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Network Assessment Tool: Interim Development Report October 2018

Electric Nation

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Glossary

Abbreviation	Term
Adjacency Model	Pathfinding, redistricting, allocation
BaU	Business as Usual
BSP	Bulk Supply Point
C#	.NET framework based object-oriented coding language
Coincidence Model	Topological overlay, intersection analysis
Convex Hull	Geometrical spatial analysis method
ERD	Entity Relationship Diagram
ESA	Energy Supply Area
EV	Electric Vehicle
Feeder	A circuit which feeds electrical energy from a substation
Geometric Model	Distances between points, buffers and perimeters
GIS	Geographical Information System
MPAN	Meter Point Administration Number
MSOA	Middle Layer Super Output Area
NOP	Normally Open Point
NCP	Normally Closed Point
WPD	Western Power Distribution
NAT	Network Assessment Tool
Raster Data Model	Matrix of pixels (i.e. image based)
REC	Regional Electricity Board
SQL	Structured Query Language
SSIS	SQL Server Integration Services
UI	User Interface
Vector Data Model	Data stored as co-ordinates
WMS	Web Mapping Server

1 Executive Summary

The Network Assessment Tool (NAT) (working title) described in this report is being developed by EA Technology as part of the Electric Nation project. This report summarises the progress and developments to October 2018 from the previous report in July 2018.

EA Technology has continued the development activities according to previously stipulated timelines. Forecast EV uptake at substation level has been implemented upon refining apportionment methodologies and applied over all WPD Licence Areas. In addition, a custom EV penetration functionality has been developed and is deployed within the NAT.

The side bar has been re-styled in order to make the information presented clearer to understand and improve the all-round user experience. In addition, the substation pop-up has been improved: When a user clicks on an LV substation, data is presented that informs the user of substation parameters and the overall status of the substation and its associated LV feeder's operating conditions.

The agile framework put in place during the previous quarter has continued to increase overall productivity and efficiency of the developmental process. The framework has allowed each procedure, from initial functionality design through to testing upon deployment, to be tracked and remain transparent to the entire team.

A demonstration platform on Microsoft Azure has been issued to WPD. A User Guide has also been submitted, containing detailed instructions on how to operate the main functionalities within the NAT. This has allowed WPD to provide feedback on the usability of the mechanisms implemented.

2 Introduction

This report details the ongoing development of the Network Assessment Tool (NAT) since the last progress report (July 2018). The tool aims to provide LV network planners with a new platform to view and assess LV network operating conditions under future electric vehicle (EV) penetrations of differing magnitudes. Also, a module will be included to measure the potential benefit of using smart charging technology as a method to delay or avoid the need to reinforce networks overloaded by EV charging loads.

The tool is currently under development. The development has been phased into three distinct workstreams: data transformation and pre-processing, the user interface and the calculation engine. A full development update on the progress to date is provided within this report alongside a status update for each development path.

2.1 The Electric Nation Project

Electric Nation is the customer-facing brand of CarConnect, a Western Power Distribution (WPD) and Network Innovation Allowance (NIA) funded project. WPD's collaboration partners in the project are EA Technology (the authors of this report), DriveElectric, Lucy Electric GridKey and TRL.

Electric Nation, the world's largest domestic EV trial, is revolutionising domestic plug-in vehicle charging. By engaging 673 plug-in vehicle drivers in trials, the project is answering the challenge that when local electricity networks have 40% - 70% of households with EVs, it is estimated that at least 32% of these networks across Britain will require intervention.

A parallel activity as part of the project is the development of a Network Assessment Tool. This enables an LV planner to assess smart charge solutions to support plug-in vehicle uptake on local electricity networks. A key outcome will be an analysis specifically tailored for highlighting plug-in vehicle related stress issues on networks and identifies the best economic solution where appropriate. This 'sliding scale' of interventions will range from doing nothing to complete smart demand control, from taking energy from vehicles and putting it back into the grid, to traditional reinforcement of the local electricity network where there is no viable smart solution.

The immediate challenge to such a tool is the prevalence of poor data quality available for LV networks in comparison to the vast and accessible datasets at HV level. As such, the tool under development will be of great interest country-wide as the next step to high visibility of LV network data at the planning stages. The outcomes of this project will be communicated to central government and the GB energy and utility communities.

This report focuses on the developments undertaken since the previous reporting cycle. These include apportionment of EVs from Energy Supply Area (ESA) forecasts to the substation level, the re-styling and progression of the User Interface (UI) and incorporation of custom EV penetration on the LV substation level.

3 Summary of Previous Progress

In the previous report (April – July 2018), developmental focus was aimed towards the implementation of the side bar (to contain the EV uptake forecasts and results from DEBUT calculations). In addition, the migration to the new agile framework was documented, including details concerning the Azure Platform, set up for WPD to observe the progression of the tool.

The major development paths remaining from the previous reports were:

- Implementation of ESA based EV forecast apportionment to the substation level
- Introduction of custom EV penetration capability on a local level
- Inclusion and presentation of substation parameters
- General UI advancements and modifications to present EV penetration and the status of network operation conditions

The following sections detail the tasks performed in the last quarter period. Following on is a short section to give an overview of the ongoing and anticipated next stages of development.

4 Overview of the Latest Progress

The primary developmental focus for the Network Assessment Tool (NAT) so far has been executing the proposals described in the previous report. Since July 2018, developmental work has largely revolved around the EV forecast apportionment method, alongside custom EV allocation implementation and general UI modifications.

The initial aim for this quarter was to implement the EV apportionment model that was detailed in the previous quarterly report and apply it to the four WPD License Areas. WPD supplied EA Technology with EV uptake data from Regen, detailing the forecasted uptake of EVs for each ESA, on an annual basis up to 2030. The mechanisms behind the apportionment and allocation are documented in this report.

It is important that the NAT is capable of accepting EV uptake as an input so that LV planners can use the tool to assess the impact of EV uptake on individual substations and their associated LV networks. From the resulting data, the designer will be able to make an informed decision on the action to be taken, should EV charger installations grow according to the forecast.

There have been multiple UI additions and modifications made during the last three-month period. These include the modification of the substation pop-up and redesign of the sidebar. Zooming levels have also been reset to allow the user to view the information belonging to a substation, whilst panning the local area. In conjunction with the EV apportionment, the mapping element has had additional features installed to present EV penetration.

WPD were given access to the July development-status NAT on an Azure platform with a User Guide to assist with the operation of the basic functionality available at the time of release. It should be noted that the release of the User Guide was early on during this three-month period, therefore many of the features discussed in this report were not available at that time.

4.1 Development and Deployment of EV Forecasts at Substation Level

During the last quarterly report, the idea of taking Regen's EV forecast work on an ESA Level and mapping this to a substation level was introduced. The mechanisms for incorporating such a method have now been tested, improved and implemented and are operational on the NAT. The following section will explain the workings of the apportionment method.

4.1.1 Levels of the NAT

The NAT has been built to display at multiple levels. The highest level is the four WPD Licence Areas. Below this is the ESA level: ESAs are defined as geographic areas served by the same upstream network infrastructure to a Bulk Supply Point or Primary Substation. These ESA boundaries were developed through GIS analysis by Regen and WPD.

The next level down is the Medium Level Super Output Areas (MSOAs), which are used in Census data gathering and reporting. MSOAs are used purely to perform the EV uptake forecast distribution function and will not be of any use to LV planners in the NAT. MSOAs are areas containing roughly 3,000 households in each. They have been categorised by household wealth, housing stock, number of vehicles owned by households and urban/rural setting. There are more MSOA data sets available, however they were not used in this process. MSOAs are in general much smaller in size than the ESAs. It should be noted that the ESAs and MSOAs do not geographically correlate to one another. ESAs share MSOAs in a lot of instances. See Figure 1 for a superposition of a sample ESA and overlapping MSOA level (within a Geographical Information System, not the NAT).

