WESTERN POWER DISTRIBUTION
INNOVATION

NEXT GENERATION NETWORKS

Project Entire

PROJECT SYSTEMS REPORT

Report Title	:	PROJECT ENTIRE PROJECT SYSTEMS REPORT
Report Status	:	FINAL
Project Reference:		WPD_NIA_017
Date	:	17.05.2019

Document Control	Name	Date
Prepared by:	Gary Swandells	24.04.2019
Reviewed by:	Jenny Woodruff	17.05.2019
Approved by:	Matt Watson	17.05.2019

Revision History Date	Issue	Status
17.05.2019	1.1	Final

Contents

Executive Summary

The Entire project aimed to demonstrate the commercial viability of flexibility services for both the Distribution Network Operator (DNO) and the service provider. Building on learning from the FALCON and SYNC projects, the project looked to develop DNO services that could sit alongside existing Electricity System Operator (ESO) services and allow participants to stack revenues, easing access to the service.

As part of the trial significant system development was required. The systems were broadly split into two: new systems and integrations into the wider DNO systems.

The requirements for the new systems were tendered out and won by Kiwi Power through their Collar system. This covered the declaration of availability, the ability to accept it, dispatch, metering and settlement. The scope of this work shifted significantly following the project review.

In addition a wide range of integrations and additional systems were required such as the development of a website, the use of a customer relationship management tool, operations support tools, links to the Network Management System, contract management tools and processes for the payment of participants.

Finally the investigation of various data sources was also carried out to maximise the value added to the project.

Each of these systems aimed to deliver project learning at minimal cost to the customer. As such many will need further development as the learning rolls out. In addition, the learning generated by the project will help specify improvements where required.

1 Project Background

Previous trials have shown the technical potential for Demand Side Response (DSR) services to provide value to DNOs. However, the roll out of such services has been limited by the commercial complexities of doing so. These are primarily focussed on the challenges customers face when attempting to stack multiple revenue streams. As such project Entire focussed on the development of a simple commercial framework that makes services easily stackable in order to widen the potential market and make the utilisation of DSR as part of Business as Usual (BaU) more viable.

In order to deliver such a framework, the project delivered a wide range of supporting measures such as:

- Network use case development
- Investigations into underlying networks
- Operational system and process development
- Product development
- Stakeholder engagement
- Participant recruitment
- Operational trials

This report focusses on the systems required to deliver a workable DSR service from both a DNO but also a participant perspective. The focus remained on developing simple, user friendly processes to make participation and operation of the service as easy and low cost as possible. This was balanced against the requirement to deliver learning in the most cost-effective manner.

Further reports detailing the service designed, the participant recruitment, the results of the operational trials, as well as the project closedown are also available.

The systems required have been split broadly into three categories:

- Core systems: these are the systems developed purely for the project and are focussed on the Collar software developed by Kiwi Power
- Additional systems and integrations: these facilitate the interactions between the new core systems and existing business processes such as the network management system, payment systems or contract management systems.
- Data: these investigations focussed on ensuring the data behind the other systems was as up to date as possible, ensuring decisions could be made on the best information possible

1.1 Project Review

The initial project focussed on delivering the simplest customer offering alongside the largest value. As such, alongside the Western Power Distribution (WPD) constraint management zone offering (aimed at existing market participants), the intention was to offer a fully managed service, aimed at bringing new entrants into the DSR market. This service would install control equipment in customer premises as well as provide additional value through Triad management and providing Short Term Operating Reserve (STOR) services to National Grid, demonstrating the ability to stack the services.

By utilising the customer trust in the WPD brand, and the accountability associated with a regulated business, the aim was also to widen the pool of potential participants, boosting the volume available to WPD for the management of network constraints.
However following discussions with Ofgem this element of the trial was de-scoped as Ofgem did not consider the model in which DNO acts as a commercial operator as being in the long-term interest of customers. As such the project was redesigned to focus on the delivery of the core WPD network management service. This impacted the services offered, the systems built as well as the customer engagement process. In addition, the project was shortened to a single operational season to ensure that any learning was delivered as quickly as possible and at the lowest cost.

2 Core systems

2.1 Initial system requirements

The initial scope was developed in order to achieve the objectives and build on learning from Project FALCON[1]. There were a few key outcomes that contributed to the initial scope:

- Participants have limited resources to dedicate to the set up and ongoing management of DSR services as for most it is a distraction from their core activities.
- Participants come from diverse backgrounds, offering flexibility from a variety of asset types. They can also include directly contracted companies as well as those that are managed on behalf of a third party such as an aggregator or energy supplier.
- The inability to stack revenues from different programmes was largely due to contractual exclusivities from National Grid rather than insurmountable operational conditions. This market barrier inadvertently creates a major issue for DNOs seeking to acquire participants and to participants.
- DNO services are geographically sensitive and on the lower voltage networks there are generally insufficient participants available to offer a reliable service or one that provides an appropriate level of response capacity.
- Reliability significantly increases with the amount of notice that is offered to participants. Moving to week-ahead notifications from a dynamic dispatch with just 30 minutes notice demonstrated an improvement in the reliability factor from 66.3% to 96.3%.

In response to the learning previously achieved there were some fundamental principles to the services that determined what the systems capabilities required to encompass.

Simplicity – Participants expressed concerns that due to multiple services in the marketplace with differing requirements they found the opportunities hard to navigate and potentially placed too high a burden on the business to commission their systems to be compatible with the DSR programmes and then the ongoing management of contracts. Some addressed these concerns already through the employment of an Aggregator to manage this for them, while others who didn't wish to engage a third party just refrain from offering flexibility. In response to this the Flexible Power service should be equally accessible to direct providers and aggregators, but that it should be simple to set up and administer so as to keep the barriers to entry very low.

Simplicity, in terms of the ongoing operation of the services was largely in reference to making the systems easily accessible, intuitive and where feasible automate processes to ensure that they weren't increasing the burden on staff to manage.

Versatile architecture – Participants have a range of control systems and end points to integrate with. The system architecture needed to be robust and versatile enough to

[1] https://www.westernpower.co.uk/docs/Innovation/Closed-projects/FALCON/Commercial-Trials.aspx

allow participation to the widest possible group of participants. This must also be done is a low cost manner. The nature of participants could include independent asset owners, asset owners using an aggregator or an aggregator with unnamed sites located within a zone, and the systems would need to have the capability to support all options.

Non-exclusivity – The contracts that would be offered to participants would not contain any terms that would unnecessarily preclude them for other commercial activities with their sites. This would have to extend to the baselining methodology to ensure that this didn't create any precedents that inadvertently compromised the ability to operate in multiple opportunities.

Response from lower voltage levels than where the constraint occurs – Learning from project FALCON the system aimed to dispatch flexibility at voltage levels below the electrical constraint. This allowed for larger liquidity and reduced over reliance on single larger assets. Systems therefore need to be able to aggregate multiple sites and consider how these can be easily operated in concert by the existing control room.

Security – Finally, and as a significant area of new learning it was recognised that in order to offer a system that could meet the other capabilities, we would be designing something that has a live downstream connection to participants and upstream connections to the DNO control room and other programme operators and therefore Cyber Security would be a major issue. In the prior FALCON trial, the dispatches were sent initially by phone and subsequently by email which provided a week-ahead schedule of demand reduction requirements. It also used conventional metering methods for data collection, providing event data 24hr after. This would be insufficient and therefore we would require establishing and specify new standards to support cloud infrastructure.

2.2 System Procurement

In order to develop the full potential of DSR services the original project scope intended the enrolment within multiple programmes to simplify the proposition to participants. The systems that WPD proposed would therefore have to reflect the various technical and contractual requirements for each programme (minimum capacity, metering standards, response times, etc.) This would demand that monitoring be available with updates polled on a maximum interval of '1 minute' up to a live real time data feed. As service capabilities develop in the future, which may include frequency-based propositions then additional functionality could include additional sensors for electricity frequency.

