WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

CARBON PORTAL

CLOSEDOWN REPORT

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Contents

Executive Summary

Carbon Portal is a project intended to further develop the Carbon Intensity view capability, delivered by the earlier *Carbon Tracer* project as a simple app and website, allowing third parties to self-serve carbon intensity data made available by WPD across its operating area. While the *Carbon Tracer* provided an app and website allowing customers to view the instantaneous energy mix, and therefore the carbon intensity for their selected location, the new project was designed to provide API programmatic based access to the same data. In this new data dissemination operational paradigm, WPD acts simply as a data access facilitation service and it is left to the third parties to design and build their apps as necessary. This may be the way forward for similar developments in the near future, allowing the wider customer base and market to define user centric functionality and services. This approach allows WPD to take a step back from the user front-end and concentrate on the data sourcing aspects within the end-to-end process of informing customers about energy matters.

We can now foresee the need for a number of new facilities which can perhaps best be delivered by the app mechanism. For example, participation in Demand Side Management and, given the expected expansion in the use of EV's, (and the certain requirement to support customers wishing to minimise the through life cost of ownership) apps which can direct customers as to when to charge these at the most beneficial time[1]. The lessons learned from Carbon Tracer and Carbon Portal prepare the way for such future app developments and the provision of infrastructure for their support.

Following the completion of the Carbon Tracer project, and the analysis of the user feedback, we also identified a small number of enhancements to be applied to the existing app and Website in order to improve app usability. These were also implemented in two separate releases as part of the Carbon Portal project, along with the API call set.

The developments described in this document proceeded to budget and largely to plan, and the deployed API's and Carbon Tracer app/website are continuing in active use.

[1] According to whatever measure is to be applied and subject to the appropriate constraints. Navigating this potentially complex area is what these apps would very likely do. Costs which reflect the benefit to the DNO/DSO of directed charging regimes are expected to be built in to operating schemes as the EV customer base expands.

1 Project Background

1.1 Previous and Related Projects

As described above, the Carbon Portal was an immediate follow-on from the Carbon Tracer NIA project which was initiated in 2016 and completed in early 2018. The route to the Carbon Portal seemed to be a logical continuation which could capitalise on the success of the earlier project to deliver the obvious next step objectives.

Continued ongoing assistance was made available to the project by the WPD Strategic Studies Programme which had just concluded the South West Region update in July 2018 at the same time as the Carbon Portal was defining the changes to be implemented. This now includes a revised BSP data set for the South West, bringing this up to date.

1.2 Statement of Problem

While an app was already available to customers from Carbon Tracer to deliver Carbon intensity (and other) information, this was proscriptive (i.e. providing functionality defined by WPD and the Carbon Trust) and required a WPD developed client side facility to operate (mobile application and/or website). The new requirement was to deliver a suite of "callable" service routines which could be built into/called from third party developed apps/websites supporting whatever functionality could be foreseen by the third parties. These API routines would then provide data on request in a number of forms and in a way which would allow app designers to construct their own apps, obtaining the data which supported them from WPD directly. There would be no costs to the third parties of WPD data access.

It was also considered that the project outcomes would assist with the development of future apps by third parties in response to customer driven demand rather than these having to be anticipated by WPD, in particular the planning of future engagement for Demand Side Management and very likely in the area of electric vehicles. The capability also required new legal "Terms of Use" to be derived in order to support the operation of the API utilities.

1.3 Method

As the project was following on from the earlier Carbon Tracer, the same development methods were used to deliver the Carbon Portal. The projects are both essentially IT implementations, with the portal making a set of service API routines (application Programming Interface) available to external third parties.

API services, in general, are “components” of utility program that are written by the source data/system owner to do things with the source system data. These utilities may be used by any system that wants access to the underlying data or service. To use them in practice, a program written by someone else "CALLS" the API service routine to do its job, and hence these are termed the “callers” of the API. The API calls therefore become integral to the calling side (which may be an app, website or any program in fact). Classically, API service routines are held in libraries to which the calling application “links”. In windows such libraries are usually DLL’s (Dynamic Link Libraries), however a more modern and innovative approach is now available, as taken by the project, using RESTful technology.

1.4 Approach

The project continued on from the earlier Carbon Tracer project and continued with the arrangements for that system under ongoing support. As such the full development lifecycle is largely irrelevant and in fact consisted of the following simplified principal activities carried out by the indicated parties:

- Requirements definition, API service routines (WPD);
- User app feedback mapping to desirable changes (WPD);
- Requirements definition, app Enhancements (WPD);
- Outline Design (WPD);
- Top level Design API’s (Enigma);
- Top level Design enhancements (Enigma);
- Functional Specifications (Enigma);
- Additional data preparation (WPD);
- Functional additions (Enigma);
- Security Penetration Test Activity (WPD/IR & External Testers);
- Host sizing confirmation (Enigma);
- Pre-release tests (WPD/Enigma);
- API Marketing (WPD, including Press Office);
- Go-live app releases * 2 and API’s (WPD/Enigma);
- Ongoing Support (Enigma).

The enhancements to the existing app were thus implemented simply as software updates seamlessly continuing the previous work and delivered as Releases 2 and 3. The additional new API services were added to the overall program suite, posting the design and facilitating review by using the online APIARY service.

2 Scope & Objectives

In addition to the straightforward requirement to add the API's, the Carbon Tracer project had previously identified several distinct areas in which the overall Carbon Tracer project could be taken forward. Of these, we determined that should any budget be available, the focus could be broadly on the improvement and evolution of the facility enabling customers to see and take action based on the carbon intensity of their supply. The original assessment had seen these general areas for improvement:

Scale-up: expand user base and ability to check user response to the information provided.

Simplify: User feedback suggested that simplification could drive increased engagement.

Improve: The Forecast feature had resulted in the least favourable response from participants as a result of the lack of resolution of the BMRS forecast data. To improve this, it was determined that the National Grid's Carbon Intensity API could be integrated into the app to show more realistic and more useful carbon intensity forecasts over a much shorter 2-3 day period and leave the BMRS forecasts for a longer term outlook. In addition, given that the app already has back-end information prepared relating to the carbon Intensity at all possible BSP locations which a user might request, we decided that this could be made available at an overview "all WPD" level presented in a map format. This and an expansion in the colour shades used to represent the carbon intensity to give better visual resolution for the presented data, along with additional supply detail, would provide a comprehensive view of this key information.

Evolve: Early testing has suggested that the app by itself does not drive long term engagement and behavioural change. However, the underlying data access, interface, and user testing method has been established to be working which provides an opportunity to evolve the application cost-effectively to serve broader objectives linked to DSO transition such as DSR, EV roll out support, local systems planning support etc. Taking the onus on action away from the user and into automated services (via APIs) was a key conclusion from the earlier project.

The result was a project scope which included the expansion of the remit of the initial Carbon Tracing project to cover external direct data access and to add selected mainly customer requested enhancements which fit the above improvement and evolution objectives, using any available budget after the delivery of the priority APIs.

Another major objective was to facilitate exploitation of the earlier work – to make WPD operational data used by existing app(s) available for third party developers, identify what

other data could also be made available and by what means to support other (future) apps. Overall we would refine the existing app to improve performance and visibility and consolidate the position of the app in the Carbon footprint awareness space to better serve those customers already using it and to encourage more users to join and use the app or externally developed apps making use of carbon intensity data.

Essentially both elements are confirming WPDs commitment to the app landscape, considered vital for DNO operations into DSO.

Objective	Status
Facilitate exploitation - make WPD operational data used by existing app(s) available for third party developers.	✓
Identify what other data could also be made available and by what means to support other (future) apps.	✓
Refine the existing app to improve performance and visibility and consolidate the position of the app in the Carbon footprint awareness space to better serve those customers already using it and to encourage more users to join and use the app	✓

3 Success Criteria

Clearly an updated app and creation of a new data service via which WPD can better serve customers are key success markers. Increased numbers and a more usable app interface will demonstrate improved user engagement and show that WPD is both committed the existing app and support for apps in general.

The Project includes the following main identifiable objective areas which can be assessed for completeness and an indication of successful conclusion:

Project Objective	Measure of Success
Facilitate exploitation – Design, production, rollout and support of a set of APIs for Carbon Intensity (and associated information)	✓ Creation and live availability of API services.
Identify what other data could also be	✓ Dataset identification inclusion in Final

made available and by what means to support other (future) apps.	Report.
Refine the existing app to improve performance and visibility – Carbon Tracing app and supporting Website UPDATES to version 2 and 3.	✓ Creation and live availability of both (the app in variants for Apple and Android).

4 Details of the Work Carried Out

The project was conducted broadly as planned and had three main activities carried out in two phases: firstly to design and implement the APIs and existing app release 2 enhancements set and then to test and release the API set along with release 3 of the Carbon Tracer app and website.