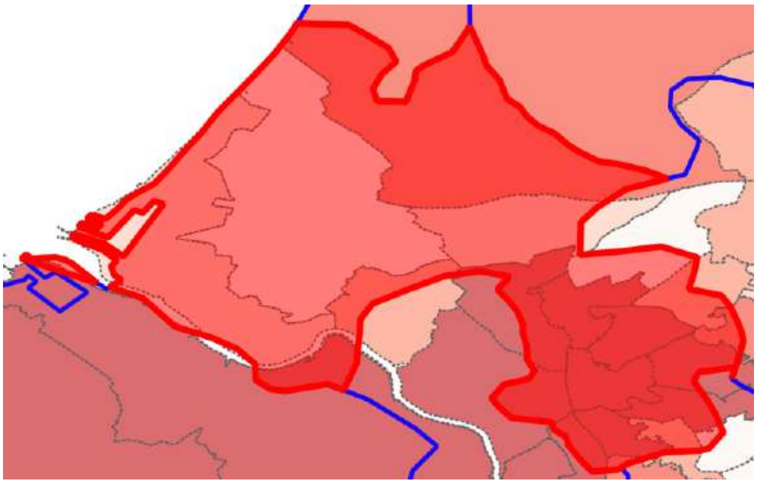

Figure 1: Here the red outline shows the boundary of an ESA, within the ESA there are multiple MSOAs. Some MSOAs are completely enclosed within the ESA and others overlap with other ESAs.

Below the MSOA level sits the substation level. One level below again is where the cable/line and customer layers used in network mapping and assessment are situated.

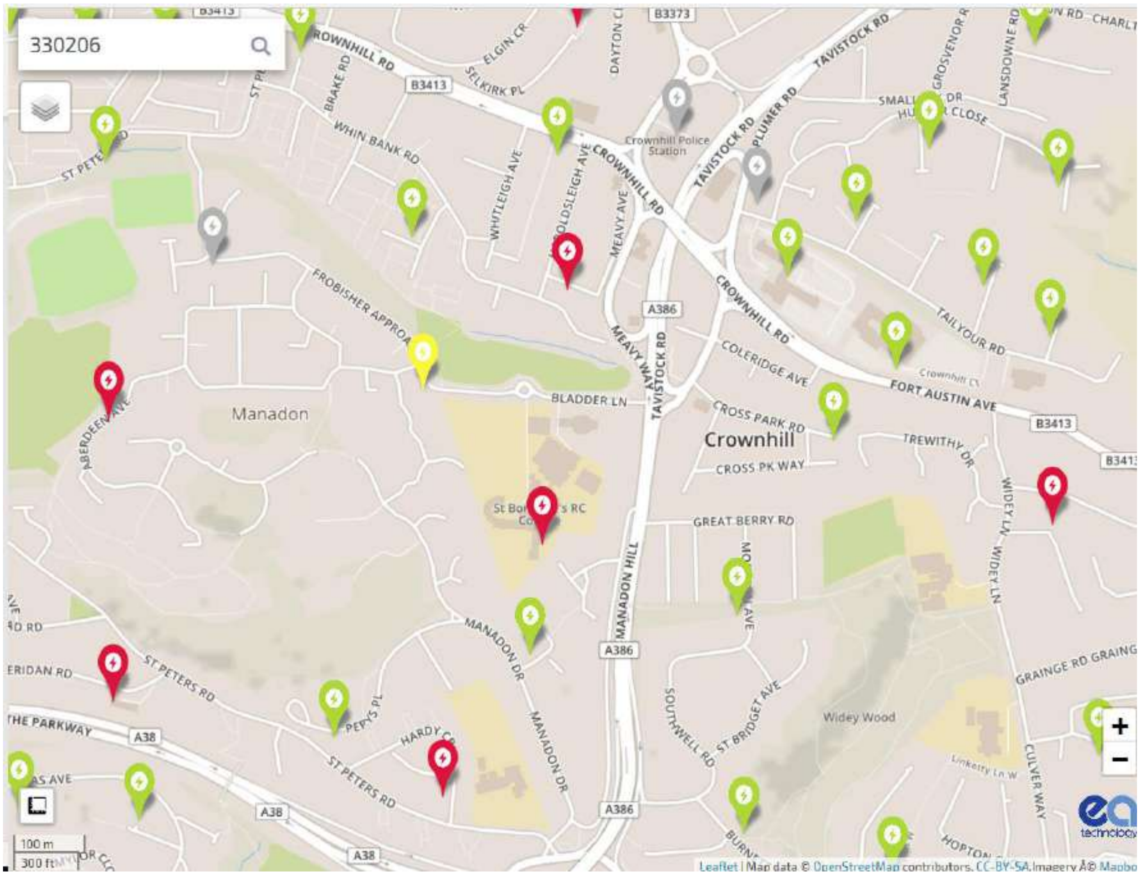

Figure 2: The substation level

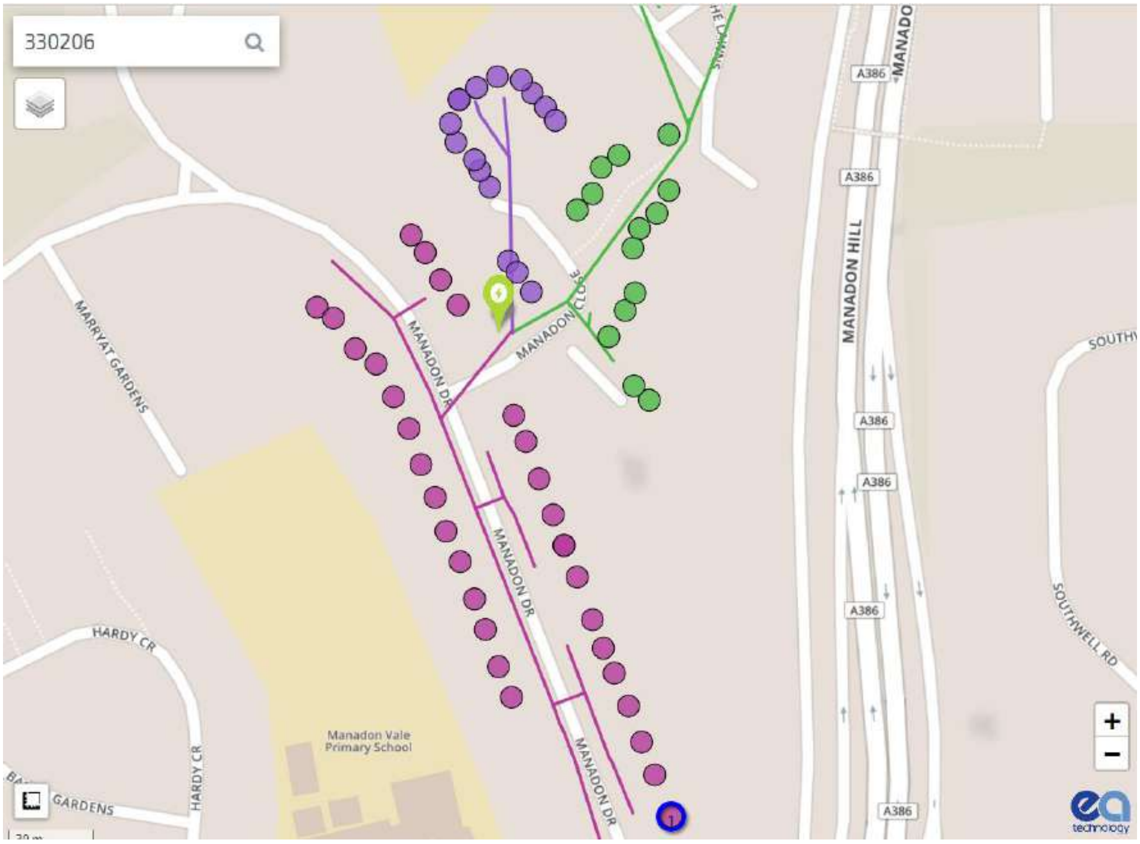

Figure 3: The cable/line and customer layers. These layers are only presented for the substation selected here.