To simplify the procurement specification the system requirements were separated into three lots. These were:

A. '**Outstation'**: a site-based device, installed at participating DSR premises. This acts as an interface between the site and the central control facility at WPD. Its primary function is to offer a site-based device that will interact between the site assets that can be diverse in type, method of control and capability. It does not supersede the local controls and limited in its range of instructions, such as start and cease DSR event delivery. It does however need to collect a wide range of status signals and relay them quickly and reliably to the Central Control Facility.

B. **'Central Control system':** enables the monitoring, dispatch and aggregation of multiple assets to participate in DSR services including those run by external organisations including National Grid. It communicates downstream with the 'Outstations' to monitor the remote site statuses and then aggregate individual sites into groups. The aggregated group information can then be relayed to external DSR programme operators by whatever communications standards they require.

C. **'Back Office system'**: takes the operational data from aggregated groups and individual sites to determine performance results and produce statements that can be used for financial settlement. In order to do this, it's necessary to measure performance of individual sites against contracted standards as well as disaggregate the financial apportioning of benefits from groups. The system also needs to audit and validate payments from external DSR programmes for which it's responsible for managing.

The tender respondents were required to offer a complete solution with consortia bids acceptable.

Figure 1 sets out the overall function of the whole system and how the components described in each of the three LOTS interact with each other as well as the third parties outside. These are shown on the diagram within the orange dashed lines.

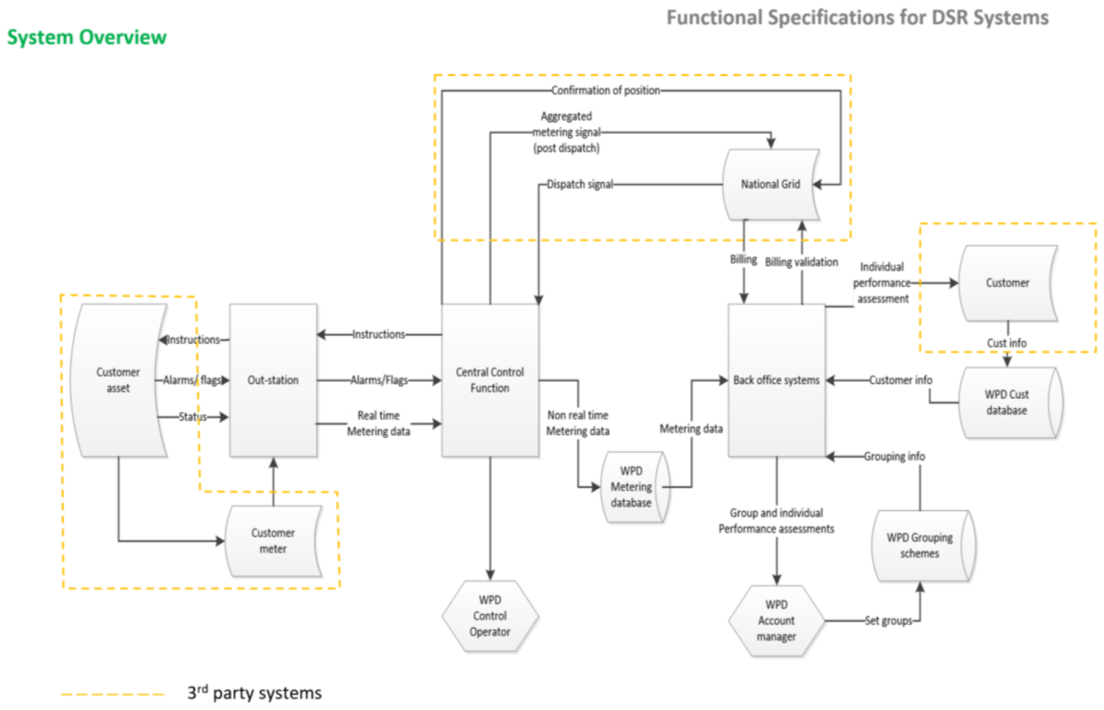


Figure 1 – High Level Design for initial system architecture

Full details of the specifications of each Lot and the nature of the request to bidders are available in Appendix A

2.2.1 Proposals and Assessment

The tender was managed by WPD's Procurement Team supported by Smart Grid Consultancy (SGC) who developed the overall project plan and the high level system design. The scoring criteria were established in line with WPD's typical structure that included expert representatives from the Information Resources the Future Networks Teams and a subject matter expert from SGC. The process took approximately three months to complete and covered:

- Publishing of notifications of intent to tender and invite expressions of Interest
- Issue of Invitation to Tender
- Notification by candidate of intention to submit a tender
- Submission of 'clarifications / further information requests'
- Issue of responses to 'clarifications / further information requests'
- Receipt of Tender Proposal Submission
- Review and score proposals
- Selection of short list of potential suppliers
- Post tender interview / negotiation meetings
- Publishing of clarifications
- Submission of best and final offer
- Final assessment and selection
- Contract Award

There were a number of bids that offered the potential to fulfil the majority of the requirements set out in the specification and the standard of all the proposals received was very high. Several respondents included suppliers and aggregators who themselves operated commercial services and therefore additional effort was required to ensure that they would be able to build and operate a service that could demonstrably respect the separation of data and potentially privileged knowledge so as to avoid a contractual conflict in conjunction with their respective duties. Following a thorough assessment process the successful submission came from Kiwi Power who already operated a system quite similar to the proposed design in multiple regions including the United Kingdom. The contract to deliver the initial scope was then awarded in early 2017 and a delivery plan was commenced with a view to have a service initially operational for the start of the Triad season in the final quarter of 2017. It was during the early part of the planning phase that the project review was conducted as discussed in section 1.1.

2.3 Impact of the project review

The project review had a significant impact on the system requirements within the trial. This included:

- The removal of the stacked service lowered the potential benefits available from the project. This increased the focus on lowering the costs of participation. As such systems were simplified and automated where possible
- This also shifted the focus to aggregators with multiple assets. This called into the question the initial hardware focus of the outstation and pushed towards a software, API link
- The removal of the managed service removed many of the requirements for asset monitoring

- The new services needed to be added to the systems

2.3.1 Updated Commercial Proposition

With the removal of the external services there was an opportunity to design and test multiple services that could meet different challenges experienced by a DNO. Three new services were identified based on a weekly declaration process with participants declaring capacity by Wednesday at midnight with the DNO accepting or rejecting capacity by 12.00 on the Thursday (see Figure 2). This advanced warning would give participants certainty over revenue and allow them to participate in multiple markets.

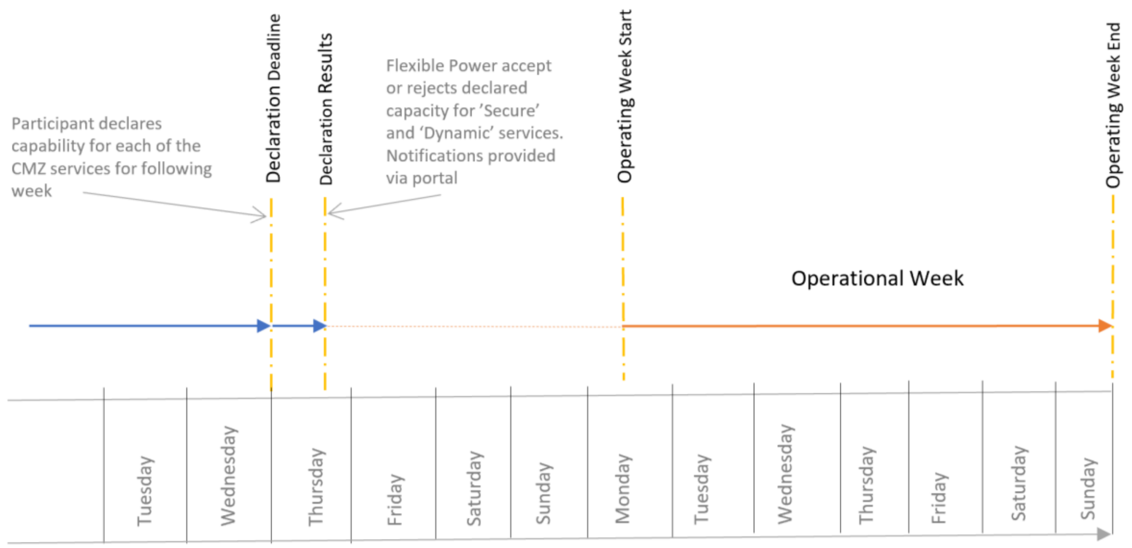


Figure 2 - Declarations and Operational Timescale

The three services were:

1) Secure

The Secure service was used to manage peak demand loading on the network. This service was expected be required on weekday evenings and occur throughout the year due to the seasonal ratings of assets. As the requirements were predictable, Secure requirements were declared each Thursday for the following week (commencing Monday). Payments consisted of an Arming fee which was credited when the service is scheduled and a further utilisation payment awarded on delivery. The week-ahead declarations were scheduled to allow customers to participate in alternative services when not required for the Secure service.