The project deployed the updates to the app for mobile phone and shadow website in July (release 2) and January (release 3, parts 1 and 2) 2019 with the API's going "live"[2], after security testing and legal terms of use development, also in January 2019. Learning from this area was gathered during the project to aid in the preparation of a possible future support and enhancement phase.

4.1 Requirements Gathering

As part of the previous Carbon Tracer project, a requirements specification had been produced in order to formalise the main requirements at the project outset. The broad functions that were required of the initially deployed app and website were identified and a number of secondary "desirable" requirements were also listed in order to add breadth to the app. It was always intended that these secondary requirements would be "tradeable" and not be formalised as development subcontractor deliverables and several were lost (due to time constraints) as work concentrated on the main functions for the initial release.

This approach was intended to allow flexibility through the initial Carbon Tracer development without constant recourse to inflexible scoping agreements, thereby allowing

[2] Going "Live" in this sense means available for use by unspecified but approved third parties, nothing is actually live until a caller system, using the WPD supplied APIs, has been implemented and has itself gone live to operations. The lead times for this could be quite lengthy and are beyond the control of WPD.

an agile approach to be adopted with the developers. The spec is in Ref [2] and it therefore included the details of a small number of postponed enhancements which might be candidates for implementation on the Carbon Portal project. The overall Carbon Portal enhancements included these initially foreseen items along with additional requirements derived from Carbon Tracer user feedback and our own view on how best to adjust the original app.

4.2 Requirements Analysis

This task followed on immediately from the user requirements gathering activity and involved collating the results and allocating priorities to individual candidate changes with a view to scoping the supply. Essentially the task concerned the fitting of a number of a activities into a budget for the work to provide the most beneficial set of updates.

App Notifications

Based on user feedback, there had been a number of requests for reminders/notifications of when there was green energy and when it would be a good time to use (or conversely, not to use) electrical devices (most applicable for those high power consumption devices which have some flexibility in their time of deployment such as washing machines, tumble dryers, dishwashers etc). A selection of some of the actual user feedback that was drawn upon is listed below:

> *…Would be useful to view any 'green' slots from main screen. Also useful to provide historical 'green' slots time so user can see if they are available often or rarely. Can then make a more informed decision about waiting for a possible 'green' slot. TO PUT TIMES OF THE DAYS IN WHEN RENEWABLE ENERGY IS PLENTYFUL*
>
> *I love the idea of using high energy demand products during certain times to save energy, I wish there would be popups to notify me the time It could send alerts when the energy mix is not green*
>
> *…Send notifications to user of green slots as they appear Alerts when renewable energy sources are readily available would be useful*
>
> *As part of the "I need to use some energy" feature it would be useful if there was a reminder function so that an alert could be received when it is more appropriate to use energy (based on live data or the forecasts). It might be useful if you could set a reminder for when it gives you the green light for using electricity.*

Notifications had been suggested for implementation in the first phase of the application development (under Release 1), but unfortunately this aspect had to be cut from scope due

to time restrictions. The original view was that such a feature would encourage users to keep using the application, by reaching out to them, instead of requiring them to realise the benefits by using the application consciously, with the attendant risk that this became too much of a chore.

Enhanced Banding Visibility

This change provides an enhanced view capability to differentiate within Carbon Intensity bands displayed as simple three colour red/amber/green "traffic lights". The majority of negative feedback that had been seen from the test group of the Carbon Tracer related to the fact that, depending heavily on the BSP/Supply area of the user, some locations will display a red intensity value for much of the time. This is particularly the case in urban areas and is partly because such urban areas are skewed more towards a higher carbon intensity due to the high volume of users and lack of space for green energy generation. A secondary negative effect for the users was also partly the result of the fact that when the app was launched, it was deep winter and therefore the solar power levels were low or very low.

> *Not that you can improve this, but I think it's fascinating to look at this app and see that there is never a moment in my area the electricity usage isn't sky high! I think the feature itself is okay, but a bit useless personally as there are very very few 'green slots' in my area, usually around 4am when I am asleep.*
>
> *This might just be for my area, but the energy levels rarely change and the app always tells me it would be better not to use energy at that time. It has never told me that it is a good time to use energy. For the moment, my app mostly shows that all times are bad. Hopefully this will change when we have some more sunlight and then the app's potential can be realised.*
>
> *Every time I have used the app there have been no green slots, which puts me off using the app, because it makes me feel like I can't help. I live in an urban area, so renewables are low. Every time I open the 'now' feature it says 'Can it wait until later?'*
>
> *I like the app, but it said that for all the time that my electricity was red so I could not choose the green times to use my appliances, as there weren't any! In my area, there is never a green slot, so this feature is not useable for me personally.*
>
> *Every time I have looked at it, it says 'wait until later' & if I did that I would never be able to get anything done! In my area it seems like there are not many green slots. It might be useful to be shown other energy saving tips I could try.*

In my area it seems there aren't a lot of renewable energy sources making it more worrying than if I didn't know. So it's good and bad It's been difficult as there have been no good times to use electricity at all during the trial period so it's a bit of a disincentive to use the app because it feels like what's the point if there's never a 'better' time.

Potential Solutions

A number of solutions were discussed during the original Carbon Tracer project, when it was first noted during development that there could be a significant skew towards red hours in some places. In general, the more effective the solution, the larger it was to implement, but some of the options were:

- Create more colours in the banding (currently just red, amber and green) to show more variation inside red in particular;
- Create good, okay and bad levels for each of the 4 different BSP types (rural, mixed, urban and light industrial);
- Use a more intelligent algorithm to identify what counts as good, okay and bad for specific BSPs;
- Change the phrasing around the 'need to use energy' feature to reward users for choosing better slots, not specifically making only green = good.

It was agreed between project stakeholders that the most pragmatic approach was simply to change the phrasing and add more colours to the banding. This was not overly complex, and would provide an acceptable ready solution. Taking a BSP specific view, while helping the users locally, would lose overall consistency of approach and would require careful selection of the criteria whereby this could be implemented. This is perhaps a matter for future development and could be based on a GSP or even aggregated regional view for areas which are particularly disadvantaged.

API Functionality

There were no immediate User generated requirements at the project outset so these had to be anticipated. Some additional facilities were added later following discussions with potential first users.

The callable API service routine set was therefore defined to include the set of service utilities described below. As mentioned previously, Representational State Transfer (REST) technology was used for the API, which uses less bandwidth than popular Simple Object

Access Protocol (SOAP) technology, making it more appropriate to be used on mobile devices where bandwidth might be limited.

RESTful APIs usually allow HTTP requests that GET, PUT, POST and DELETE data from a server, however the API created only allows GET. This means that all information on the backend server is 'read only', and cannot be changed in any way using the API. POST, PUT and DELETE were not required for the project, and also removing them removes a layer of risk to the data, and security risk.

The Call set was as follows.

- BSP Information from post code - Return the BSP that supplies energy to a postcode.
- BSP Information from latitude and longitude - Return the BSP that supplies energy to a location identified by latitude and longitude.
- BSP Polygons - Return the supply area of a BSP in the form of a polygon, identified by the BSP's ID.
- Carbon Intensity Table - Return list of all BSPs in the WPD area, with their name, ID and the carbon intensity for the current hour.
- BSP Carbon Intensity Now - Return the carbon intensity for a BSP for the current hour.
- BSP Energy Mix Now - Return the energy mix for a BSP for the current hour, split by generation type.
- BSP Demand Now - Return the current energy demand on a BSP.
- BSP Carbon Intensity Forecast - Return the carbon intensity value for each hour of the next seven days (including today) [TS] for a BSP.
- BSP Energy Mix Forecast - Return the energy generated for each hour of the next seven days (including today), split by generation type for a BSP.
- BSP Demand Forecast - Return the expected demand on a BSP by hour for the next 7 days (including today)
- BSP Carbon Intensity History - Return the carbon intensity for each hour of the next seven days (up to yesterday) for a BSP.
- BSP Energy Mix History - Return the energy generated for each hour of the previous seven days (up to yesterday), split by generation type for a BSP.
- BSP Demand History - Return the demand on a BSP by hour for the previous 7 days (up to yesterday)
- BSP Marginal Carbon Intensity Now – Return the difference between the carbon intensity for BMRS and the carbon intensity local, in either a positive or negative value

- BSP Marginal Carbon Intensity 2 days - Return the difference between the carbon intensity for BMRS and the carbon intensity local, in either a positive or negative value, for the upcoming 2 days (including today)
- BSP Marginal Carbon Intensity 7 days - Return the difference between the carbon intensity for BMRS and the carbon intensity local, in either a positive or negative value, for the upcoming 7 days (including today)
- BSP Generation Capacity List – Return a list of the generation capacity for a BSP, split by type
- BSP Generation List Now – Return a list of actual generations for a BSP, split by type
- BSP Load Now – Return the current load on the BSP and the global maximum load

Expanded BSP Information

Along with the objective to provide carbon intensity information to customers, allowing them to act on this if they wished to do so, it had been an objective of the original Carbon Tracer project to inform customers about the nature of their electricity supply. We had long intended to provide more details under the BSP information that is displayed once the user has selected their location, and this enhancement follows up on this intention. Provision of such information might be foreseen in a number of applications, for example for new connections, so this was another pilot mechanism.