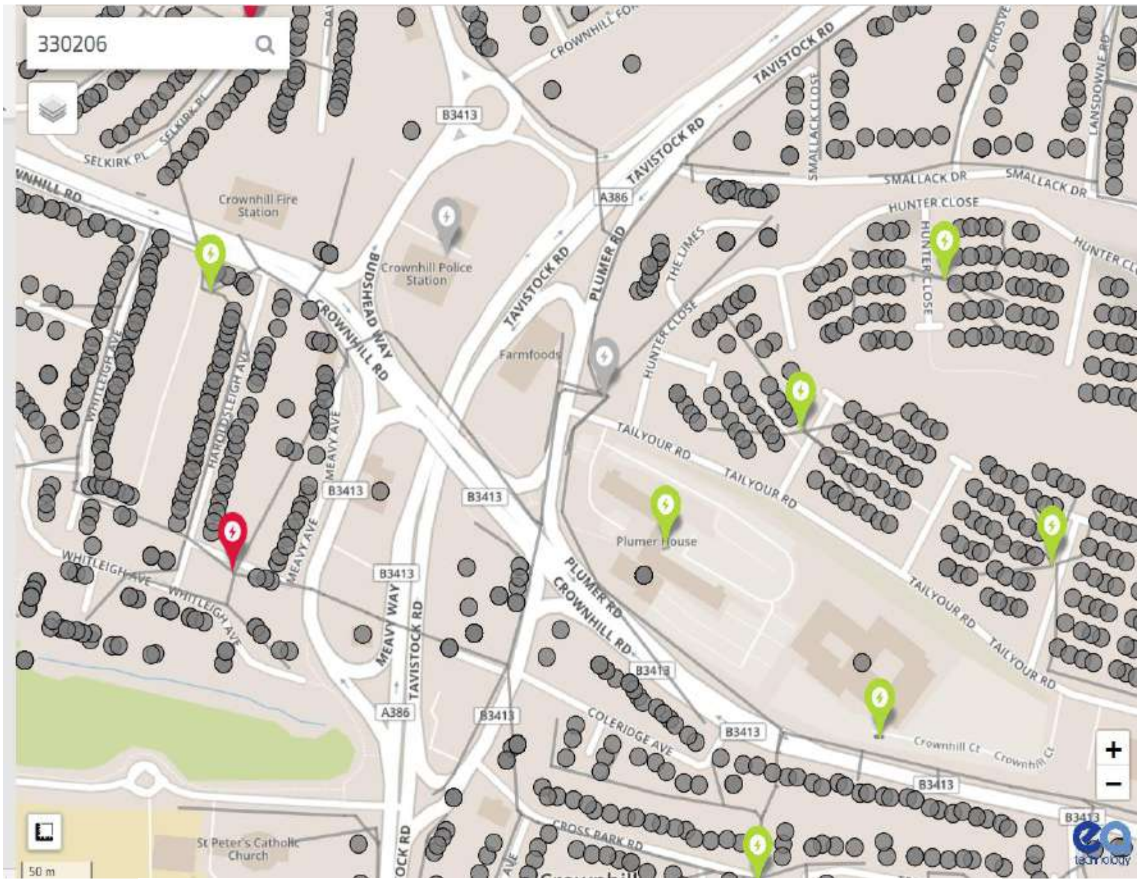

Figure 4: Here the all line segments and all customer layers are displayed.

Each MSOA overlap with an ESA will have a number of substations located within it. An EV forecast needs to be provided to each substation in the WPD area for every year up until 2030. This will eventually allow WPD to prioritise substations and/or geographical areas on the level of intervention required.

4.1.2 Data Inputs

The data used to forecast EV uptake within the WPD License Areas is in the form of a spreadsheet supplied by Regen. Regen's EV uptake forecasts are on the ESA level. For every year from 2018-2030 there is a forecasted EV uptake figure for each ESA. The EV uptake figures need to be distributed amongst the lower levels, firstly to the MSOA level, then to substation level, and finally to individual customers. For the purposes of the NAT it has been assumed that all of these EVs will be charged at domestic properties, this being a worst-case scenario. In reality some of the EVs may well be depot based and charged in a commercial setting or at other public and workplace-based chargepoints. In addition, public transport, government/council owned vehicles and any other non-domestic type vehicles are not considered.

4.1.3 Transitioning from ESA Level to MSOA Level

Each MSOA has been assigned an EV Uptake Factor. These factors were calculated by taking into account an MSOA's median household wealth after housing costs, the percentage of residents that own one or more cars/vans, the percentage of detached and semi-detached houses within the MSOA and the urban/rural setting of the MSOA. The number of domestic customers in an ESA/MSOA overlap is also known (using Mpan data). The uptake factor is multiplied by the number of domestic customers within the ESA/MSOA overlap to give a weighting. The weights are summed and normalised. For example, an ESA/MSOA overlap with a large population and high uptake factor will have a relatively high weighting. The EVs at ESA level are then distributed to the MSOA areas within the ESA boundary using the obtained weights.

Throughout this section a hypothetical example is used for illustration: Say an ESA called ESA1 overlaps with four MSOAs (MSOA1 - 4). These MSOAs all overlap with other ESAs, but are partially covered by ESA1.

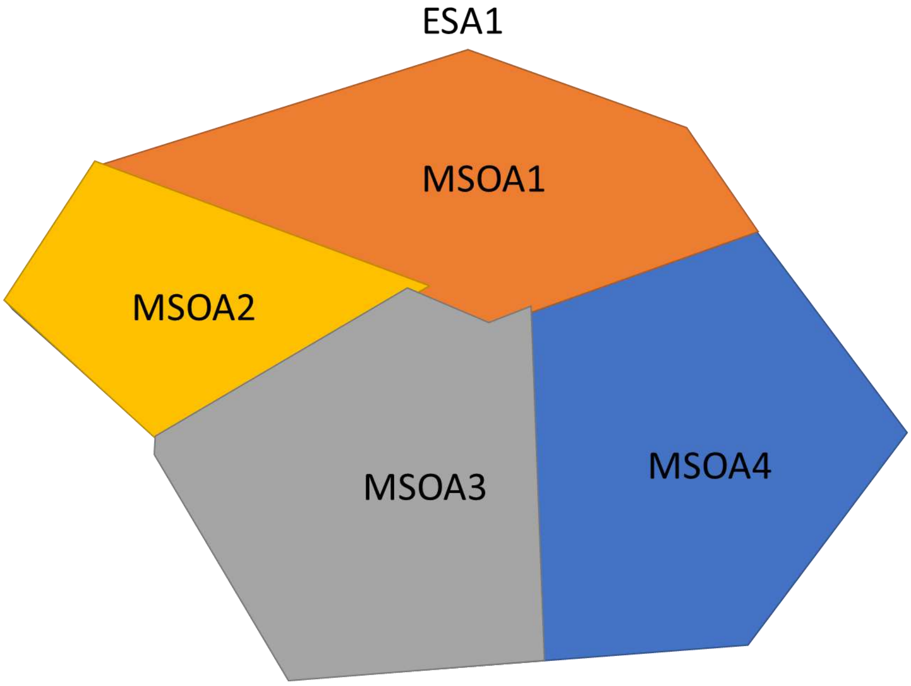

Figure 5: A hypothetical example of an ESA called ESA1, which contains within its boundaries 4 MSOAs (MSOA1-4).

Existing domestic EV charger installations within the WPD Licence Areas are known for Year 1 (2018) (from EV charger installation notifications, it is assumed an EV charger is equivalent to one EV at a location). For the first year's forecast (and every year thereafter) those customers with notified EVs (chargers) must be allocated an EV. So, for the 2018 forecast, firstly the notified EVs must be allocated and then the remaining EVs from the forecast are allocated using the apportionment method.

Say ESA1 has an EV allocation of 35 for Year 1. The current number of EV chargers notified in ESA1 is 5, 3 are notified in MSOA1 and 2 are notified in MSOA2. The NAT will highlight the 5 consumers that currently own an EV (have a charger). The left-over forecast (30EVs) is distributed using the apportionment model.

The MSOA weights are used to apportion the ESAs forecast:

$Weight_{MSOA1} x\ L1_{2018} = Allocation_{MSOA1}$

Where $L1_{2018}$ is the left-over forecast (forecast minus registered EVs) for ESA1 during Year 1.

MSOA	**Uptake Factor**	**Number of Domestic Customers**	**Weight**	**Weight After Normalisation**
MSOA1	5	1000	5000	0.598
MSOA2	3	800	2400	0.287
MSOA3	1	700	700	0.0838
MSOA4	0.5	500	250	0.029

Table 1: Table showing how MSOAs are weighted

Continuing with the example, MSOA1 has a weight after normalisation of 0.598, therefore the allocation to MSOA1 would be 18 (0.598*30=17.96 rounded to the nearest integer is 18). This calculation is run for all the MSOAs within ESA1. The final MSOA weight is a number between 0 and 1, as the sum of the MSOA weights within an ESA is normalised. The resulting MSOA allocation is then rounded to the nearest integer. The rounding up or down at this high level will have a negligible impact on the allocations at the lower levels of the NAT.

MSOA	Weight After Normalisation	EV Allocation	EV Allocation Rounded
MSOA1	0.5985	17.96	18
MSOA2	0.287	8.62	9
MSOA3	0.0838	2.51	3
MSOA4	0.029	0.89	1

Table 2: Table showing how MSOA EV allocations are obtained. The weight after normalisation is multiplied by the EVs available from the ESA level.