2) Dynamic

The Dynamic service has been developed to support the network during maintenance work. This would generally occur during British Summer Time. As the service would be required following a network fault, it consisted of an Availability and Utilisation fee. By accepting an Availability fee, participants were expected to be ready to respond to Utilisation calls within 15 minutes. Dynamic availability windows are declared each Thursday for the following week (commencing Monday). The week-ahead declarations are scheduled to allow customers to participate in alternative services when not required for the Dynamic service.

3) Restore

The Restore service was intended to support the network or help restoration in the occurrence of rare faults. Such events are rare and offer no warning as they depend on failure of equipment. Under such circumstances, response can be used to reduce the stress on the network. As the requirement is inherently unpredictable, Restore was based on a premium 'utilisation only' service. This would reward response that aids network restoration, but would pay no arming or availability fees. Participants declared available for the Restore service would be expected to respond to any utilisation calls within 15 minutes and receive an associated utilisation fee.

These services are summarised in Table 1

Table 1: Flexible Power Services Summary

	Secure	Dynamic	Restore
Advance Payment	Arming	Availability	None
Utilisation Payment	Medium	High	Premium
Customer declaration	Week Ahead	Week Ahead	Week Ahead
FP Accept / Reject	Week Ahead	Week Ahead	Auto- Accept
Dispatch Notice	Week Ahead	15 minutes	15 Minutes
Seasonal Requirement	All	Summer	All
Generation	✓	✓	✓
Load Reduction	✓	✓	✓

2.4 Updated System Design

Following the review and the updated service proposition a revised design was developed with a new system architecture in order to fulfil the criteria set out for the new service capabilities. The new architecture was based on a cloud based system that required minimal hardware to be installed at either the participants' site or in the WPD Control Room (see Figure 3).

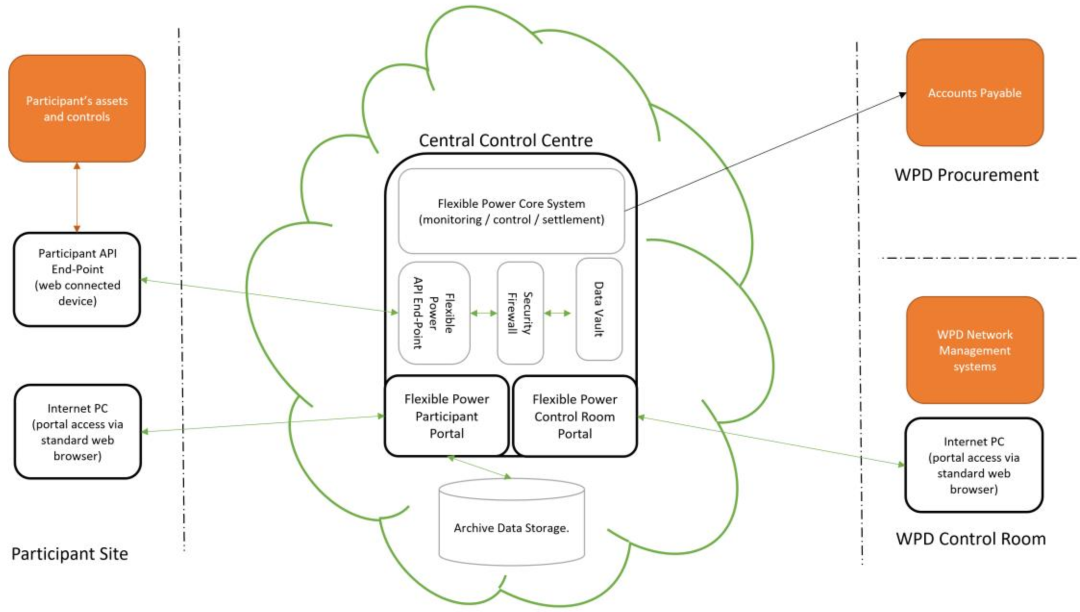


Figure 3 - Revised architecture for re-scoping

From a technical perspective the cloud computing approach enabled a lower cost and agile deployment approach. This type of software development helped ensure a versatile system that can adopt many different standards and even offer a hardware independent option for participants to connect through an Application Programme Interface (API) using a web connected device that could cost a few hundred pounds using simple devices such as a Raspberry pi or basic computers. Interaction with participants would be primarily facilitated through the use of a 'Customer web Portal' that would enable a host of self-service functions, ranging from set-up and testing through to declarations and paperless billing. Similarly, this would decrease the need for any bespoke monitoring equipment to be developed for the control room. The same technology would enable the control room to access participant declarations, as well as manage and monitor DSR events. The Control Room portal would adopt the same web based format with screens tailored to the functionality that would be required and this could be accessed using a low cost internet connected PC that would be designated as the 'Control Console'

The revised system specification included a host of rules base automation that would automatically accept or reject declarations in the event that users or operators fail to update systems during the specific time frames set out for processing DSR declarations or events. When events have taken place, tailored performance reports and statements would be automatically generated and published to each participant's portal and ultimately culminate in automated settlement and payments processes.

In the following sections we will be focussing on the process of the build that developed in conjunction with Kiwi Power with the Programme Management fulfilled by SGC. To assist with the comparison to the initial system design and its components we will adopt a similar structure (Table 2).

Table 2: System components

LOT	Original	Revised
(A)	Outstation	Participant Site

(B)	Central Control	Core System
(C)	Back Office	Data Vault

2.4.1 Participant Site

The site could be that which has the asset(s) located at it or alternatively an aggregator's central control if they are managing sites on behalf of their customers and already have their own capability to remotely monitor and manage third-party assets. For connecting assets to the system, participants were offered two options.

- **API interface**[2] – Option 1 and the preferred route moving forward. This sought to avoid dependencies upon any dedicated or specialised hardware that would typically be used for any other DSR Programmes. An API interface could be achieved with a wide variety of low cost hardware including a PC with an internet connection. The API did not demand a specific type of connection to the asset and could be authored using one of several different scripting languages which should make it versatile and able to be tailored to the skills and preferred technology that participants are most comfortable with. The prospect of a software interface could raise concerns about establishing vulnerabilities to the wider IT network but this was be easily addressed. The device designated as the API endpoint on the participants side didn't have to sit on a wider corporate network as long as it had internet access. Even where internet access was facilitated via the corporate systems there were many measures that could be used to ensure there was adequate protection including placing it behind the network firewall. In addition, it was possible for Flexible Power to specify the IP range for the endpoint at the central system. The communications could be secured with Secure Sockets Layer (SSL) certificates, but ultimately the signals being carried by the API were limited and shouldn't provide any wider access to the networks at either end. Ultimately the security was initially provided through provision of a complex password called an API Key that needed match at both ends, and participants had the ability to change this as often as they wished through the 'self-service setup'. The API acted as a gateway to transfer data and anything that didn't conform to the expected data format was therefore ignored. At the customer site the only instructions that would require an action would be a 15-minute start notice or instruction that a DSR event has ceased. It was then entirely at the discretion of the participant how to interpret the signals and what action to take. While it was possible to integrate this to automatically send a machine instruction directly to a generator or BMS, it was equally acceptable to trigger an email or even flash a light which an individual manually acts upon. The upload of the metering signals was sent at 1 minute intervals to the 'central control end point' which utilised the same API key principal to identify and verify the data being received. If for any reason there is an issue with the data continuity it was possible to resend a batch of data to rectify inconsistencies. The metering source could be directly from generator assets, battery control systems, BMS or an additional metering device at the point of

[2] A guide on how to build and test the Application Programme Interface (API). https://www.flexiblepower.co.uk/downloads/46

supply, providing it is accurate and capable of 1-minute granularity. This API signals are summarised in Table 3.