This enhancement was a lower priority however, not relating to making the app easier to use or clearing any noted issues. It was therefore planned for inclusion in app release should implementation budget permit.

The expansion in BSP information was foreseen to now include the following elements:

- BSP Name, Icon: Same, Copy: Same, Further Link: 'How does the energy get to homes?' (Leads to Primary substation Further Info). This will now allow the user to explore the substation primaries, with an explanation of how the energy gets transferred between the BSP, primaries, and homes.
- Wind Capacity, Icon: Same, Copy: Same, Further Link: 'When is the best time for wind power?' (Leads to Wind Further Info). The information on how wind power is generated and calculated is presented as a graph with the current reported local wind speed indicated on the graph.
- Solar Capacity, Icon: Same, Copy: Same, Further Link: 'When is the best time for solar power?' (Leads to Solar Further Info). The information on how solar power is generated and calculated is included as a graph showing the normalised curve, relating this to when the normalised max value of 1 is attained in June and showing

shortfall from the ideal curve due to other weather parameters (cloud and precipitation)

- Peak Time, Icon: Same, Copy: Same, Further Link: 'What is peak usage?' (Leads to Max Demand Further InfoPrimary Further Info). This overlay will explain why there is a peak time for usage, and what that usually is in MW.
- Local Solar Noon. The solar noon is based on the equation of time and longitude offset of the BSP from the Greenwich meridian. It is already used in the application, and should be applied for each BSP in the form of the time of that BSPs local noon. Icon: New, Copy: for example 'Occurs today at this location at: 12:02 when the sun is at its highest point in the sky', Further Link: 'What is Local solar noon?' (Leads to Local Solar Noon Further Info).
- BSP Type, Icon: Same, Copy: Same, Further Link: 'What does [TYPE] mean?' (Leads to BSP Type Further Info). Displays the potential local generation capacity and an explanation of each.
- Information. This is a new field on the BSP metadata file. If this is empty, hide this element on the BSP page. Otherwise, output whatever has been added in this field. Icon: New, Copy: [Information], Further Link: None
- Primary Further Info – primaries under the BSP and polygon outlines. To reach this overlay, the user will have clicked on the link: 'How does the energy get to homes?'

As the space available on a mobile device is very limited, further information on the BSP information listed above would be shown in an overlay/popup format, allowing space to show images, expand on detail, and which potentially could be scrollable. FAQs would still be used for any additional extended information. A significant benefit of this approach was that the information could be readily included in other areas within the app – for example on the Now screen which could link to solar and wind information.

Improvement to the Forecast Functionality

One of the main issues that arose with the Carbon Tracer concerned the effectiveness of the next 7 day Forecast function. Of the Now, Today, Forecast and History, this feature proved to be the most disappointing due to the pessimism of the forecast information contained in the 2-14 day out BMRS prediction which was used to help complete the overall prediction. The detail provided in the BMRS is limited (by intention) as there is a market linkage which prevents complete freedom of forecasting. The result of this was therefore that, particularly in the winter at the time of the first app launch, the forecast feature was disappointingly red and this contrasted with the history feature in a way which implied that one or the other must be incorrect (as the history displays actual recorded values, it was clearly not this feature that was at fault).

To improve the position with the overall forecast, it was proposed to add a short term two-day forecast using a new National Grid facility which could be used by customers to inform/drive behaviour given that a 2 day horizon would be sufficient for this purpose, leaving the longer term forecast as purely informational but integrated as part of the same forecast display. This made sense as postponing elective consumption operations by customers on a time horizon longer than twelve hours, in fact, makes little sense. The National Grid 48-hour forecast initially included only the bottom line carbon intensity value, not make-up information by generation type, so would initially be incompatible with the Carbon Tracer which allows the user to drill down to further information on energy source. It was also necessary to use a regional rather than local prediction in order to avoid double counting the local generation in the overall National Grid/WPD aggregated view. There were therefore technical challenges with including this enhancement and it was therefore set aside for implementation and rollout as Release 3 part 2.

Carbon Intensity Mapping

It became clear that a much wider view of the prevailing Carbon Intensity could be delivered by the overall system. In the original concept, the Carbon Intensity was delivered for a single location matching that specified by each customer. However in order to achieve this the server has to have the information computed and available for all possible locations (i.e. at all 270 BSPs) so that it can be delivered at a speed consistent with the performance that is required for a mobile app. At any particular time therefore, an overview was possible which displays the Carbon intensity, by BSP, across the entire WPD operating region and as a further feature this could rank the BSPs in a sort of carbon league table. The functionality implemented in the project therefore enabled this view at any time (one hour granularity) selectable by the user within the history and forecast window of available data.

It was further realised that as the information is determined at half hourly intervals and can be stored, that an animation (film or “movie”) of the evolving Carbon intensity could therefore be provided (as an eventual offline activity by the support team once sufficient data had been gathered over a suitable time span). This would illustrate both the diurnal variation as well as the seasonal evolution of the carbon intensity values and could prove an engaging feature of the system. This could readily be achieved by colourising the BSP supply area polygons using the expanded RAG colour bandings. This change was therefore fed into the list of enhancements as a priority item.

The same map functionality was also used to allow the user to select (via choosers above the map display itself) an “all WPD” colourised display of the allocated BSP types (urban, rural, mixed etc) and information on attached generation capacities.

General Updates

The Carbon Tracer app and website were already being maintained under a support and maintenance contract with developers Enigma prior to the commencement of the Carbon Portal. This allowed routine adjustments to the build of the system to keep it current in terms of software and to some extent also with data updates included in the Generation File (as the attached capacity information evolves on a roughly monthly update cycle).

The Carbon Portal offered an opportunity to make some additional changes to the system to:

- Add revised data for the SW based on a new Strategic Studies output for the South West operating region – so bringing the data for this region more up to date;
- Improve some small aspects of screen layout and copy text.

4.3 Scoping, Agreements and Team Formation

The existing team from Carbon Tracer was carried over to the Carbon Portal project, however the limited budget meant that with the bulk of the research to define the main project drivers, objectives and technical basis for the project already completed in the Carbon tracer work, we would be doing only minimal user engagement in the new project. This meant that Carbon Trust were no longer directly involved with the Carbon Portal. Enigma continued as developers for the API and app enhancements with the same small team bringing their expertise and familiarity to the new work. Hyve were retained as Enigma's hosting service.

Scoping was defined in the Requirements derivation phase outlined above, but included the major elements of API production and rollout and existing app Enhancements using any remaining budget from the primary API development activity.

4.4 Design, Development & Test

Each planned release was backed up by a Functional Specification [Refs 9, 10 & 11] defining the design. This was reviewed and approved and actual implementation in code then followed. The enhancements were treated as simple extensions of the original Carbon Tracer app supply. The API set, being new, was coded from scratch with the design posted on the Apiary tool for test, review and feedback.

This section describes the main design elements for each of the major components of the development along with any salient points in the development and test programme.

App Notifications

Notifications were added to the applications only, creating reminders that show on a user's mobile device, prompting them to change their energy usage patterns.

Every hour when the 'current' carbon intensity is calculated for all of the BSPs within the WPD area, the system monitors whether the hour's intensity differs to the previous hour. If there has been a change, an event is sent to a Google product called Firebase. Firebase collects these events and then identifies which of the applications users are subscribed to receive notifications for the event.

Users can subscribe to notifications for any BSP (choosing from their five most recently used instances), and to be alerted when the carbon intensity changes to either green, amber, or red. This was designed to be flexible for the user's needs, for example they might want to make sure that they don't want to use energy when the carbon intensity is very high, so they could subscribe only to red alerts. Alternatively, they could subscribe only to green alerts, to use a lot of energy only when carbon intensity is low3.

To aid the user experience, these notifications are switched off as default, and the user can choose not to enable them. To test this feature, a test instance of Firebase has been created on our UAT (test) environment so that we can run through a list of common actions before any release.