4.1.4 Transitioning from MSOA Level to Substation Level

Each MSOA within an ESA boundary has a number of LV substations located within it. Each MSOA is given an allocation of the ESA's EV uptake forecast as described above, this is further apportioned to the substation level by using the number of domestic customers associated with each substation as a weighting.

The hypothetical example will be continued by analysing MSOA1.

The total number of domestic customers associated with MSOA1 is 1000 and Substation1, which is inside MSOA1, supplies 400 customers. The substation has a weighting of 0.4. So, the allocation to MSOA1 is multiplied by 0.4 to give the allocation for Substation1. It is most likely that the allocation to substations will be non-integer values. It is illogical to deploy a fraction of an EV to a network; therefore, the value is always **rounded down**. However, the non-integer value is stored, as this will be used in the next year's calculations. This process is repeated for all substations within the MSOA.

Substation	Number of Domestic Customers	Substation Weighting	EV Allocation	EV Allocation Rounded Down
Substation 1	400	0.4	7.2	7
Substation 2	300	0.3	5.4	5
Substation 3	200	0.2	3.6	3
Substation 4	70	0.07	1.26	1
Substation 5	30	0.03	0.54	0
			EV count:	16

Table 3: Table showing how substation weight is obtained and how this is used to obtain the initial EV allocation on the substation level

The sum of all the substation allocations (once they have been rounded down) is calculated and compared to the original total forecast of the MSOA. Here the sum of the rounded down values is 16 and the forecast on the MSOA level is 18, giving us a difference of two EVs. Due to the rounding down at the substation level it is likely that there will often be a difference between these numbers. The surplus EVs need to be allocated on the substation level. In order to do this the substations are ranked by the number of customers **without** an EV. The surplus EVs are then allocated to the substations with the largest number of customers without EVs. So, the substation with the most customers that have not been allocated an EV will receive the first EV, the substation with the second highest number of customers without an EV will receive the second and so on. The substations that have had an additional EV donated to them will have their stored non-integer allocation for that year rounded up to the nearest integer due to this addition.

In the hypothetical example, MSOA1 has three EV chargers currently notified, these must be taken into account when allocating the surplus EVs. All three EVs are associated with Subtation1.

Substation	Number of Domestic Customers	Number of Domestic Customers with EV	Number of Domestic Customers without EV	Additional Allocations
Substation 1	400	10	390	1
Substation 2	300	5	295	1
Substation 3	200	3	197	0
Substation 4	70	1	69	0
Substation 5	30	0	30	0

Table 4: Table showing how surplus EVs from the MSOA level are allocated on the substation level. Note here for substation 1, the number of domestic customers with an EV is 7 from the forecast, plus three existing registered EVs, giving 10.

Therefore, the final allocations to the substations within MSOA1 for the first year are:

Substation	Final EV Allocation
Substation 1	8
Substation 2	6
Substation 3	3
Substation 4	1
Substation 5	0

Table 5: Final EV allocations for the worked example

4.1.5 Allocating EVs to Individual Customers

Once the forecasted number of EVs has been assigned to an LV substation for a given year, these then have to be distributed to customers served by that substation. In order to do this, a scheme that adopts a realistic estimation of the distribution of EVs on a radial network called 'The Three Bucket Method' is used, as shown in Figure 6. If there were a spectrum created, running from the worst possible distribution scenario (all EVs allocated to customers furthest from the substation), to the best possible distribution scenario (all EVs allocated to customers closest to the substation), then the Three Bucket Method would fall closer to the worst possible scenario end of the spectrum in all possible network configurations. It is by design a realistic, worst case scenario approach.

The population of the substation is divided by three. Three concentric areas (easiest to illustrate as circles, but in reality would be very irregular shapes) are then overlaid on the map of the substation's network. They are positioned so that in each of the 3 enclosed sections created there is an equal number of customers. There is an outer section, a middle section and an inner section. Each section will cover one third of the total number of customers (when the total number is not divisible by 3, then the outer most section will get the first remainder and second remainder will go to the middle section). The first EV allocated to the substation is given to the furthest customer from the substation, located in the outer section. The second EV is given to the outer most customer in the middle section. The third is given to the outer most customer in the inner section. This is then repeated, so the forth EV would be allocated to the 2nd furthest customer from the substation, located in the outmost section.

Note, for Year 1 (2018) existing EV charger registrations are already assigned to customers. The customers that currently have an EV charger will be identified first, then the Three Bucket Method is used to allocate EV forecast chargers beyond these existing locations.

Using the below illustration as an example, say one EV is allocated to the substation in year 1, this will be given to the furthest customer from the substation, as they are in the outer bucket and the furthest customer from the substation within that bucket without an EV allocated to it. In the second year say the substation gains an additional EV, this is given to the middle section (which includes the 3rd and 4th furthest customers from the substation), the algorithm will select the 4th customer as it is further away from the substation than the 3rd customer and it does not yet have an EV allocated to it. The next forecasted EV, allocated in a future year, will be given to the 2nd furthest customer from the substation (which is the furthest customer from the substation in the inner group). This entire process then repeats, so the outer group will receive the fourth allocation. The fifth furthest customer from the substation is now the customer furthest from the substation within the outer group without an EV, so that customer will receive the allocation. Once every customer has been allocated an EV the process starts again, so customers will start to receive two EVs (i.e. two EVs for one charger).

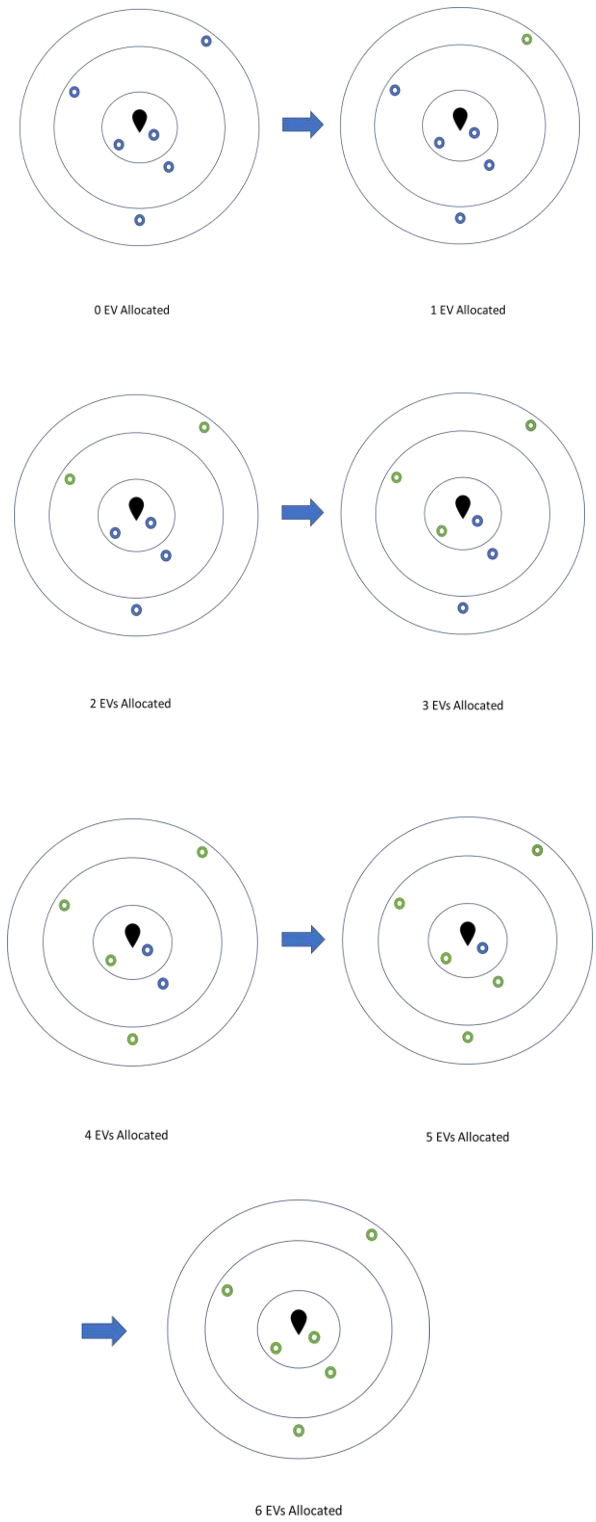

Figure 6: Illustration showing The Three Bucket distribution model. The black icon is the substation, the blue discs are customers without an EV and the green ones are customers with an EV. The concentric circles are the imaginary boundaries of the buckets.