Table 3: API data summary

Data	Participant	Flexible Power
1 min metering	send	receive
Emergency Opt-out	send	receive
Start	receive	send
Stop	receive	send

- **Outstation / Hardware Interface –** As the API was a very new concept for communicating with Participants it was determined that a second option in the form of a hardware interface should also be developed to ensure that restrictions were not placed upon potential participants that prevent them accessing the opportunity. Kiwi Power had a low cost site interface already developed called the Fruit and therefore a specification was created based upon its capabilities and the requirements of the trial. The small standalone device would still communicate with the central control system via the same API and wouldn't require any additional development at the central control also ensuring no added cost or complexity to communicate with multiple communications protocols. The signals that need to be transferred are the same as those with the API Interface. The outstation itself would then offer the flexibility of options of how to interface with the participants systems. The potential interfacing options are listed in Table 4.

Table 4: Fruit interface options

Interface Name	Connection and Type	Number	Input/Output from Main Processor	Protocols Understood / Spoken
Relay	Single-Pole Double-Throw, Screw Terminal	2	Output	Switches Pole when energised
Pulse Input	24-240V, Dry, Optoisolated, Two Wire, Screw Terminal	3	Input	Counts Pulses within a given period, Measures time between pulses
Door Contact (General Purpose In/Out)	Wet, Optoisolated, Two Wire, Screw Terminal	1	Input	Records 'high' or 'low'
RS232	Screw Terminal (TX, RX, GND)	1	Input/Output	MODBUS, Serial ASCII
RS485	Screw Terminal (A+, B-, GND)	1	Input/Output	MODBUS
Ethernet (Electric Imp)	RJ45	1	Governed by Electric Imp	Governed by Electric Imp (WAN Internet Connection)
Ethernet (Local)	RJ45	1	Input/Outp	MODBUS TCP/IP

			ut	
BlinkUp	Phototransistor	1	Input	Electric Imp BlinkUp Process
Status LEDs	Multi colour LEDs	2	Output	-
WiFi Antennae Extension	(Unconnected, resistor not populated)	1	-	-
DC Power	12-24VDC, Screw Terminal (+, -)	1	-	-
SPI Bus	Connection between processor and ICs	1	Input/Output	SPI
Micro USB	Non-populated on PCB	1	-	No code to support operation
Serial Communication	Connection between processor and ICs	2	Input/Output	UART
I2C	Connection between processor and add-on segments (See note 1)	2	Input/Output	I2C
On-board WiFi	Printed WiFi Antennae on Board	1	Governed by Electric Imp	Governed by Electric Imp (WAN Internet Connection)

Participant Web Portal – Alongside the direct customer interface, a customer portal was also developed. This would establish a process in which both parties could communicate efficiently. Rather than the API based communications this is an exchange of the operational requirements and the financial aspects of the service. In order to avoid onerous processes based around direct phone calls or email it was important a system should manage and automate where possible any interactions.

A self-service setup was necessary to enable participants to undertake the API connections to their own timescales and avoid the need for site visits or scheduled support calls. Similarly, this avoided the cost of WPD having to provide a dedicated resource to connect sites which would result in added costs that would potentially have to be charged back to participants.

The portal design incorporated a diary system that allows a participant to make a week-ahead declaration of all the times during which they are able to make their capacity available. The portal also allowed for participants to adjust their capacity which is essential as the system calculates and automatically update the baseline on a monthly basis. To avoid misuse of any assets, the participant could also define operating parameters such as minimum and maximum run durations that become part of the operating automation rules.

The Declarations process would be automated so that a participant wouldn't have to actively submit their declaration, instead it would be based on time-based triggers. Whatever declaration was present at midnight on a Wednesday would be presented to the control room console for a period of 12 hours, during which they could accept capacity if was likely to assist with constraint issues on the network. If they didn't accept any capacity, then it would be rejected automatically. Any accepted capacity was then published to the participant portal at midday.

Finally, the portal would provide a paperless billing process to generate event reports, financial statements and pre-populated invoices that use time-based triggers for approval. The statements were assumed to be correct and therefore a participant only needs to take action if there is a query, otherwise the settlement and payments process occur seamlessly without any manual intervention.

2.4.2 Core System

The cloud-based system that provided the basis of the participant portal is intrinsically linked to the core system. It used the exact same general infrastructure and differentiates between the functionality offered to users based on sets of permissions. While a participant would be offered the ability to set up sites and make declarations, the control room would see an operator console enabling them to accept declarations and manage the scheduling and dispatch of events. The core system is made up of a few key components that are all cloud hosted.

Interface and Security – The interface for the API communication is covered in the previous section of the document for the 'Participant Site' functionality. The principles for the upstream API were the same as downstream with the same security mechanisms. Security for the participants and control console to log-in was based on using conventional username and password principles. To avoid issues with the third-party access to passwords, the system was initially accessed via a password reset link sent to the email address which doubles up as the username.

Servers are hosted at Amazon Web Services (AWS). This provided the system with their protocols for secure use, including:

- Use of a web gateway and associated security policy to ensure that external devices connected to the web subnet can only use encrypted Hypertext Transfer Protocol Secure (HTTPS).
- Separate subnets and security groups to ensure that only traffic over known ports travel between the web subnet and the back-end subnet.
- Use of a bastion server for developer access, using individual Identify and Access Management (IAM) accounts and temporary access using Amazon Security Token Service. No direct Secure Shell access was permitted.
- Risk of system intrusion was managed by third-party penetration testing, and by careful system design

Applying the above guidelines, user authentication was managed with salted and hashed passwords, login timeouts and HTTPS connections. Authorisation ensures that users only saw data they are entitled to see, and allowed for separation of control functions, which is applied through authorisation user groups. With AWS, the system was deployed across two or more AWS availability zones. Auto-scaling groups allowed the creation of new nodes automatically whenever an existing node failed. Allowing management of both backup and recovery.

Communication between server and browser was carried out over certificate-based HTTPS-only connections. Web services were also HTTPS-only. Cookies were Http only and only used to track unique session IDs with a 30-minute timeout.

The system also used Amazon Route53 for Domain Name Server (DNS), to give the best possible protection in case of a name-server Denial of Service (DDoS) attack. In the event of an attack targeting any system Uniform Resource Locators (URL)s, external Internet Protocol (IP) addresses causing an excess of traffic will be blocked. Third-party penetration testing supports this.

Data Vault – The data vault was the receiving location for the metering data provided by participants. The data was held in an open structure that allowed it to accept different formats in but also extracted for processing event performance, payments and baseline. Data could be overwritten but not without authorisation of an administrator at WPD.

System Logic – The system logic was at the heart of what the Flexible Power system functionality is. The logic represented all the rules and calculations which include managing what users are authorised to see and do, the algorithms that calculate performance and apply the complex payment mechanics and manage event operations. The core logic was created by SGC and them coded by Kiwi Power.

The platform used a variety of open source components. Java Virtual Machine (JVM) based languages were directly supported for service implementations (with the majority of the code being written in Scala), and in addition there was extensive support for Python in the data warehouse and analysis service.

Power data from aggregated sources were sent to the core platform through metering REST APIs. The live data was sent to *Influx*, which is the operational time-series database. The User Interface which is further detailed in the following section, allowed participants to add their capacity declaration and availability. Power and availability data were used by our control algorithms to dispatch.

Data was loaded in the data warehouse - the Vault - at regular intervals. The vault was built on Amazon Redshift, which was stored in a bi-temporal manner allowing changes to be tracked. This provided an environment for analytical reporting and data application support, for investigating historical events. It held all contextual information relating to Flexible Power programmes for example zones, participants and corresponding programme fees as well as the readings and availability. This was the data source of which operational and financial reports were calculated. Data from the Vault via structured queries (SQL) were then processed into charts using Stethoscope which formed part of performance and earning statements.