Enhanced Banding Visibility

The 3 colour bands (red, amber and green) were increased from 3 colour variations to 9. This was to resolve a lack of variation of carbon intensity that existed for some BSP areas, specifically those that were consistently red. This was suspected to cause a decrease of interest for users who saw no opportunities to vary their energy usage.

For some functionality in the application (e.g. notifications and identifying the next green hour), the 3 groups are retained, for simplification of user options. Each group was split, meaning that there are now 4 red bands, 2 amber bands and 2 green bands. Finally, there is a black band, which is used when the carbon intensity exceeds 360g/KWh4 – identified as being outside an acceptable range. Users who live in areas with a mainly red carbon

[3] Both approaches have been indicated in customer feedback.

[4] 2018 values. The 2019 banding values will be introduced as a support item.

intensity can now choose to use energy when the hour is less red than at other times, therefore still managing to adjust their energy usage.

API Functionality

The API accesses the same data as used to power the applications and website, but retrieves it in a batch of information, similar to the way that it is calculated. For example, even though the application only receives the current carbon intensity for one BSP, at the time of calculation, the server runs through all BSPs and calculates the carbon intensity. By delivering the information in a 'bulk' form like this, it becomes more valuable and usable for third party users who would like to utilise it to develop their own applications, or to further modify their energy usage.

Rather than restrict access to the API via an account authorisation, it is open to any user who wishes to connect to it. The API and server are resistant against misuse by utilising best practice rate limiting and blacklisting to ensure that users do not overload the service, or misuse its content. The API has been penetration tested, and load balanced.

Expanded BSP Information

- Primaries
    - Information on the primaries that are attached to each BSP were added to the BSP Metadata, purely to be able to provide the number and names of them to the users
- Solar noon
    - The calculations that are performed by the server to identify the local noon of the substation are now also used to identify the time of local noon on the BSP information page
- Solar irradiance
    - A visualisation of the solar irradiance is now available to the user, identifying how the power of the sun varies depending on the position of the sun
- Weather scalar
    - The weather values of cloud cover and precipitation create a scalar, used in combination with local noon and solar irradiance by day of year. Unfortunately the weather API provider specified that their data not be displayed on its own, but while the cloud cover and precipitation levels are not visible, there is a graph to demonstrate how much this scalar has affected the solar power capacity
    - The same applies for the wind speed – this is displayed in a visual taken from wind power generation data about how wind speed affects wind power generation
- Maximum Demand

  - Using the BSP load files that are already used to identify carbon intensity at a BSP, we now share the maximum demand and daily load curves to the user, the latter visualised as a graph
- BSP Further Metadata
  - The BSP type is used to identify which set of load curves are appropriate for the BSP, but is now also displayed to the user, with a short explanation of what the type means about the carbon intensity at that location
- Generation data
  - The regularly updated 'Gen Info' data file lists all generation types and values that are generated per BSP, this is shown to the user.

Improvement to the Forecast Functionality

Many different approaches to how to display the 2 day forecast data were discussed and compared, but it was decided that the 2 day and 7 day forecasts serve different purposes, and therefore both should be retained. The 7 day forecast satisfies users looking for a high level informational view of upcoming carbon intensity, and allows them to identify patterns of high and low intensity. The 2 day forecast serves a more practical use, as this is the window in which users are most likely to move their energy usage based on predicted carbon intensity.

A new screen was added to the existing four (becoming History, Now, Today, Next 2 days, Forecast) which was optimised for this kind of usage, allowing users to identify the best hour for them to use energy in the upcoming two days.

Carbon Intensity Mapping

This capability was piloted using a geographical display system, importing the carbon intensity data (and also other data such as installed generation capacity by type and BSP classification) and using this to provide a numerical "value" attribute to colourise the supply area polygon set.

Examples of prototype displays as illustrated below:

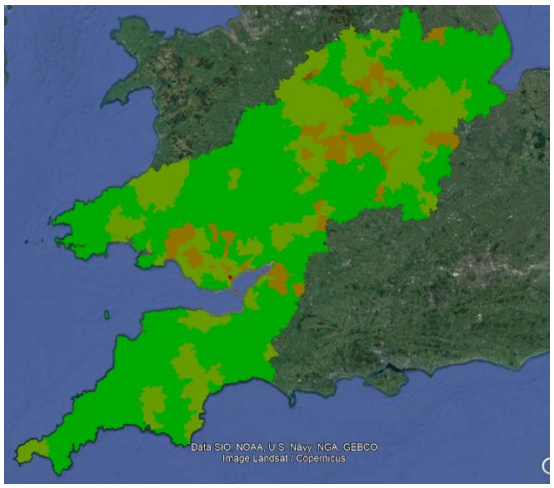


Figure 1 – Carbon Intensity by BSP Across WPD

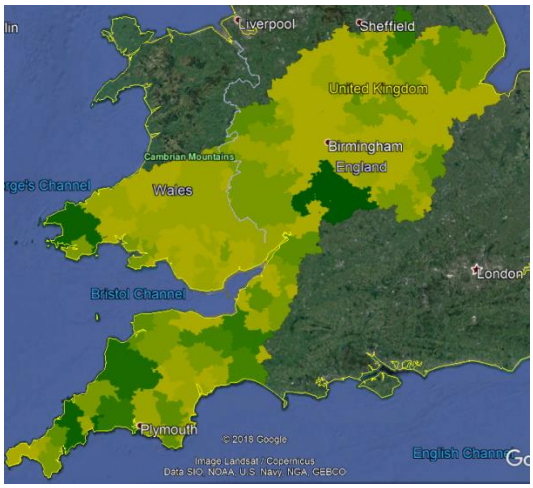


Figure 2 – Installed PV Capacity by BSP

This pilot for the functionality was used to inform the design process within the website.

It was decided that due to the size of the map and the detail of the data, this would be a feature that would be best used via the website. To build on the colour classifications that users are familiar with on the website, the polygon data for BSPs has been coloured using the updated 9 colour band for carbon intensity, and using further colour classifications for other values.

The collected data that is already available allowed us to present a historical data set as well as current, so users can select a day in the past as well as reviewing the carbon intensity currently. Other data that is available was also reviewed, and the sets which were deemed to be most interesting for the user base were selected to be viewed and filtered on the map.

The user can choose between what they want to view:

1. Carbon Intensity
2. Potential Renewable Generation Capacity
3. Substation Type

Carbon intensity can be selected by day, using a date picker that shows all historical data that is available. If the user is viewing the carbon intensity for today, it will show the current carbon intensity of the hour. Storing the historical data by day and by hour is possible, although it would take further data manipulation and speed improvements, so was not done as part of this project. Instead, the carbon intensity for historical days is an

average for the entire day – this could be broken down by hour for future improvements to the project if a lot of interest in this feature is seen from users.

Filters allow the user to show only red, amber, or green for carbon intensity, to show a subset of substation types, or to show only high, medium or low renewable generation capacity.

As part of adding this feature, we reviewed how polygons are stored and displayed, to investigate improvements in the speed of processing and displaying them. Also to improve data retrieval speed, the calculations that were required to manipulate the existing data set to produce the data for the map are now done on a daily basis, and saved on the server.

General Updates

Multiple small improvements were made across the course of the project, usually as part of other larger tasks:

- Speed improvements, the majority on the server side when it comes to storing, processing and transmitting the data set
- User experience improvements based on findings of how people use the application and site – for example as part of the task to add enhanced BSP information, the Now page was tweaked to make the page more usable
- The security of the database that supports the server was improved, based on some 'Low' priority level recommendations from the penetration test
- General copy and information was refined based on feedback from the user base
- Behind the scenes code improvements were made, allowing future work to be carried out faster and for new developers to pick up the code more easily

Release Planning

The Carbon Tracer app enhancements were chosen as follows within the overall release framework:

Release 2

- Improved visibility of Carbon Intensity through the availability of addition colour bands for the now, history and forecast screens within the app;
- Deployment of a Notification capability within the app (only, not a website feature);

API Release

Summary of features by main functional area:

- Get BSP from location (gives global indexing lookup value);
- Get BSP details from indexation lookup value;
- Get BSP polygon(s) outline;
- Get current, history and future carbon intensity;
- Get current, history and future energy mix;
- Get carbon intensity across all BSPs in all regions

Release 3, part 1

- Expanded BSP information;
- Carbon Intensity mapping and rankings;

Release 3, part 2

- Forecasting improvements.

Testing

The testing activities were carried out in-house by developers Enigma Interactive. This included their unit and integration tests and high level system tests on suitable hosts in-house. A dev system is available for this purpose and is paid for under support that has been extended for a further year by the Carbon Portal project.

WPD became closely involved once again for the security inspection penetration check (*pen check*) via WPD IR using a third party specialist pen check organisation. WPD IR mandated a full inspection for the new API service even though there was no connection to any WPD business systems and the data was non-personal and in some cases already accessible for the public. This approach was to guard against the possibility of an attack causing adverse publicity and/or reputational damage. A pen check had been done during the Carbon Tracer project implementation.

