand for public charging for those who do not have access to off-street parking is only part of the wider EV charging picture. There are many other aspects of the transition to electric mobility that Cenex, as a **not-for-profit** organisation, can offer **expert, independent advice** and consultancy on.

Infrastructure Strategy

Higher level strategy work for local authorities, private businesses and charities to understand their current transport systems, the challenges faced and a roadmap for change:

- **Vehicle and infrastructure baselining** for both fleet and private vehicles.
- Review of existing and upcoming **national policies** and the impact on transport.
- **Benefits** of the transition to Electric Vehicles including **emissions** and **air quality**.
- **Stakeholder engagement** and creation of a local **vision** and **roadmap.**
- **Market review** of the available charging **hardware** and **solutions**.
- High level **business case** for chargepoint networks.
- Evaluation of **other mobility solutions** and how this integrates with EV charging.

Implementation

Planning and support with implementation of strategy:

- Deployment planning for different **types of charging infrastructure** and locations -such as hubs, Park & Ride, destination, and workplace charging – alongside on-street residential charging to meet different user needs.
- Chargepoint **ownership model** analysis.
- **Distribution Network Operator** (DNO) engagement and grid connection evaluation.
- On-street charging **site selection** and **depot site surveys.**
- Project public **communications** management.

Procurement Support

- Industry **engagement** and **events**.
- **Bid writing** for Research & Development (R&D) **grant funding** opportunities for innovative charging technologies.
- Authoring of **technical specifications** for public **procurement**.
- Supplier scoring scheme creation, **bid evaluation** and supplier **interviews**.
- Installation **design review** and technical **auditing**.

The VPACH2 Project

Virgin Park and Charge 2 (VPACH2) is a demonstrator project, funded by Innovate UK as part of the "Electric Charging for Public Spaces: Real World Demonstrators" competition. The project began in October 2019 and is due to finish in December 2021 and includes a consortium of 16 partners including seven local authorities.

The project seeks to address this issue of providing electric vehicle charging infrastructure for households that do not have access to off-street parking. The concept being demonstrated is using the widespread power and communications infrastructure network from Virgin Media (part of Liberty Global) – comprising 170,000 km of ducts and 40,00 grid connections – to more easily deploy charging equipment at lower cost. The concept is shown in ***Figure 6***:

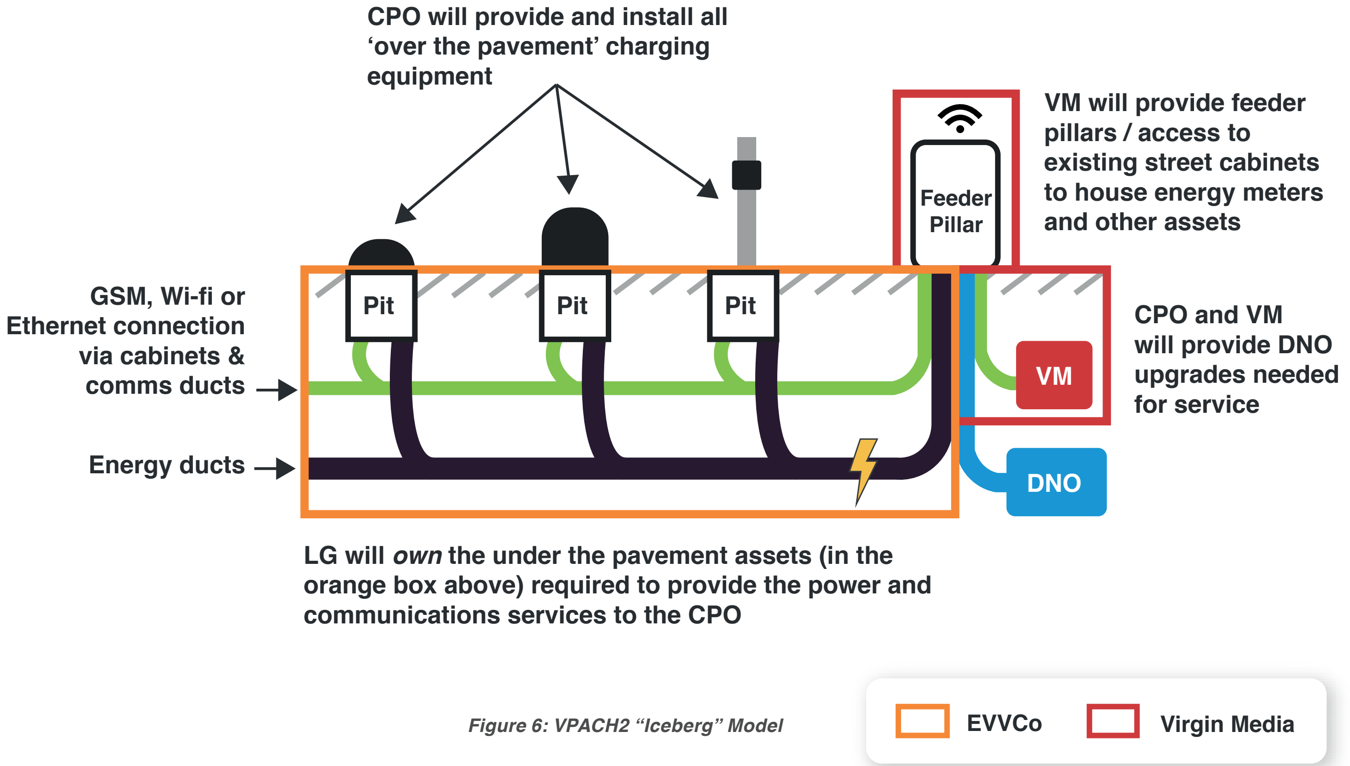


Figure 6: VPACH2 "Iceberg" Model

This concept yields the "iceberg" model whereby the below ground infrastructure and distribution equipment is owned and maintained by Virgin Media and the CPO – to which the VPACH2 solution is agnostic – provides and operates the charging equipment.

There is then one or more commensurate concession type agreements between the involved parties to agree the revenue share from the CPO to the local authority and Virgin Media, as well as contract lengths and terms.

References

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[8] Image Source - https://images.app.goo.gl/WwnLTL1xV32bw5179

[9] Further reading - https://gridserve.com/braintree-overview/

[10] https://chargepoints.dft.gov.uk/login

[11] https://www.worcestershire.gov.uk/info/20044/research_and_feedback/795/population_statistics

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