Graphical User Interface (GUI) - The term GUI is appropriate when looking at the interface with control software, but in reality the 'Operator Console' was a web browser providing a portal access very similar to that of the participant portal. It used the same technology and accessed the same data resources but with different screens reflecting the different activities that an operator requires to carry out. Like the participant portal this included a diary-based system to review the declarations that were locked down at midnight on Wednesday. This diary could only be interacted with to accept and reject for the 12-hour window up until midday Thursday. The diary needed to show the aggregated capacity from all participants within a zone as well as their individual parameters that may limit how they can be used. The trial limited the functionality of accepting declarations from all available participants and for windows where they would all be dispatched for the same duration. The diary therefore had a very similar appearance but due to the different logic relating to the operator, the functionality is very different from participants.

The operator portal also included an additional 'monitoring page' which showed the declared participants and presented the operator with a start and stop buttons against each zone. It also had a live metering signal to provide a feedback loop on the performance of assets during an event. This could be coupled with alerts or alarms to flag to an operator when the DSR event wasn't delivering its expected capacity or experiences a fault such as loss of communications feed.

Overall, the cloud based software approach as opposed to a hardware or Supervisory Control and Data Acquisition (SCADA) systems should reduce the cost of the systems and through its versatility, ensure that it can be continually be adapted to the learning and evolve through continuous improvements.

2.5 System delivered

The completed system met all the objectives that were set out in the design although a number of further functional enhancements that would be required in order to operate a full commercial service.

The main interface for both Participants and WPD Operators was via the web-based portal that was created. This section of the document will therefore share a number of screens that have been captured from the systems to demonstrate the general capabilities of the Flexible Power system.

The Web-based Portal is actually two discreet portals. This was done in order to further the principle of trying to make the Flexible Power system 'self-service' so as to keep the barriers to access as low as possible. The two portals are near identical and are referred to being in different 'environments' The first was called 'UAT' or User Acceptance Testing and provided new participants with a safe environment where they could familiarise themselves with the system, how it operated, and critically setup and test their API. The other in environment was known as 'Production' and was the full live system where all participant interaction took place once they are happy with the level of learning they have completed in UAT.

The initial landing page for all users will be at either

- **UAT** - https://uat.flexiblepowerwpd.co.uk/ or
- **Production** - https://flexiblepowerwpd.co.uk/.

An example is shown in Figure 4.

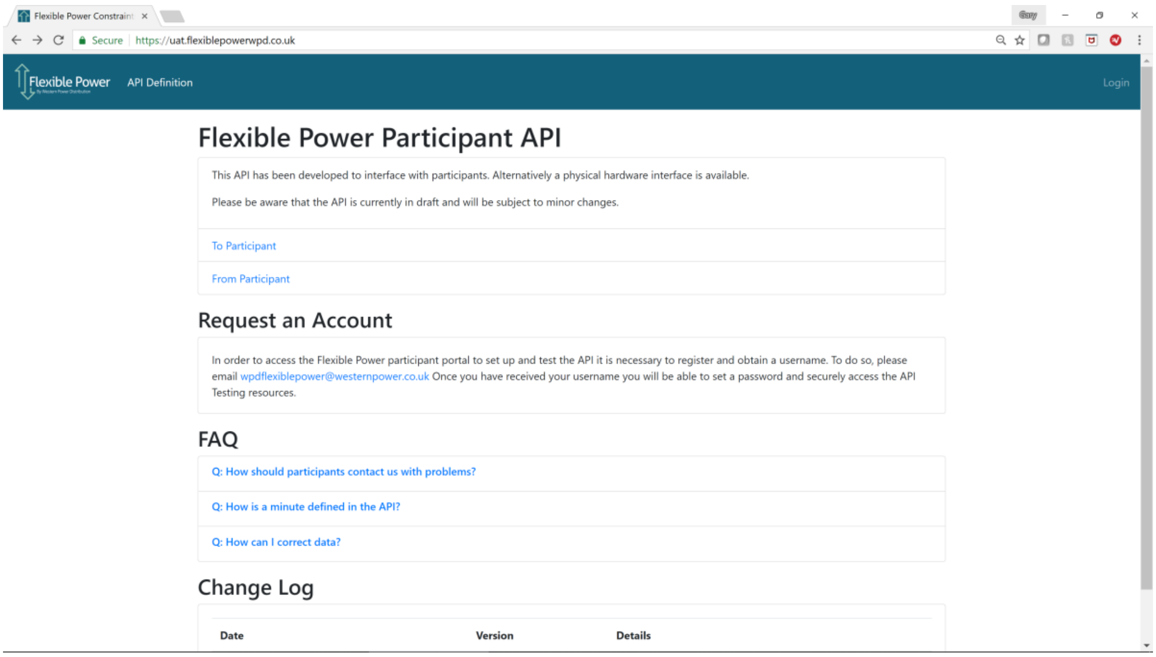


Figure 4 - Initial landing page (UAT)

First time Participants would initially be provided with a user account for the UAT environment.

2.5.1 API

Setting up the API could be done using many types of device or programming languages but applying the same general principles. The participant had the ability to create an URL endpoint wherever they wished and to provide Flexible Power with that virtual address to which instructions can be sent via the internet. Similarly, Flexible Power provided its URL endpoint as a location to which the participant can send their metering outputs.

One of the advantages of REST APIs was that you can use almost any programming language to call the endpoint. The endpoint was simply a resource located on a web server at a specific path. Each programming language has a different way of making web calls. Rather than providing different methods to make web calls in a multitude of different languages such as Java, Python, C++, JavaScript, Ruby, and so on, we are able to show the call using curl. Curl provides a generic, language agnostic way to demonstrate HTTP requests and responses. Users could see the format of the request, including any headers and other parameters. This allowed Flexible Power Participants to translate this into the specific format for the language they're using.

To connect an API an API Token was needed that will both identify the data feed as well as secure the communications. The tokens could be generated as often as the participant requires as shown in Figure 5 using the self-service facility within the portal.

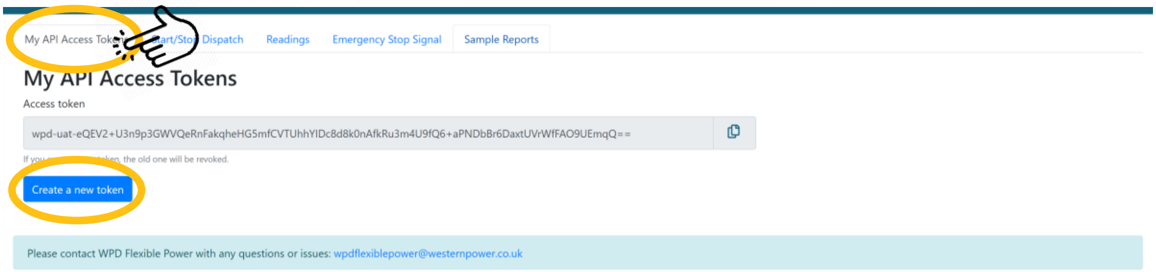


Figure 5 - API Token

In order to let the participant, set up their API metering connection with the Flexible Power system, it provided the facility for them to view the receiving location, which would show the most recent readings via the portal as shown in Figure 6.

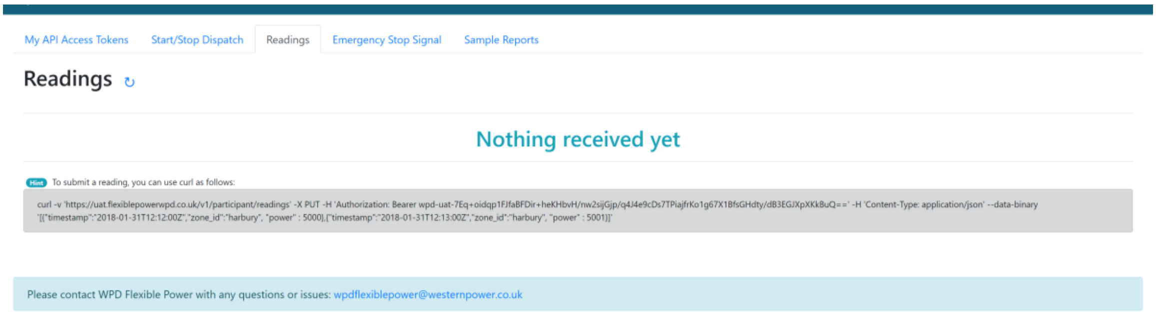


Figure 6: Readings page

A similar facility was provided to enable participants to set up their own API endpoints to receive instructions so that they knew when to start and stop their assets for DSR events. Figure 7 shows the page that provides ability for the participant to specify their URL endpoint, along with details of the service and constraint zone that they have set up on their receiving device. Once this has been set up the participant can trigger the system to issue start and stop instructions until they are satisfied that they have created an effective connection.