The report on the Pen Test revealed a small number of minor issues, mainly with the database system, which were corrected. These are not detailed here for obvious reasons (although are available to be shared with other DNO's on request).

APIs were load balanced to ensure that the application servers did not fall over with increased usage and demand. They were also checked to ensure that the restrictions on usage worked correctly and that they could not be misused.

The host sizing exercise verified that the existing Carbon Tracer server and dev/test support system with Hyve could continue to be used for the existing app and also the new APIs

(which require access to the same underlying data). For details refer to the Carbon Tracer Final Report, [Ref 12]

4.5 Marketing

For the APIs, the marketing campaign involved the use of Linked-In to contact potential participants from within the industry, this being a more appropriate channel for engaging with such parties.

The app itself and social media were used to advertise the app updates via the WPD press office.

4.6 Data Sources

An objective of the project was to investigate the availability of additional data sources that could potentially be of use when developing future apps.

Limitations on Data Access

Perhaps the main limiting issue in this area concerns the connectivity supported by WPD which (for very good reasons of security) does not allow full Internet connectivity of the business and operational IT systems. For the Carbon Tracer project, the system was open to a pragmatic solution to the connectivity issue and it was designed in such a way that the underlying data used to drive the app and website could be bulk exported once at project outset to the external app host servers and then "animated" by feeds of time/date and prevailing weather conditions. Occasional data updates would then pull the initial datasets up to current versions, keeping the overall system effectively up-to-date with some slight lag from the operational systems in WPD, but not enough to be significant given the nature of the App. Processes do already exist for WPD to send block datafiles overnight to externally hosted web servers (such as for the Generation Capacity Website), giving a medium term (day level) data refresh capability. Further, the Power Cut app receives the same files that are used for the Web based power cut map via FTP transfer to the external provider at five minute intervals[5]. FTP transfer is the only mechanism that is used for the Power Cut app. In most respects, these mechanisms are already well suited to the sort of file based data management that would be required for app support. More investigation coordinated with the WPD Digital Communications department to provide a strategically aligned solution would be required to provide any sort of real-time data feed.

[5] Consideration has been given to increasing this to two minute intervals which remains a possibility.

Another issue concerns data integrity if presenting WPD operational data externally, especially if this is in a raw state. While external apps will not be expected to have safety critical implications and would be accompanied by agreement for use terms which made clear that reliance should not be placed on the complete accuracy of the information, it would nevertheless be highly desirable for the data to be as complete, correct and self-consistent as possible.

A complication with data taken across the whole of WPD concerns the subdivision of the whole DNO into four separate operating regions. It is the case that there are differences between the data in these four regions, some of which stems from their different provenance and operational handling. In the South West, for example, there are some very proscriptive and systematic naming conventions which are not replicated elsewhere. Naming in general is an issue, although WPD innovations such as the INM/CIM NIA project are leading the way by eliminating the scope for naming mismatches through cross system referential integrity checking and feedback of detected issues into the source systems.

Security is a further consideration. The question needs to be asked about how secure the data we make available is, in terms of what it conveys/tells potentially malicious users. There are two main areas to be considered here: the protection of individual customer data by requirements such as GDPR, and the protection of critical national infrastructure. While the first is largely clearly defined and understood, the nature of the wider network information that we might make available should be investigated and understood so that it would not be possible for this to be exploited inappropriately.

Usable Datasets in WPD

There are numerous datasets in WPD, most being deeply embedded and integrated into operational systems such as PowerOn or are within supporting systems such as MPAS (MPAN metadata). These main frontline operational systems are also supplemented by a number of derived datasets which the business uses for tasks such as regulatory reporting. Various utilities such as PSSE (network modelling and power flow analysis) also contain their own data “islands”.

The main datasets, their associated systems, functional areas and likelihood of general use are as follows:

Functional Area	System	Dataset	Comments
Operational monitoring & control	PowerOn	Network Schematics	Forms part of INM integrated network model dataset, available as CIM format for

Functional Area	System	Dataset	Comments
			exchange. A pseudo real-time PoF shadowing system is also now available (a recent innovation) and which could be used to source this information.
Geographical Information	EMU/Electric Office	Geographical data	Forms part of INM integrated network model dataset, available as CIM format for exchange
Asset Information	Crown (EAM)	Asset details	Forms part of INM integrated network model dataset, available as CIM format for exchange
Metering Information	Durabill	Usage by MPAN, metered point.	Confidential customer information, traceable to single MPAN, not for use outside WPD.
Analogue values	PowerOn, Datalogger	Histan Database (PowerOn) Datalogger Database	Some analogues reflect what is in fact derivable as confidential customer information (perhaps commercial), and could be traceable to single customer. Thus selected entries are not for use outside WPD (unless averaged in some cases).
PSSE	PSSE	Network topology and characteristics	Network modelling and power flow
Blossom	Blossom	Network characteristics	
MPAS	MPRS	MPAN metadata	Confidential customer metering details, not for use outside WPD but may

Functional Area	System	Dataset	Comments
			ultimately form part of INM integrated network model dataset.
Supply Area Polygons	Any	2D geographical extents – areas covered by specific supply areas. E.g. there is a BSP polygon set and a primary polygon set.	Contains large numbers of coordinates defining ESA extents and interpretable by GIS systems and therefore can be rendered by a GIS system to illustrate supply area boundaries. Also supports Spatial query to identify coordinates within the shape (as covered by it). Available currently at BSP level via the Carbon Portal API service under this project.
Strategic Studies Network Analysis	Abstracted	Multiple Strategic Studies datasets	Used to form the regular network reports, by region. Contains BSP standard profiles by categories, housing densities by BSP, peak (net of generation) demand analysis by BSP etc. Already used by Carbon Tracer app.
Carbon Intensity and energy mix by BSP	Carbon Tracer/Portal Data	Carbon Tracer/Portal CSV fileset exchanged with Enigma for external app use	Data at the BSP level describing the various BSP attributes and defining wind, solar and other scaling curves for use in the Carbon Tracer functionality.

As can be seen from the table above, the three main operational systems (listed at the top) have had their data integrated into the Integrated Network Model under a pilot innovation

project initially covering the SW WPD operating region. This data has been created in a Common Information Model (CIM) format specifically to allow export from WPD and ready import by third parties working to the CIM standard. This dataset is therefore not only available in a standard format, but includes the main network information that defines the WPD distribution system. As such it could form the supporting data backbone for any number of future systems facing both inward to the business and outward to customers and other collaborators. The INM/CIM data is however already available externally via the WPD Data Partners Portal as part of the data dissemination function of the INM/CIM project. The datasets themselves, while limited currently to the SW region, are already in use by the around 20 individuals/organisations who have formally registered to use it. This data is probably best dealt with as a block export of specific network sections, however access via API might provide additional flexibility in some cases and could clearly be considered for a future implementation. This would perhaps best be associated with a delayed view of the network (given the likely time to generate and prepare for use an INM/CIM dataset) of at best a day, and is currently only available for the South West region until the INM rollout project completes the expansion of the model scope.

This project and system linkage shows how the NIA process is able to play a pivotal role as an enabler for innovative functionality, while the further linkage to the ongoing WPD Strategic Studies Programme demonstrates how analysis and data generated in one specific area can be leveraged to provide a sound basis more widely for parallel developments not necessarily anticipated previously.

4.7 Next Steps

For the future, now that the Carbon Portal API[6] services are available, it becomes possible to take the decision making and management of the shift in energy use for customer elective actions (i.e. those which are time movable) appliance operation away from requiring the direct involvement of the user and into some form of home based intelligent controller (purely as an example, of the Hive type) which could switch appliances automatically according to Carbon Intensity projection or other criteria. This requires third parties to develop apps or computer programs to call the WPD Carbon Intensity APIs and

[6] API services are elements of program (routines) that are written to manipulate and provide a view of our data. To use them, a program written by someone else "CALLS" the API service routine to do its job and hence these are the callers of the API service.

initiate the necessary hardware based actions (charge EV, turn on dishwasher etc). In this case all that is then required is a willingness of the user to allow such control using this as the criteria, and as discussed above this is likely to enhance the sort of deferment (or more generally energy usage shift) that we would wish to see.

By deploying such integrated automation capability solutions we might therefore expect much higher uptake for DSR than that resulting from App driven situational awareness because the user is not then personally inconvenienced by the management of the task and having to remember when to do it. However, there will always be the inconvenience associated with the delay in availability of the processed items (dishes, washing, fully charged EV etc.) and the motivation for customers to participate may also become a significant factor to be taken into account.