4.1.6 Year 2 and Beyond

ESA1 will have a new forecast for 2019 from Regen's ESA data. In order to progress the forecasts at the lower levels, the forecasted increment from 2018-2019 is considered. This increment is then added to the previous year's apportionment.

So, for instance, if ESA1 had a forecast of 35 EVs in 2018 and then 50 EVs in 2019. The increment would be 15 EVs. These 15 EVs are apportioned in the same way as described for Year 1. First apportionment takes place at the MSOA level and then the substation level. The Three Bucket Method is then run to include any additional EVs the substations gained since the previous year.

This annual process is then repeated until 2030, giving each individual LV substation within the WPD License Areas a model of the predicted uptake on their network over the next 12 years.

4.2 Updated User Interface for EV Uptake Analysis

4.2.1 Sidebar Development

In the previous report the sidebar concept was introduced as a feature used to present EV uptake information to the LV planner.

The side bar has been redesigned in order to increase the clarity of the presented data. See Figure 7 for an evolution of the UI. The substation's name and number are still presented at the top of the side bar.

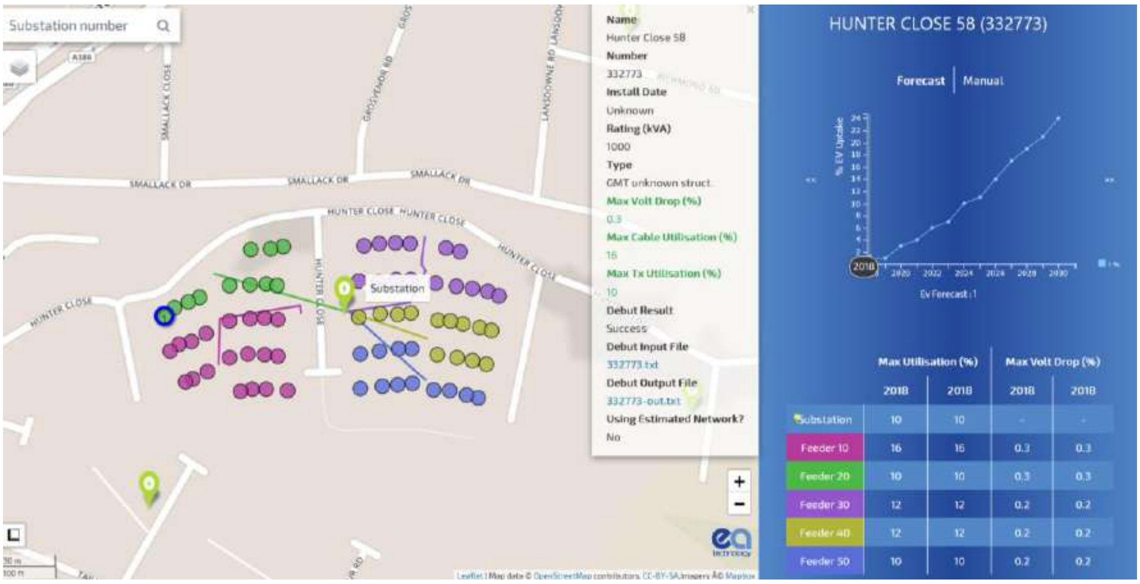

Figure 7: The evolution of the side bar (the first screenshot shows the original UI and the second shows the UI at the time of writing). Modifications include a toggle between the forecasting functionality and the custom EV penetration tool.

Below the substation name and number, the EV uptake forecast for that LV substation for every year up until 2030 is presented as a line graph. The y-axis is expressed as percentage EV penetration. In this model 100% penetration means that each customer associated with the selected substation has one EV allocated to them. The maximum penetration is 200% (this represents every consumer owning two EVs). The x-axis represents the forecast year (ranging from 2018-2030). The graph does not currently differentiate between hybrid cars and EVs. This assumes a worst-case scenario – all cars are fully electric, with larger batteries (24kWh and above). The slider tool, allowing the user to progress through future years to update DEBUT results on screen was introduced during the last quarter. The total number of EVs deployed to the network for a given year is stated in the legend of the graph. Also included in the legend is the percentage uptake figure, as the y axis is presented in integer increments - it can be difficult for the user to obtain an exact percentage, so this feature was introduced. The user can then either work using percentage uptake or by number of EVs. Figure 8**Error! Reference source not found.** shows the user operating the forecasting tool.

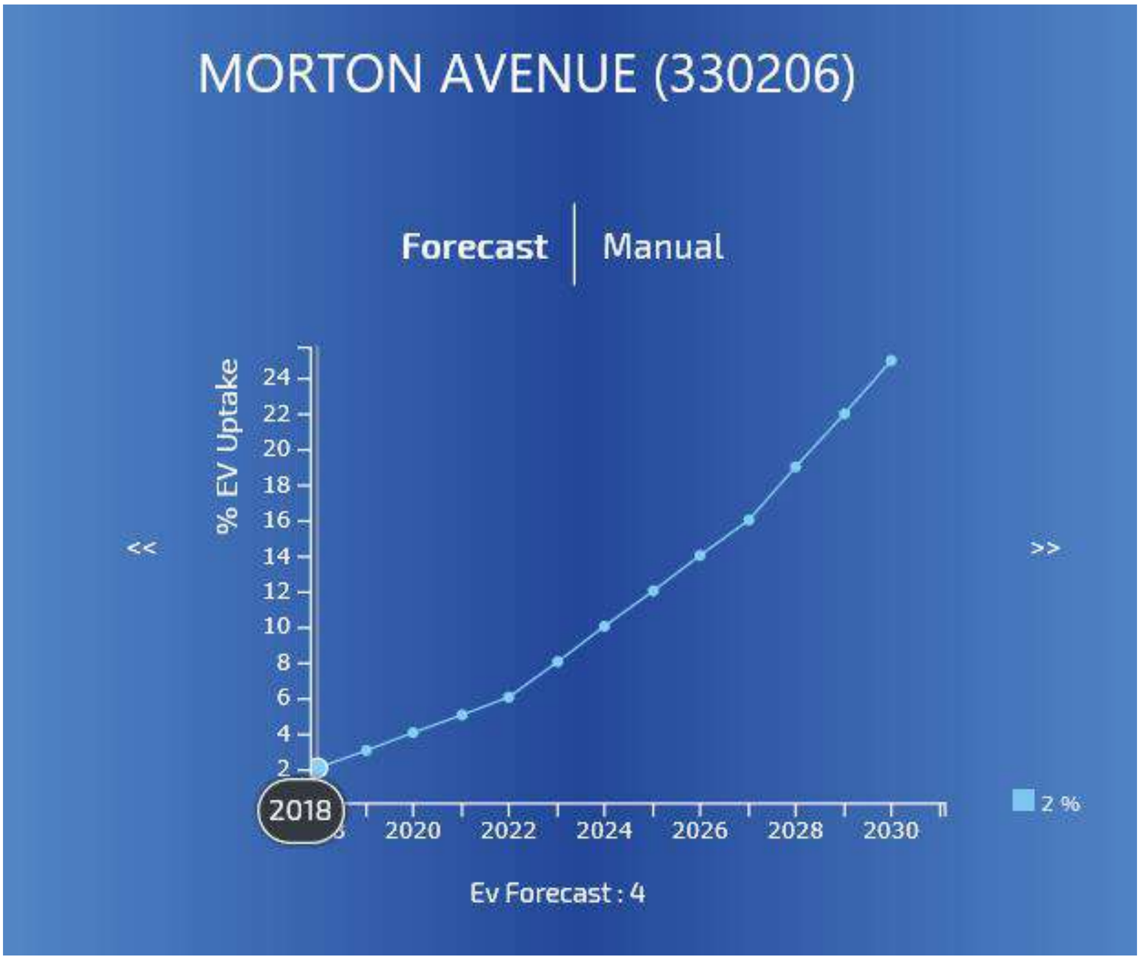

Figure 8:The forecasting functionality in operation. This shows the predicted number of EVs using the network associated with the selected LV substation on a given year. Note the modified legend showing the number of EVs on the network and the percentage EV penetration.

Below the forecast is the table detailing the status of the operating conditions of the LV substation's network. This table is dynamic, as the slider is repositioned and additional EVs are added to the network, the table updates according to the change in the input data to the DEBUT engine. These calculations using the DEBUT engine will be pre-processed in order to prevent the tool lagging whilst the user progresses through the forecast.