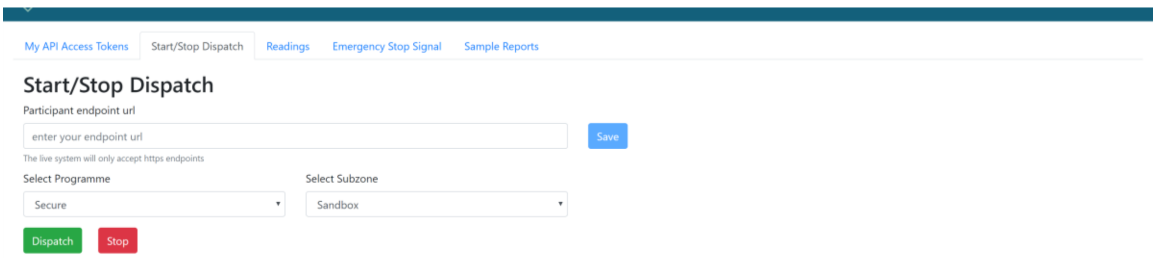


Figure 7 - API instructions

Once an API had been established in UAT the participant is provided with access to the full production environment in with zones activated where they had contracts to provide flexible capacity. Using the experience gained in the UAT environment the participants could then Log-In and generate a new API Key for the fully operational environment and complete the full set-up of their live assets.

2.5.2 Diary based declarations

After establishing an API connection, the basis of most interactions for participants was via the portal to make and check the results of weekly declarations.

UAT was developed with a specialised 'test mode'. Given that the declarations processes work on the basis of time based cut-offs for submitting declarations and receiving the results, the test mode allowed a participant to change the effective date and time to simulate each stage.

The screen in Figure 8 shows the drop-down menu in UAT with a choice of zones in which to carry out practice declarations. In Production this provides a drop down menu of all the geographical zones in which a participants has a contract to provide capacity.

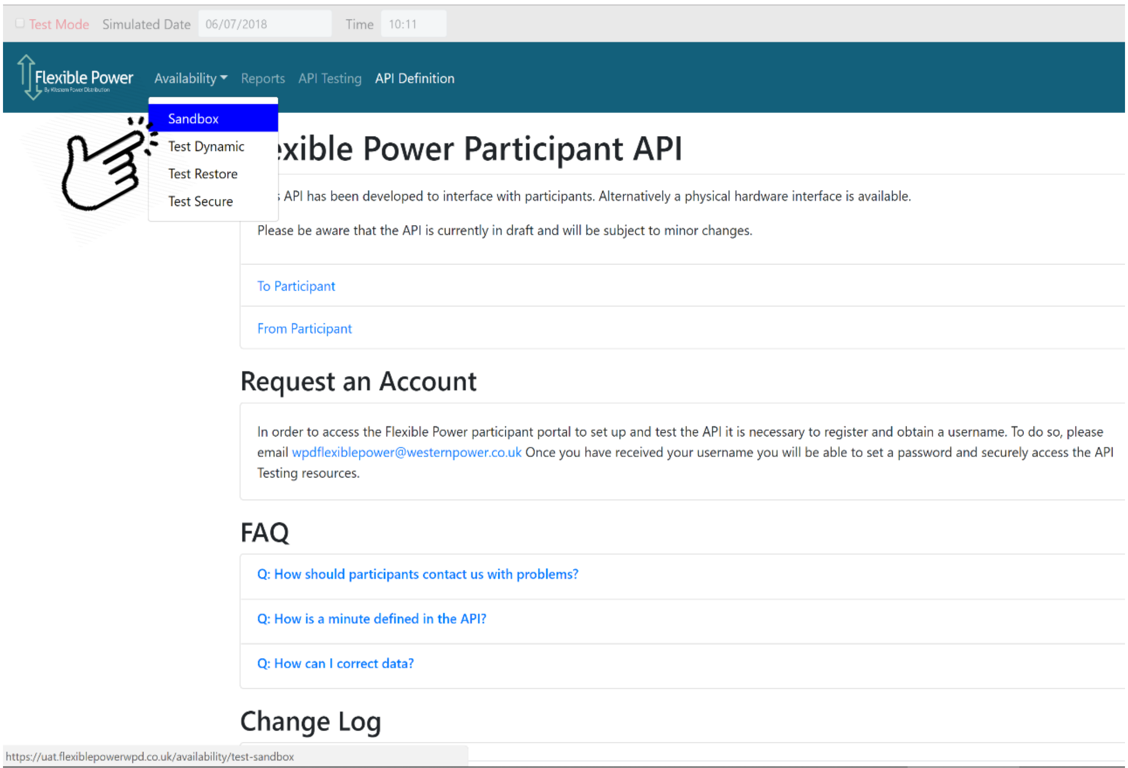


Figure 8 - Selecting Zone to declare Availability.

The diary held a record of a participant's declarations, and the starting point for each week will be the previous week's declaration. In Production the only week that could be edited was the following week from the cut-off at midnight Wednesday (see Figure 9).

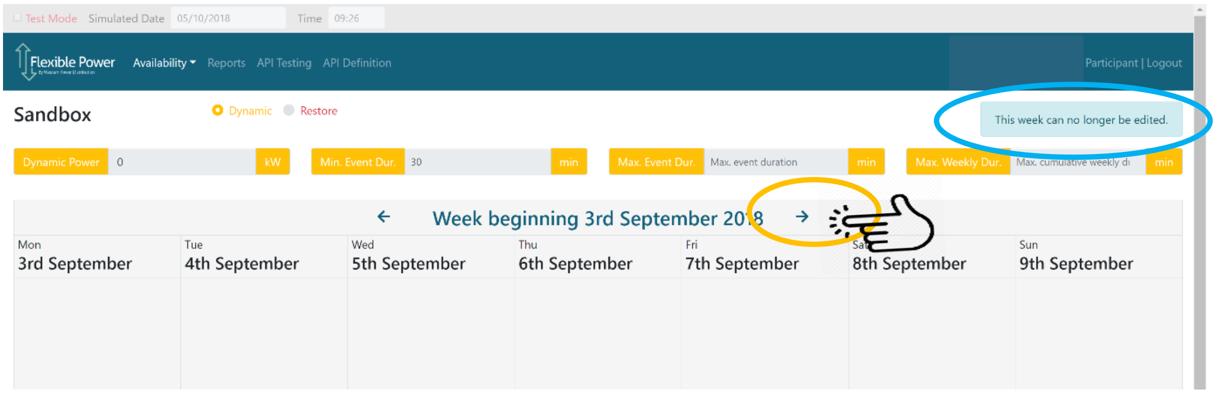


Figure 9 - Diary navigation

Figure 10 highlights the operating limits that could be set by the participant.