Ideas for future apps/API services might include:

Customer oriented:

- EV Charging strategy, when and how depending on choice of controlling factors (cost, local network load/constraints, carbon intensity);
- DSR participation;
- Elective operational profile appliance control (as discussed above);
- New connection support.

Peer organisation oriented:

- New connection support;
- Network visibility;

5 Performance Compared to Original Aims, Objectives and Success Criteria

The project met its objectives in deriving a design for and deploying a set of API service calls for use by external third parties and also in delivering updates to the Carbon Tracing app in two major and one minor release.

The “Success Criteria” identified in the Project Set-up Documentation (Carbon Tracing Project Outline Document) stated the following:

These success markers have been met and therefore as initially specified, the project has been successful.

A summary of the app objectives, measures of success (from the Project PEA Documentaton), and results in achieving them are shown below.

Facilitate exploitation

To make WPD operational data used by existing app(s) available for third party developers. Identify what other data could also be made available and by what means to support other (future) apps. Refine the existing app to improve performance and visibility and consolidate the position of the app in the Carbon footprint awareness space to better serve those customers already using it and to encourage more users to join and use the app. Essentially both elements are confirming WPDs commitment to the app landscape, considered vital for DNO operations.

Success Criteria

Clearly an updated app and creation of a new data service via which WPD can better serve customers are key success markers. Increased numbers and a more usable app interface will demonstrate improved user engagement and show that WPD is both committed the existing app and support for apps in general.

Objective	Measure of Success	Result
Make WPD operational data used by existing app(s) available for third party developers.	API Service available	✓
Identify what other data could also be made available and by what means to support other (future) apps	Survey and checks completed. Information available in report	✓
Refine the existing app to improve performance and visibility and consolidate the position of the app in the Carbon footprint awareness space to better serve those customers already using it and to encourage more users to join	Enhanced App and website available. Continuing the work of the Carbon Tracer app alone in this area. Expansion in user numbers	✓

and use the app. To help people have an improved understanding of their local energy supply		

6 Required modifications to the planned approach during the course of the project

The project proceeded to completion broadly as planned although the overall project was extended past the Release 2 milestone to accommodate a further (delayed) external security penetration check and to develop the legal terms of use for the new API service as a first for WPD. There was an additional delay to avoid making the main release just before Christmas when the various tasks described above were completed. This was decided upon as there would be no developer support available for the new system through this interval.

The approach to developing the APIs was flexible and the mechanisms and major design elements delegated largely to Enigma Interactive. The App enhancements that were introduced were largely dictated by their usefulness in meeting customer driven requests and delivering significant functionality benefits without losing the main direction of the app, and also by the usefulness as proof of concept for future apps (notifications in particular).

WPD/IR again required a full third party security Penetration Check (Pen Check) to be carried out for the API service. There was no repeat of this testing for the existing app.

7 Project Costs

Activity	Budget	Actual
CARBON PORTAL PROJECT COSTS	149,135.00	144,382.39

The project remained within planned cost throughout against the overall budget, however a small amount of contingency had to be released to cover additional costs for covering off the legal issues and the security Pen Checking activities. There was a slight lengthening of the overall timescales to accommodate these and create a suitable release schedule (interval between release 2 and 3).

8 Lessons Learnt for Future Projects

Given the overlap between this project and the earlier Carbon Tracer, there was a reduced scope for generating learning points. The table of learning generated by the project is presented in this section.

Topic / Area	Learning Generated
Data Management	FTP mechanisms are already in use in WPD which transfer pseudo-real-time updates as bulk file transfers at intervals as short as 5 minutes (reducing to 2 minutes) if this is required in support of functionality.
Data Management	Any future enhancements to external data transfer via these noted FTP mechanisms should be closely coordinated with WPD Digital Communications who currently operate these mechanisms for use by the Power Cut app.
Data Management	The core data powering the app is mainly derived from the WPD Strategic Studies programme which is on a roughly annual update cycle. The App also already includes the facility to update attached generation capacities via the WPD-GEN-INFO file which is used by the separate Generation Capacity website so this can be put in place at any time. Bringing the new Strategic studies data into the app dataset has been done as part of the Carbon Portal and Tracer projects but once these stop there will need to be a stand-alone process to keep this data current. A handover document directing how to do this is therefore required.
Data Management	It has recently been found that some large generators, while declared with a capacity figure, are not actually active at all. This was particularly clear with the Hayle offshore wave power project which had a declared capacity of 30MB. On checking up, it was found that this site has not been generating at this level at all and therefore the entry had to be manually removed from the Generation capacity file, WPD-GEN-INFO, to avoid distorting the picture at Hayle BSP.
Data Management	In case of enquiries regarding lack of green slots, it should be noted that some locations (BSPs) have large non-renewable local generation. Cardiff Central for example has a poor reported CI as it has a 30MB Energy from waste facility.
Future Enhancements	Given that some locations have a very poor renewables capability, it may be that the CI reporting for these locations could be at the aggregated GSP level to avoid disenfranchising the potential app users in these places. This is

Topic / Area	Learning Generated
	equally valid, just less granular, as the decision to use the BSP at the aggregation point was taken to make the number of data entries manageable (around 27 entities to manage) while being sufficiently "local" in extent. Conversely it is also now possible to report some information at the Primary level, though with over 1000 locations this would require a lot of data management to be carried out.
API Deployment	API deployment is a straightforward process and the systems can be hosted on the same server as an active app/website using the same underlying data. This saves both time and cost if this approach is acceptable.
Marketing	Linked-In is an appropriate platform for communicating with organisations about API services, rather than individuals.
Marketing	Interest in the APIs is there but this is difficult to convert into commitment by app developers. Having the APIs available is a facilitator for app development and a comprehensive API set will allow for the potential development of a variety of apps. WPD will act in this paradigm as a data provider/facilitator and will not necessarily need to participate in the app design, development and support (other than committing to maintain the provision of data in agreed formats)
API Documentation	Documentation can be hosted on the APIARY (or similar) API web service systems meaning that the WPD corporate network and the application hosts do not need to be used for this purpose.
API Testing	The APIARY API web service facilitates testing of the service calls in addition to holding the documentation for the API set.
API Use	Pending user engagements.

8.1 API Design

Data Management

The approach taken was to run the APIs from the same data set in the same location as the Carbon Tracer app itself. This is possible as this common data area can drive both the app/Website and support API service calls. Traffic was not expected to be excessive from either source and in any case even were the traffic levels to increase to a high level, the server could always be upsized (with additional hosting / support cost).

8.2 Enhancement Design

The designs for the enhancements drew on two main sources, internally from the wider development team and using previous user inputs obtained by the customer engagement carried out by the Carbon Trust. While it would have been desirable to have maintained this customer feedback linkage, the available budget for the portal did not permit this and it was deemed that there was already a large pool of significant unresolved comments from the Carbon Tracer project.

The designs themselves were, as would be expected, significantly assisted by the presence of the existing app and website which both constrained and defined the boundaries, standards and processes required. The app already had a defined ”look and feel” and the enhancements would follow this lead.

8.3 Marketing

Linked-in was chosen as the key marketing tool for the API set as it was expected to target a more applicable audience. The general public were considered as being very unlikely to be involved with app development although contact with some individuals did reveal an interest in direct data access in some cases.

app enhancements for the existing Carbon Tracer were signalled in planning and also announced when available on social media and within the app itself (News Blog), and the availability of a new front-end software release is in any case flagged by the app Stores. This was effective in pulling the user base up to the new release (Release 2) with over 90% of active users taking this on within the first month.

8.4 Operations

The two operational Hyve servers deployed in the final configuration for the Carbon Tracer app hosting/support function were continued under extended support arrangements agreed with the developers Enigma Interactive. The support will continue through 2019 in the current format and discussions have been opened with WPD Digital Communications to merge the Carbon Tracer/portal suite into their wider app portfolio after 2020. This rationalisation is the natural progression into BAU from Prototyping under NIA and Future Networks team involvement.

9 The Outcomes of the Project

The project successfully delivered the API’s and also the planned app & website enhancements.

The Carbon Tracer app is continuing in operation into year 2 ops and is supported by the developer under their standard support terms. It remains hosted in the original locations, at Hyve and will continue in its current form until January 2020. WPD will need to take a view on the future of the app before this time and must also remain committed to supporting the API set once use of this has been initiated by any third parties. While the support costs for the host system necessary for this are modest, the ongoing data management position needs to be defined in such a way as to provide the necessary commitment to continuity and data quality that will be needed to underpin third party API based implementations and the integrity of live customer facing apps. We will also take a position later in 2019 regarding take-up/usage of the API and potentially the Carbon Tracer App so as to inform future options.