The sidebar's table shows data for both the substation and the feeders associated. The DEBUT engine calculates the maximum utilisation anticipated for the substation and the associated feeders in isolation. In addition, the maximum volt drop percentage for each feeder are computed.

	Max Utilisation (%)		Max Volt Drop (%)	
	2018	2025	2018	2025
Substation	38	45	-	-
Feeder 11	27	34	2.2	5.7
Feeder 12	9	16	0.4	3.9
Feeder 21	38	45	3.6	7.1
Feeder 31	34	41	2.5	6
Feeder 41	18	25	0.5	4
Feeder 51	13	20	0.4	3.9

Figure 9: The substation results table. Here the colour scheme used to classify results into groups can be observed.

The calculations are run for 2018 as a baseline and also the year that is selected by the user using the slider on the graph. This then gives two comparative figures, each calculated using different EV penetrations. A colour coded system is used in the table to indicate stress on the network. For 'Max Utilisation' a cell is coloured amber if *90% ≤ Max Utilisation < 100%*. If a cell contains a value greater or equal to 100% then it is coloured red. Otherwise the cell remains clear. For 'Max Volt Drop' percentages, if the value within a cell is in the range *4% ≤ Max Volt Drop < 5%* then the cell will be amber in colour. If the volt drop is greater or equal to 5% then the cell will be red in colour. Otherwise the cell remains clear. WPD will be able to adjust the boundaries of this colour scheme to align with their intervention agenda.

N.B. The data used to determine forecast substation and feeder utilisations and volt drop (as illustrated) is currently mocked-up - the Volt Drop percentages increase by 0.5% every year and the Maximum Utilisation percentages by 1% every year. This will be updated to display the actual results once an EV charging profile has been generated and fed into the DEBUT engine as an input.

4.2.2 Substation Pop-Up

An updated substation pop-up box has been deployed on the tool. This presents the basic parameters of the selected substation, including the transformer rating and type. It also gives links to the DEBUT input and output files that were used to calculate the volt-drops and utilisations. An indication is also given as to whether an estimated network was run, in the cases where the network has failed to map due to data issues.

As can be seen from Figure 10, the pop-up has transparency in order to maximise the visibility of the mapping area on the UI.

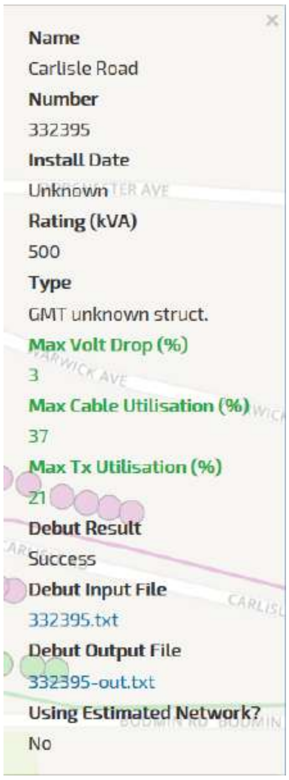

Figure 10: Substation pop-up box

Upon testing the tool, WPD have requested that the total number of customers belonging to the selected substation and individual feeders should be made available to the user. The next development phase will include the addition of these values to the pop-up box.

4.2.3 Updating Mapping Elements

As the user interacts with the sidebar, the mapping elements are now updated to represent the network on the year selected.

Representing EVs:

When an EV is allocated to a customer, the customer is highlighted with a blue ring. In addition, the number ‘1’ appears on the customer, representing 1 EV (this will increase to ‘2’ should the customer receive a further EV by user manipulation or under certain forecast conditions). See Figure 11 for an example of EV representation on the map.

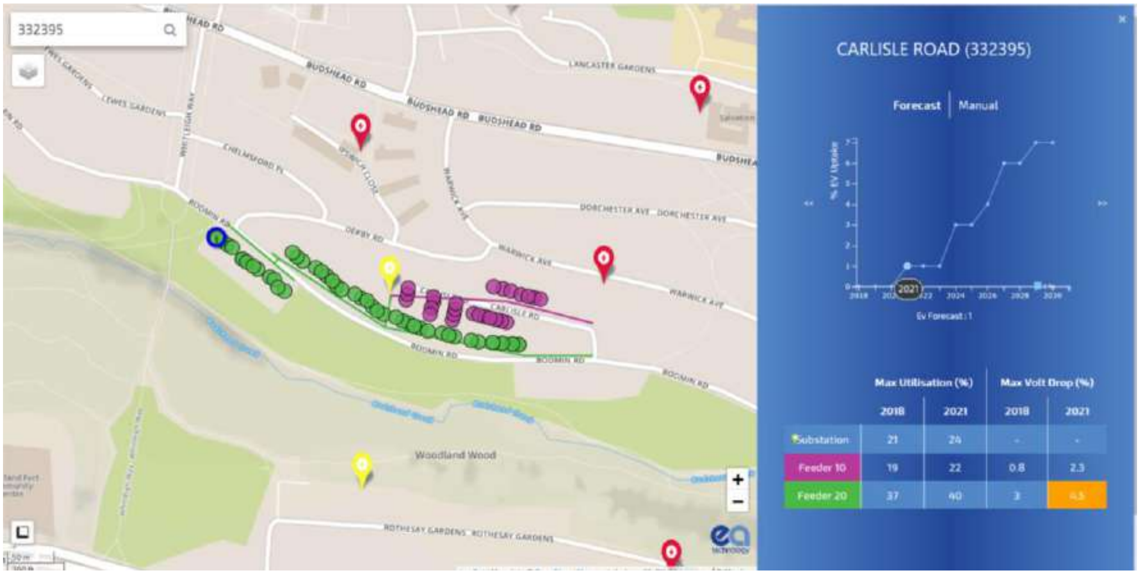

Figure 11: EV representation on the map. The furthest customer from the substation is highlighted with a blue ring.

There are a number of EV chargers already installed on the WPD network. These EVs are represented on the map in a distinct manner (highlighted red within a blue ring), so the user can distinguish between a predicted and actual EV charger deployment.

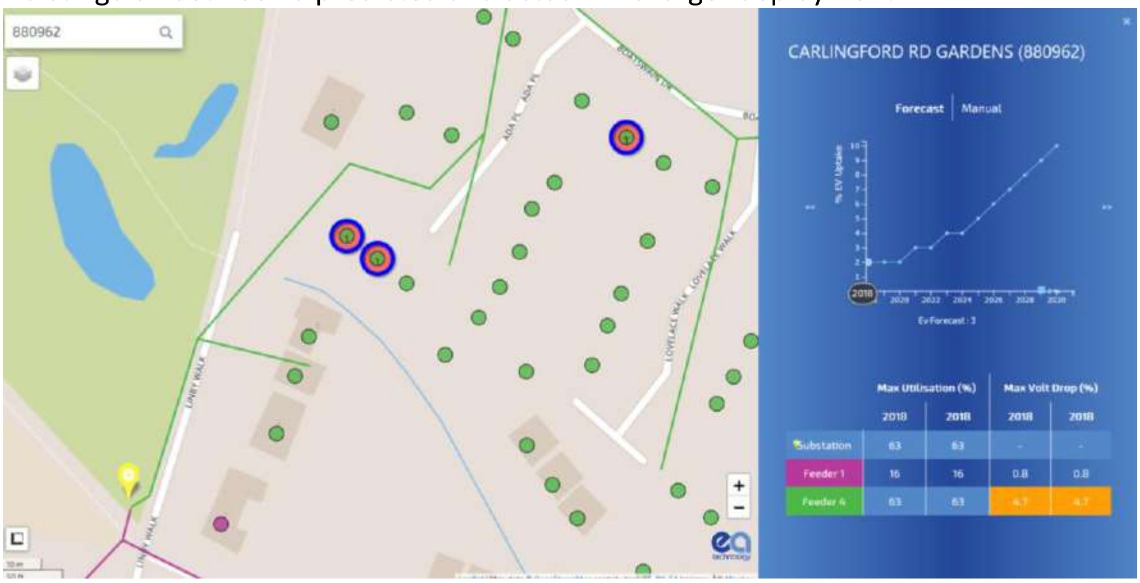

Figure 12: Registered EV representation on the map. Customers that currently have EVs are highlighted in red and enclosed within a blue ring.