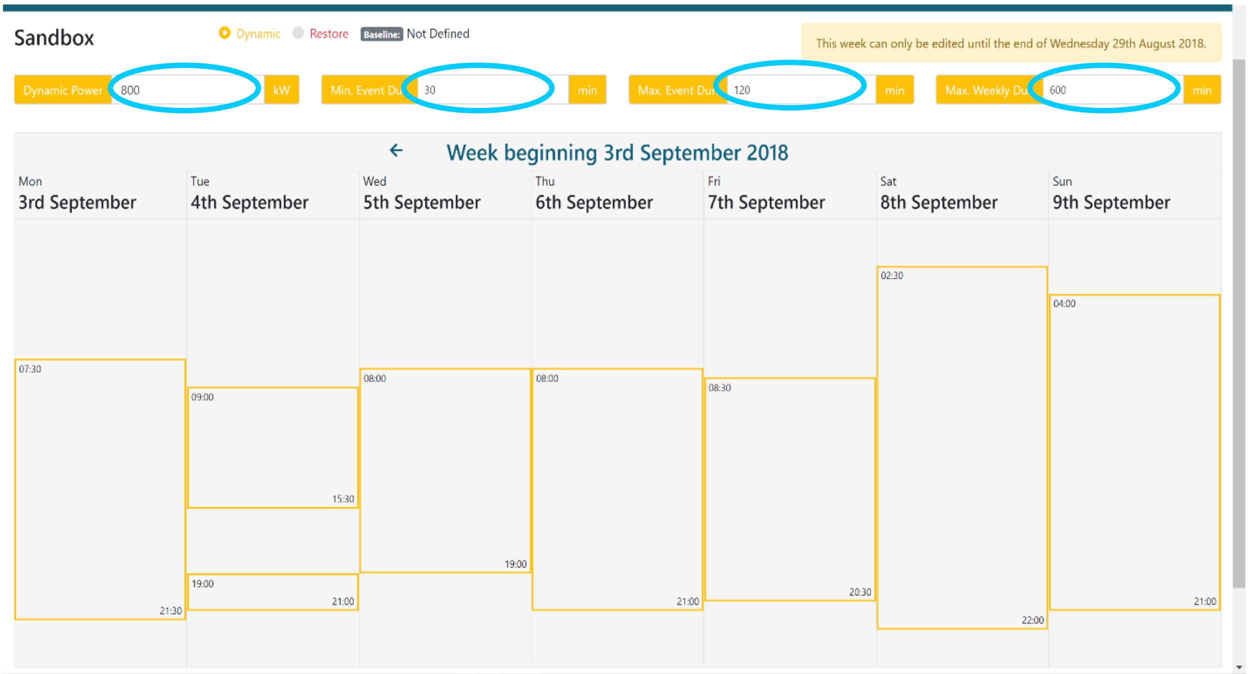


Figure 10 - Operating limits

Accepted declarations would then be highlighted from 12.00 on the Thursday (see Figure 11).

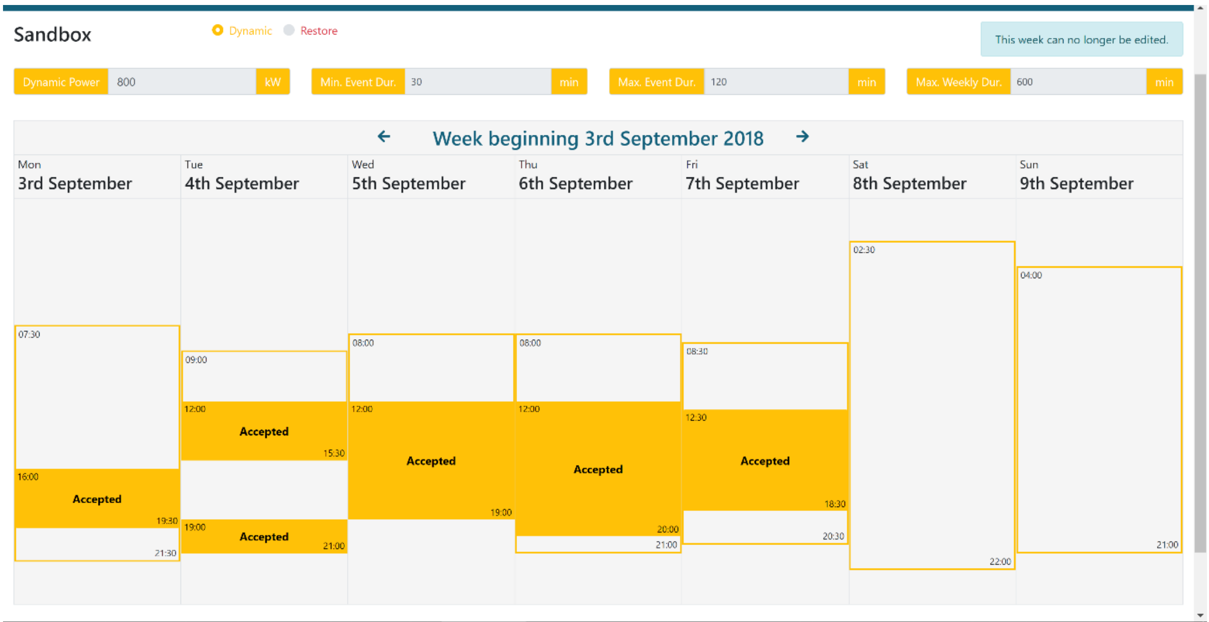


Figure 11 - Acceptance and rejection

2.5.3 Control Room GUI for accepting capacity

The control room operators encountered the same initial log-in page as participant users but were associated with the appropriate view following log-in. The key requirement for Operators was the ability to see the declarations being made by participants and then to interact to accept and reject appropriately.

When an operator wanted to view the diary screen to see what capacity had been declared, it initially looked the same as that for participants. A drop-down menu lists all of the available zones that were open for flexibility recruitment in the same was as a participant would have a drop down for the zones that they have a contract to provide capacity within. The most conspicuous difference between the operator and participant view was the input boxes for capacity and run time limits which were not present (see Figure 12).

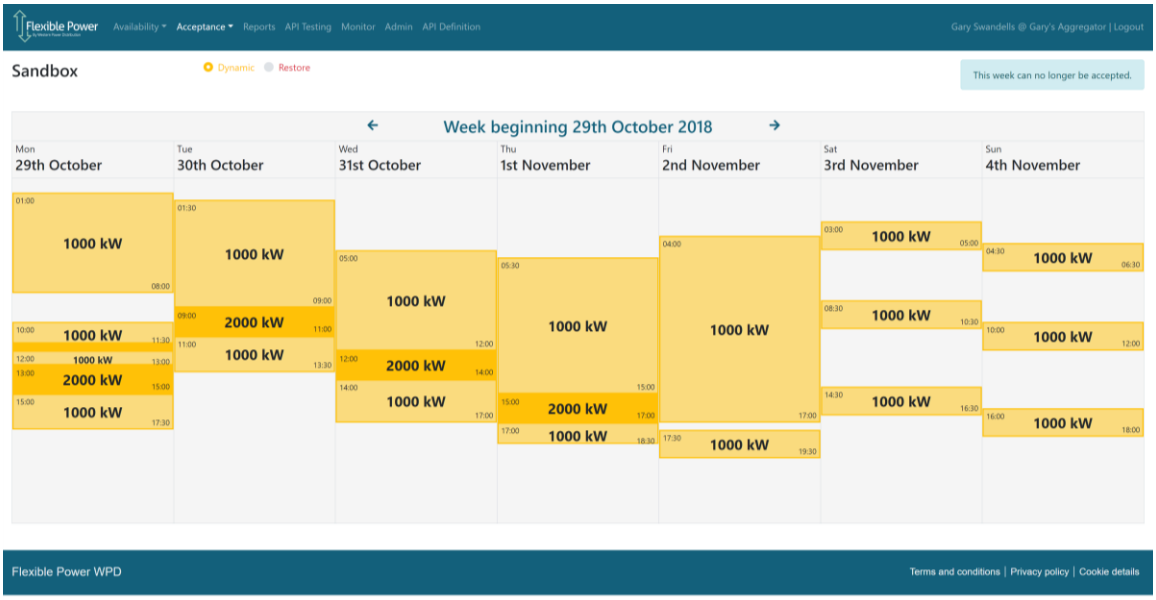


Figure 12 - Operator diary view

Additionally, the time time-based rules around the process meant that, when an operator arrived at the diary at any time outside of the 12-hour acceptance window they would find their interactions very limited. Outside the acceptance window on Thursday, they will see the declarations that represent a composite view of all the capacity offered by all the participants. Unlike the participant view, clicking on the diary isn't associated with an action which allows the operator to input any data. Instead, the operator could roll their cursor over any declared capacity showing on the diary and a breakdown is provided as shown in Figure 13 below.