9.1 Products/Services Required

The key elements to allow for successful replication of this project (beyond that required for the initial Carbon Tracing project) were:

- Internal engagement with FNT/PSD projects and BAU systems support providing data sets;
- Internal engagement with Corporate Comms for marketing;
- Internal engagement with Digital Comms for ensuring alignment with other existing apps, process and future support arrangements;
- Legal services (via Osborne Clark) for defining the new “Terms of Use” for the APIs. This took longer than expected by the project being a new area for WPD;
- Developer support – app/website design/develop/test/deploy/operate/support;
- Hosting Support – External hosting service for the app, outside the WPD firewalls;
- Penetration Testing Service for security checks;

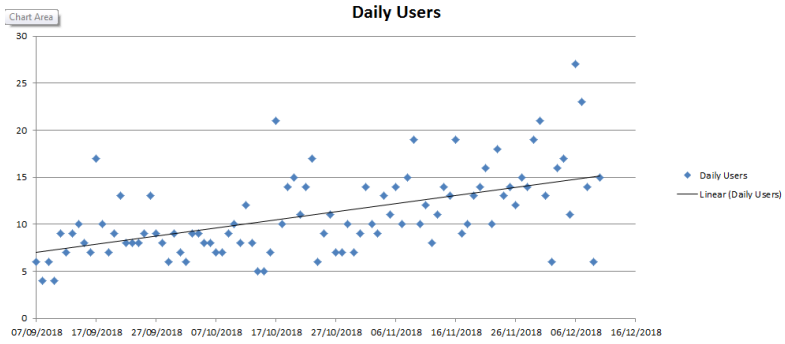
9.2 Carbon Tracer Application – Extended Operations

By continuing the support for the Carbon Tracer application and at the same time extending its capabilities, the Carbon Portal project allowed further insight into this system. The following have been noted (which would not otherwise have become apparent following closure of the earlier Carbon Tracer NIA project):

1. Contact was established with Sheffield Solar (Sheffield University) as part of a wider initiative to conduct mutually beneficial investigations into the two solar modelling approaches adopted by the WPD and Sheffield teams. This involved supporting data exchange and conducting meetings where key findings and approaches to

modelling were shared. This is an ongoing activity at the time of production of this report.

2. Google analytics continued to be monitored to follow user activities in relation to the app and website. While user numbers continued to expand, in terms of downloads, active user numbers appeared to plateau or even shrink slightly through the summer. However, in spite of there being no active marketing (other than the publicity achieved during events in June like the WPD Balancing Act, ENA Networks day and the LCNI in October), there was a sustained growth in active user numbers between October and December. In the absence of there being any specific active marketing campaigns, we can possibly attribute this increase to engaged customers making use of the App to locate the ever scarcer green intervals available as the season progressed and the solar contribution (in particular) shrank.



3. Direct user feedback was rare but a number of enquiries were received from active customers pointing out perceived shortcomings and asking questions.

The all WPD carbon Intensity map display implementation resulted in the following main map display (taken from the website version). This image, in Figure 3, is followed by a further figure (Figure 4) showing the main BSP information screen on which the pop-up shows the new options and behind this the enhanced BSP supply area outline can also be seen.

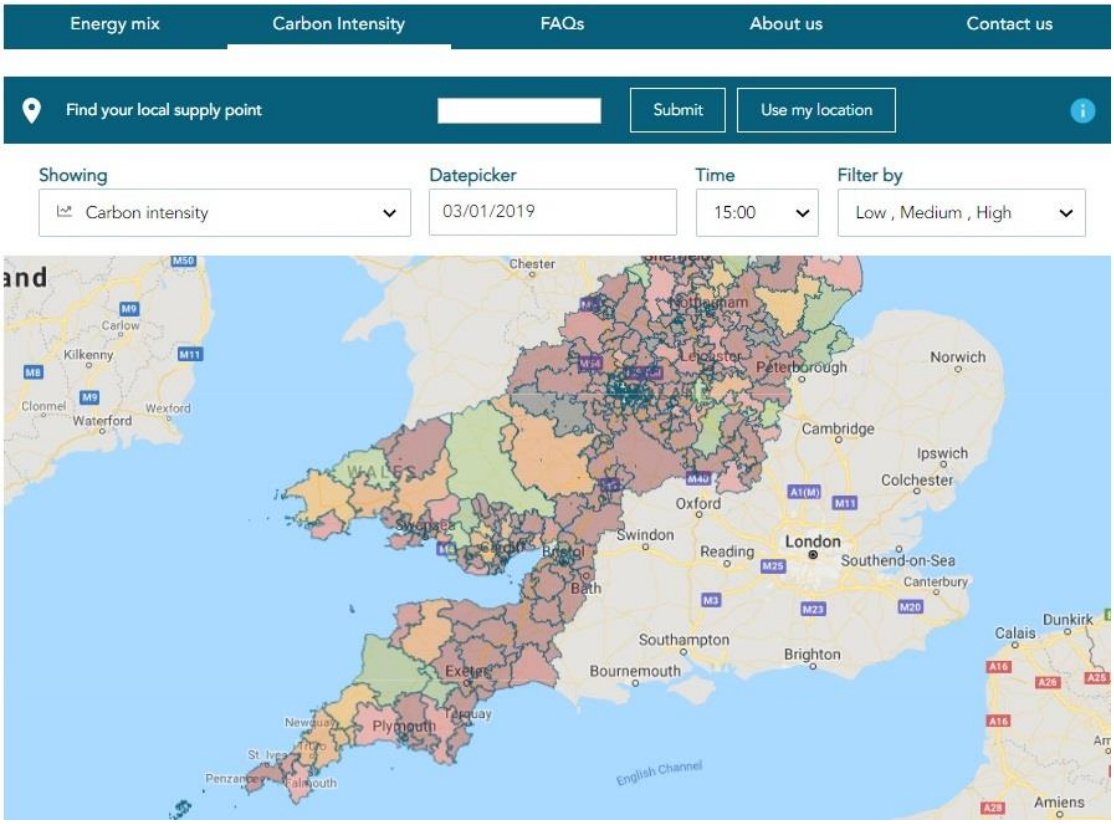


Figure 3 - Carbon Intensity Map Display (Website)

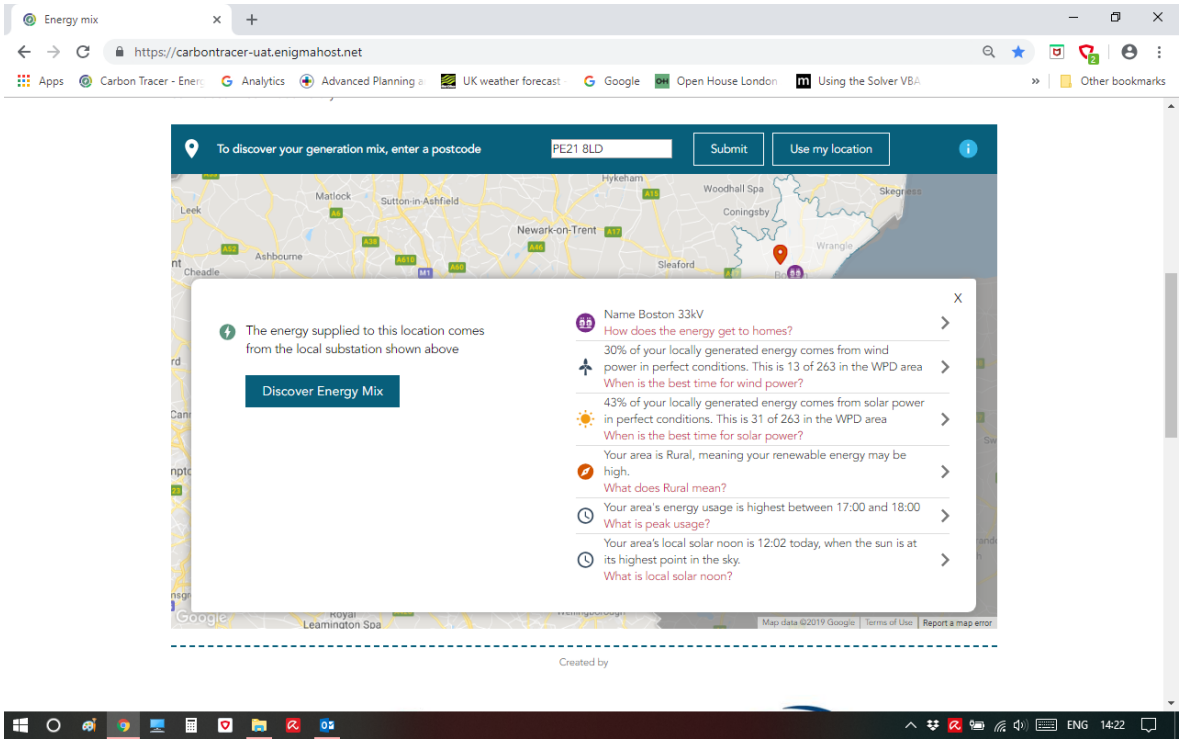


Figure 4 - Expanded BSP Information

10 Data Access Details

When Western Power Distribution gathers significant amounts of data during the execution of innovation projects, our innovation strategy requires us to actively seek to share this data with interested parties, where this is possible and not covered by confidentiality restrictions. Carbon Portal makes the app data available for onward use by third parties who are better placed to leverage such data for the purposes of customer engagement, an area which is certain to be become more important as new innovations like electric vehicles become more popular.