Representing Cable Over-Utilisation:

Cable segments belonging to the selected substation which are over-utilised are highlighted. This is of great use to LV designers. Even without EVs on the network the NAT will identify cables that are currently in operation, that are likely to be over-utilised and may need upgrading.

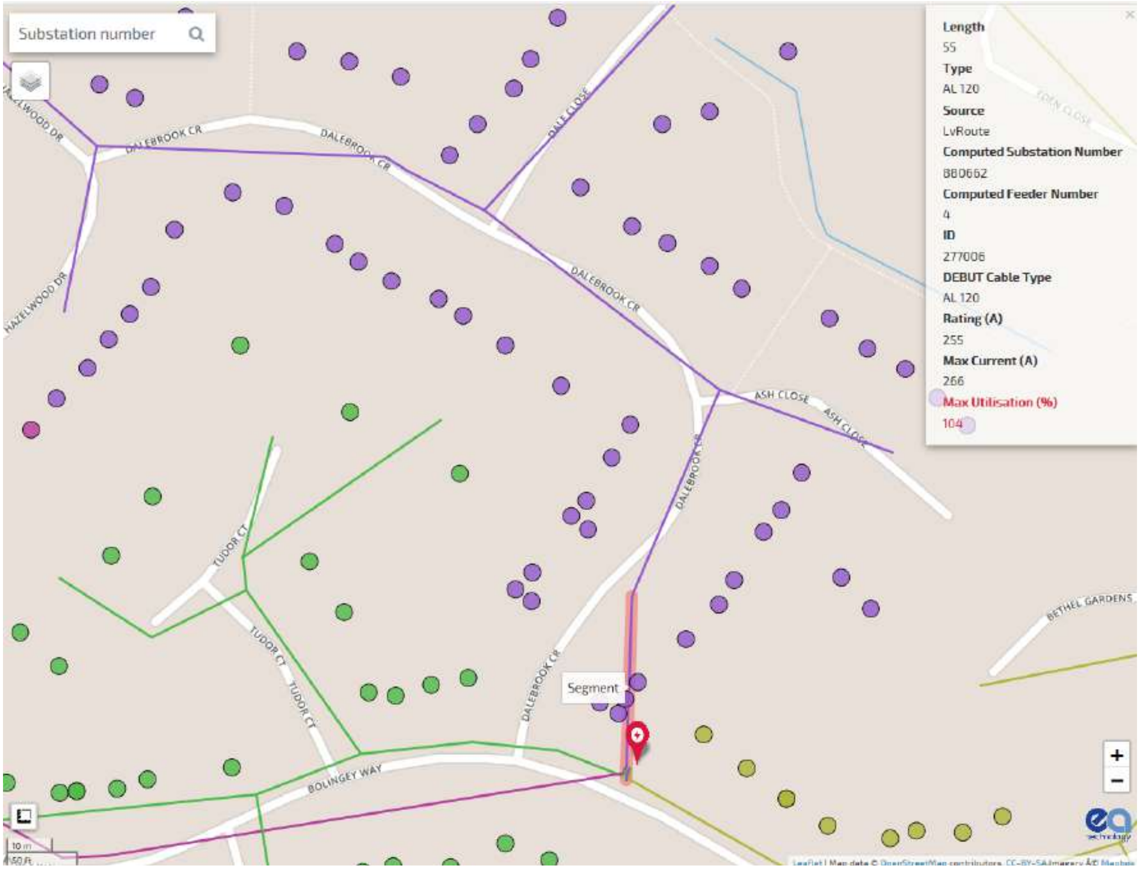

Figure 13: An example of cable over-utilisation depicted on the mapping element

Representing Voltage Drops:

Voltage drops at nodes which are equal to, or greater than 5% are highlighted in red on the map for clear identification. The percentage threshold is a modifiable variable.

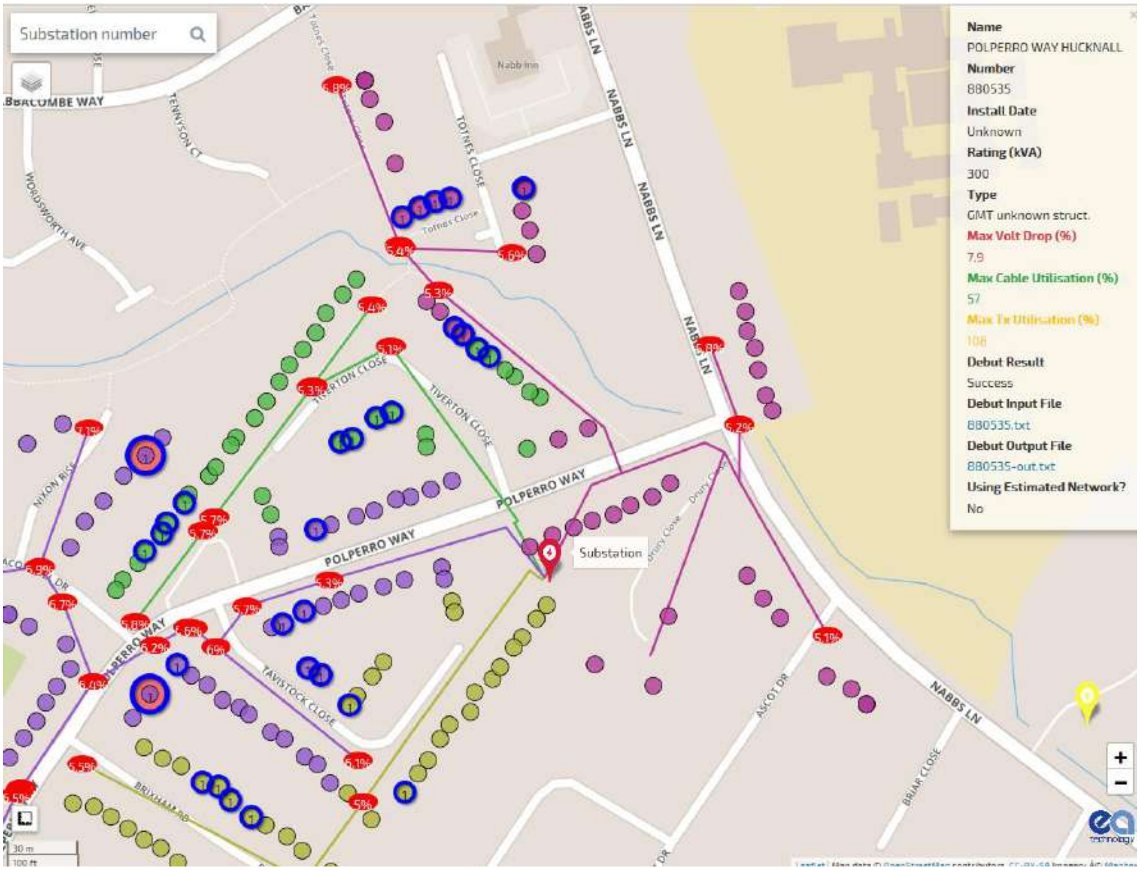

Figure 14: An example of the voltage drops at nodes exceeding the 5% limit.

4.3 The Introduction of Custom EV Penetration

The custom EV penetration functionality has been designed and installed on the NAT. The user can now manipulate the uptake penetration. Thus, for a given LV network, an LV designer will be able to test how many EVs can be added before some form of intervention is required. Figure 15 shows the tool which can be located by using the toggle on the side bar.

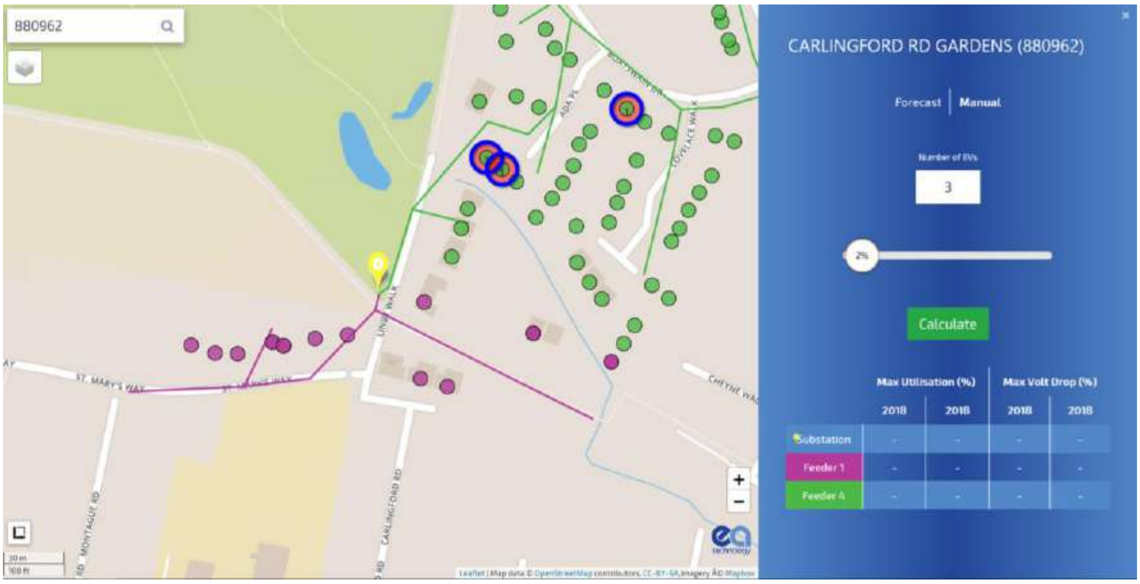

Figure 15: The custom EV Penetration tool. The user operates the slider to increase custom penetration. This runs from the initial (actual) EV charger installations (in 2018) to 200% (all consumers have 2 EVs). There is also an option to enter a specific number of EVs onto the LV network.

The resulting EV allocation to the network is then distributed to the customers using the three-bucket method (see the section - Allocating EVs to Individual Customers).

The DEBUT engine will have to run network calculations 'on the fly' for custom penetrations. Therefore, the results of the calculations will take a greater time to appear in the table than the pre-processed forecasted results. The user will have to click 'Calculate' and then the DEBUT engine will run for the network set-up selected by the user. This is expected to take a few seconds each time the function is used. The table will then update.

As the user manipulates the penetration levels, the map is continually updated with forecasted EV allocations as shown in Figure 16.

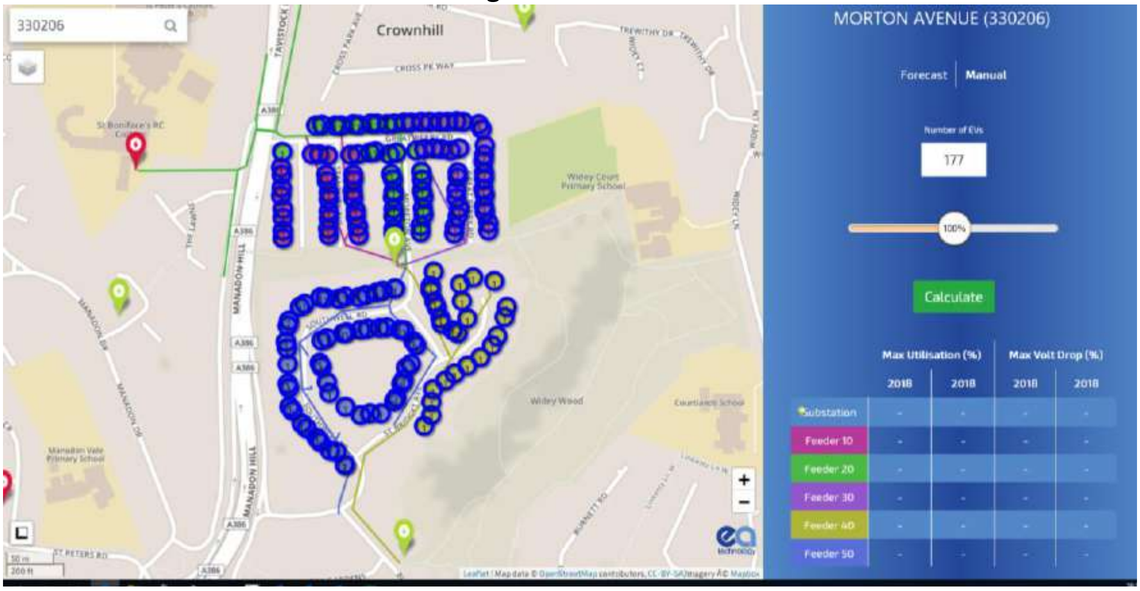

Figure 16: Here the custom penetration has been set to 100%. As can be seen from the map, all customers have been highlighted, meaning they all have one EV.

4.4 Progress Using the Agile Development Framework

All work carried out over the last three-month period has been planned and tracked using the agile development framework, introduced in the last quarterly report. The work to be performed by the development team for the upcoming month is discussed and agreed upon during sprint planning meets at the beginning of the month. The Project Manager discusses the objective that the Sprint should achieve and the Product Backlog items that, if completed in the Sprint, will achieve the sprint goal. This plan is created by the entire design and development team, who individually propose their opinions on the work required, front-end UI design and estimations of time needed to complete tasks.

The product backlog has been continually updated by all members of the design and development team during the last three-month period. This mainly revolves around recording ideas for potential user stories that could be integrated into the tool. Also, bugs are reported when discovered whilst implementing user stories. The items on the Product Backlog are prioritised at the sprint planning meetings, giving the team a schedule for the month ahead.

Finally, following completion of the sprints there has been sprint reviews, during which all the user stories that the team agreed would be implemented are assessed. This then allows the team to plan for the impending sprint.

The agile development framework has proven to be an efficient system for managing the project deliverables. EA Technology will continue to operate under this framework for the remaining development period.

4.5 Western Power Distribution Demonstration Platform and User Guide

During the previous quarter, EA Technology engaged with WPD to put in place a demonstration platform on Microsoft Azure to provide a link to developments delivered in the previous sprints. A User Guide was issued to WPD at the beginning of this quarter to assist in the use of the tool in its interim form. This allowed WPD to use The NAT and provide input to the design and developmental process. The points raised by WPD have been entered into the product back-log.

5 Ongoing Development Path

The following immediate development paths are in progress or awaiting a pre-requisite task before development can progress:

- Incorporation of previously identified missing customer and cable/line data into the NAT – this data has now been supplied by WPD. Incorporation of the data will entail a complete re-run of the mapping and assessment routines.
- Generating interim EV charging profiles for the DEBUT engine to use in assessment of networks with EV chargers in place or forecast. DEBUT calculations will then be run for all of the networks in the WPD area, for each year up to 2030. This will produce network assessments with an interim EV load incorporated (later in the project, data from the customer trial will be used to produce a more realistic EV load profile). This interim profile will eliminate the current "mock" results presented to date.
- The estimated networks employed to overcome mapping failures will be run by the DEBUT engine. These will include assessment with the interim EV load profile for existing and forecast EV uptake.
- A refinement of the DEBUT assessment will also be incorporated to eliminate a common assessment failure mode where the number of customer groups (dumb feeder number assignment in Crown) exceeds the number of mapped feeders. This is mostly caused by apparently erroneous dumb feeder assignments within Crown (e.g. the majority of customers assigned to three feeders numbered 01, 02, 03 and a handful of customers assigned to feeder 999, but only three feeders are mapped as leaving the substation). The solution is to ignore the apparently erroneous customer group with no feeder and to calculate the assessment of the "good" feeders. Where such decisions are made, assessment results will be flagged as having a low confidence result. The UI will also be modified to inform the user that the NAT has provided a modified network to DEBUT.
- Implementing a confidence metric to score the reliability of the results obtained for each LV substation's network. As mentioned in the previous report, the factors that will affect the successful mapping of a network have been identified. Once all the networks (including the estimated networks) have been processed by the DEBUT engine, the weightings of all the factors that affect the successful representation of a network will be decided upon by analysing a large number of network maps and assessments.
- A strategy will be defined for analysing the uptake and resulting network stress at a high level. The design of wider-scale analysis methodologies can now be decided upon as the local penetration mechanisms are in place. This high level comparative analysis may be carried out on the licence area level or the ESA level. The UI will need to be modified accordingly.
- The mitigation assessment module needs to be defined and designed – which will enable assessment of smart charging as a mitigation method (vs reinforcement) for networks overloaded by forecasted EV loads. This work stream is in the early stages of development. It is expected that the tool will have the ability to give results for differing uptake of charge management.

- Research will continue to obtain diversified charging profiles for EVs with different charging rates and battery sizes, using the data gathered from the Electric Nation trial. The DEBUT engine requires profiles made up of mean consumption for every half hour period of the day and the standard deviation of consumption for every half hour period. In addition, the total annual consumption of the EV is required. The different EV types can then be placed into the DEBUT engine in much the same way as domestic properties are.