Issues to be resolved to achieve this will include licencing for derived information which uses external data feeds along with resolving the position for other licenced material; hosting mechanisms and access routes (API, bulk download etc.), marketing/publicity of the availability of the data via this new delivery channel, support for third party developers or data users.

The main live app data for the Carbon Tracer is located on hosted servers covered by service contracts with the project service providers (Enigma and Hyve). The animated/derived data which has the instantaneous values available based on the application of computational algorithms is what serves the app and website. There is also the source, static data which is used as the basis of the animated dataset. This is held in CSV/Text file format.

11 Foreground IPR

The project implemented a new API Service routine set and also updated the computational mechanism, which is itself described earlier in this document, for informing customers of the instantaneous carbon intensity of their electricity supply. These functions and the supporting data constitute the main elements of project IPR. The "legal terms of use" explain how third parties may use the WPD API service to create their own Apps and their relationship to WPD IPR. Section 4 of the Terms states the following:

> *4. Intellectual property*
>
> *4.1 The copyright in the material contained in the WPD API, together with the WPD API design, their selection and arrangement, and all software compilations, underlying source code and software (including applets) belongs to us, our subsidiaries or the providers of such information. All rights are reserved. None of this material may be reproduced or redistributed without our written permission.*

4.2 We own the trademark WESTERN POWER DISTRIBUTION. Other product and company names mentioned on the WPD API may be the trademarks of their respective owners. You are not entitled to use the logos and brand names owned by us without our express prior written permission.

12 Planned Implementation

The API Calls, app and website are fully live, so the project was not a trial implementation that would need further work to become a fully rolled out BAU capability. Rather, the project is a proof of concept trial of a customer facing capability in a specific functional area (carbon footprint). It is our intention that the work carried out by the project should facilitate additional customer (and/or internal) apps using learning gained during this project, making such implementations much easier to produce, although the sourcing of the necessary driving data remains a challenge for WPD. The API mechanism means that WPD can limit its participation to the production of the necessary datasets and API infrastructure specific to the data. By making the API calls sufficiently wide in scope and general in nature, this should allow developers to come up with their own innovative app designs.

The issue for app developers will always be the ability to profit from the venture. This is not an option for WPD and some of the terms relating to the underlying data may prevent onward use in future cases. This would need to be investigated as new cases are identified.

WPD will commit to a short update on API usage in around 12 months at the start of 2020.

12.1 Knowledge Required

The main knowledge areas for the project are:

- Algorithm development for app main engine and supporting functions including time / location analysis (for local noon), solar output as function of time and weather, wind output as a function of wind speed, scaling of other forms of generation;
- Familiarity with the location of data sources within the business and how to access and marshal the various contributing elements into a usable dataset for the app;
- app /website design, software development, hosting and support (mainly subcontracted to specialist supplier);
- User ergonomics, user “psychology”, user surveying and feedback processing;
- Marketing, publicity and ongoing support to users;
- Analytics processing and feeding back into app design.

These points may form the basis of a follow on project to look at how app development (with data support) might be productionised / templated.

In particular, the ESA polygons (from another project), and the mechanism for locating a user on the network using these, could become a standard piece of library functionality for other apps/website facilities.

The whole map operation and icon set are also available for re-use.

Data was bespoke created for this project and looked to another project doing strategic studies of the network for the load data, essentially the normalised demand profiles for the BSPs and the maximum demand values for each necessary to scale the normalised demand profiles to actual MW values at each required time/date. However it is readily apparent that this sort of approach is where the extra cost lies with app development and identification of datasets which can support such functionality is important going forward. The issue is that the data is often "derived" after much analysis and is not available in any standard business source repositories. To be truly reusable, the data must be regularly produced in an automated manner and be available for dissemination to interested parties both internally and possibly externally. The difficulty comes with the "special data" which requires analysis to derive it.

One important point concerns the use of a global unique WPD internal system identifier called the Network Reference ID, which is unfortunately not attached to all objects in all data sources. To enable data re-use and save time in lookups (as well as to improve reliability in lookups) the Network Reference ID should be made available everywhere. This piece of work is not insignificant but would certainly pay dividends in the sort of future projects which can be envisaged for the DSO landscape. This one action could genuinely facilitate replication across many areas.

Perhaps the most reusable aspect of the project is the overall approach to app design, rollout and management. Features here include:

- app premise, top level design approach, main screen flows;
- Data sourcing and optimisation, update cycles;
- Lifecycle stages, durations for these and individual responsibilities;
- Preparation for go-live and operations;
- Use of marketing and marketing channels;
- Wireframing, trials and test user feedback;
- Tools for supporting testing;
- Analytics;

- Feedback and user engagement.

13 Other Comments

At the present time we have no information on API use as it has only recently gone live as available to developers. Discussions were held during the implementation with the developers of the Cornwall Local Energy Market with a view to the API providing the details relating to the installed capacities, and also with the producers of the Electricity Map, https://www.electricitymap.org who are currently using the National Grid API service to provide an all UK view of carbon intensity for the country.

Contact

Further details on replicating the project can be made available from the following points of contact:

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Glossary

Abbreviation	Term
BMRS	Balancing Mechanism Reporting Service (Elexon)
CI	Carbon Intensity
CSV	Comma Separated Values. A file format where data elements are separated by commas on each row and structured in multiple rows for each new record. CSV data is easily imported into inspection and analysis programs such as MS EXCEL.
DNO	Distribution Network Operator
DSM	Demand Side Response
EAM	Enterprise Asset Management (system). For WPD this is CROWN.
ESA	Electricity Supply Area. BSP based in this analysis, each of some 266 ESAs covering the whole of WPD are defined as geographic polygons whose boundary is the limit of the feeders of each BSP/BSP group.
EV	Electric Vehicles
FNT	WPD Future Networks Team
FTP	File Transfer Protocol. A standard file transfer mechanism for managing data exchange between computers over network links (including the Internet).
HH	Half Hour (or Half Hourly) data points, being averages over this interval
LTDS	Long Term Development Strategy
NIA	Network Innovation Allowance
PowerON	Power on (Fusion), the WPD NMS system and also referred to sometimes as PoF.
RAG	Red/Amber/Green traffic light visualisation method
SCADA	Supervisory Control And Data Acquisition. Systems for remote monitoring and control operations via communications channel via which analogue values are returned from the remote sites to the centre (PowerON).
VBA	Visual Basic for applications, Embedded Excel programming language
WPD	Western Power Distribution

Reference Documents

1. Carbon Tracer Background Research (CT). Version 2.
2. Carbon Tracer Requirements Specification (WPD). Requirements Specification V2.2 dated 4/7/2017
3. Carbon Tracer Functional Specification (Enigma)
4. The Equation of Time corrections in UKHO Publication AIS 58 are from HMNAO, UKHO (UK Hydrographic Office).
5. UK Department for Business, Energy and Industrial Strategy, Fuel Mix Disclosure Data Table. (The information constitutes the 'fuel mix disclosure data table' as defined in The Electricity (Fuel Mix Disclosure) Regulations 2005. The data are for the disclosure period 01/04/2015 – 31/03/2016).
6. The solar radiation model used is solrad (version 1.2), A solar position and radiation calculator for Microsoft Excel/VBA implemented by Greg Pelletier of Washington State Department of Ecology, Olympia, WA. (With permission of the author).
7. The Regen reports are named "Distributed generation and demand study Technology growth scenarios to 2030". There are now 4 of these reports, 1 for each licence area.
8. The corresponding WPD report to [7] is called "Shaping Subtransmission to 2030". There is also one for each licence area. All the reports can be found on the WPD website.
9. Carbon Portal, Tracer Enhancements Functional Specification (Release 2) WPD_CarbonTracerapp_Phase2_Functional_Specification v1.2.pdf
10. Carbon Portal, Tracer Enhancements Functional Specification (Release 3)
11. Carbon Portal API services set (Apiary definition).
12. Carbon Tracer Project, Final Report Version 3.2 July 2018.