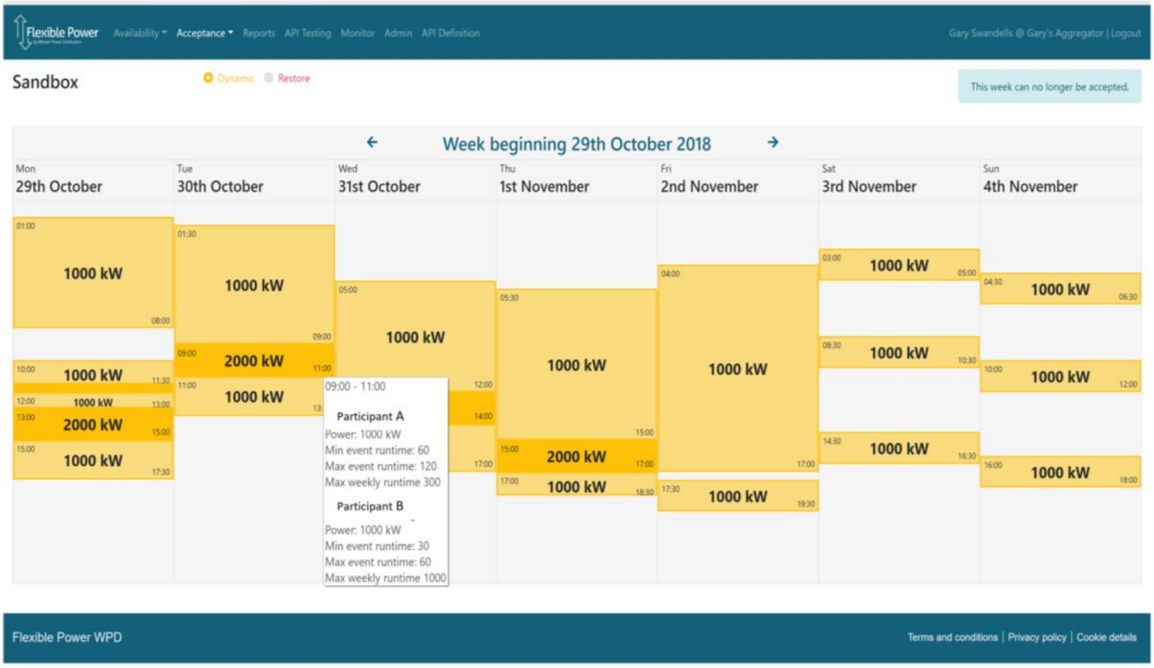


Figure 13 – Declaration parameters visibility

During the weekly acceptances window on Thursday morning there was a brief 12-hour window during which a different interaction was possible, and where operators instead of just viewing declarations could interact with them. During this time, the participant would find that they couldn't interact with their diary, but if the operator clicked on a yellow block of capacity they would receive a pop-up window where they could specify the start and end time for a window. For the 'Secure' service this would be stipulating what capacity was expected to be operational. If it was for a zone with the 'Dynamic' service and it would be possible to accept everything being offered to place it in a holding state where it could be dispatched. For this reason, a shortcut was included that enabled an operator to very quickly 'Accept All Dynamic Declaration' in a blue box at the top of the screen, shown in Figure 14.

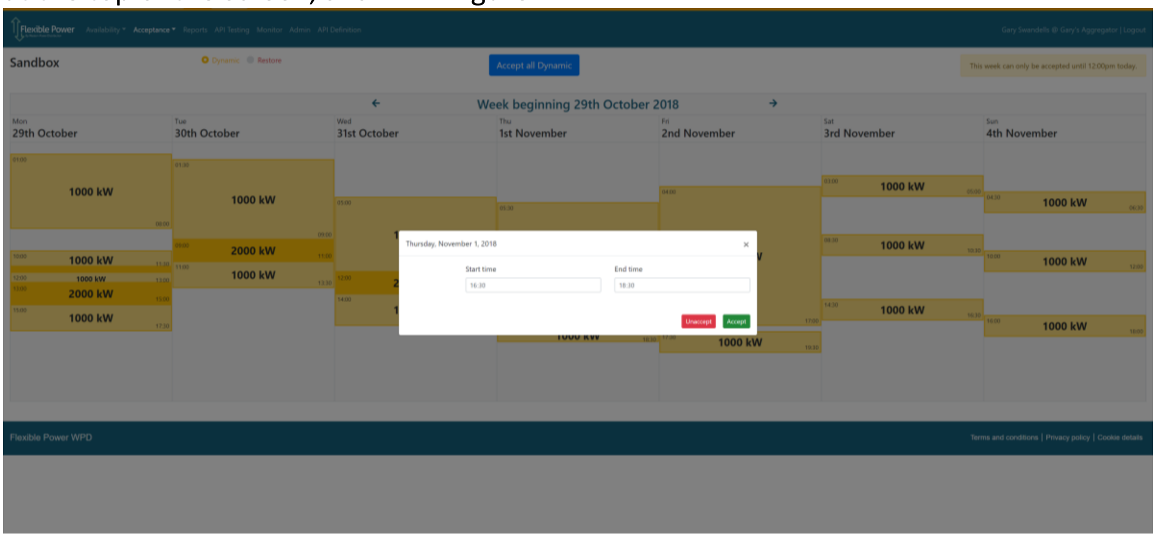


Figure 14 - Accepting capacity

As an operator completed their weekly exercise of reviewing declarations, they could see what they had accepted immediately on the diary screens in the form of grey boxes overlaid on top of the participant's declarations (Figure 15). This could be reviewed and edited as often as the operator wished, and they did not have any facility where they can lock their intended operating scenario or submit these arbitrarily. Instead these relied on a time-based trigger which would automatically contract whatever capacity was shown on the diary view at the end of the 12-hour window, at which time it would no longer be editable and would automatically convey the results to the participant(s) diary screens, as previously show in Figure 11.

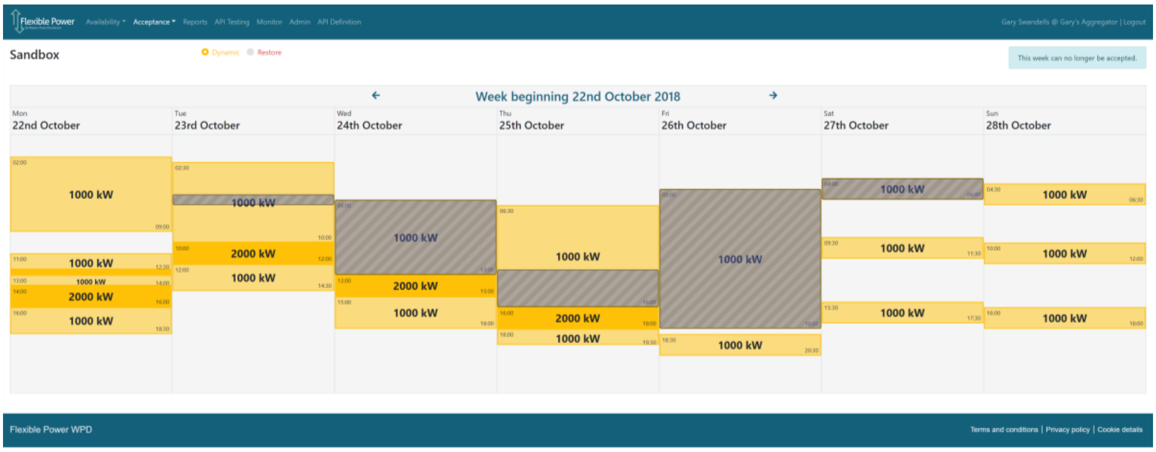


Figure 15 - Operator view of accepted capacity

2.5.4 Control Room GUI for monitoring and event control

The final aspect of the operator GUI relates to the screens provided to allow events to be monitored and dispatched from the Central Control Console. As with the acceptance screens, the functionality was intentionally restricted during the trials as it was known that further development once operational experience had been gathered. As the control console screens could only be accessed and interacted with internally by WPD staff it was possible to manage expectations and the functional limitations of the system

Figure 17 shows the simplicity of the monitoring screen developed for the trial. This was only possible due to the decision to not only accept participants for identical windows, but also extend that to their utilisation within an event. By implementing this policy we were able to create a single dispatch mechanism for a complete zone.

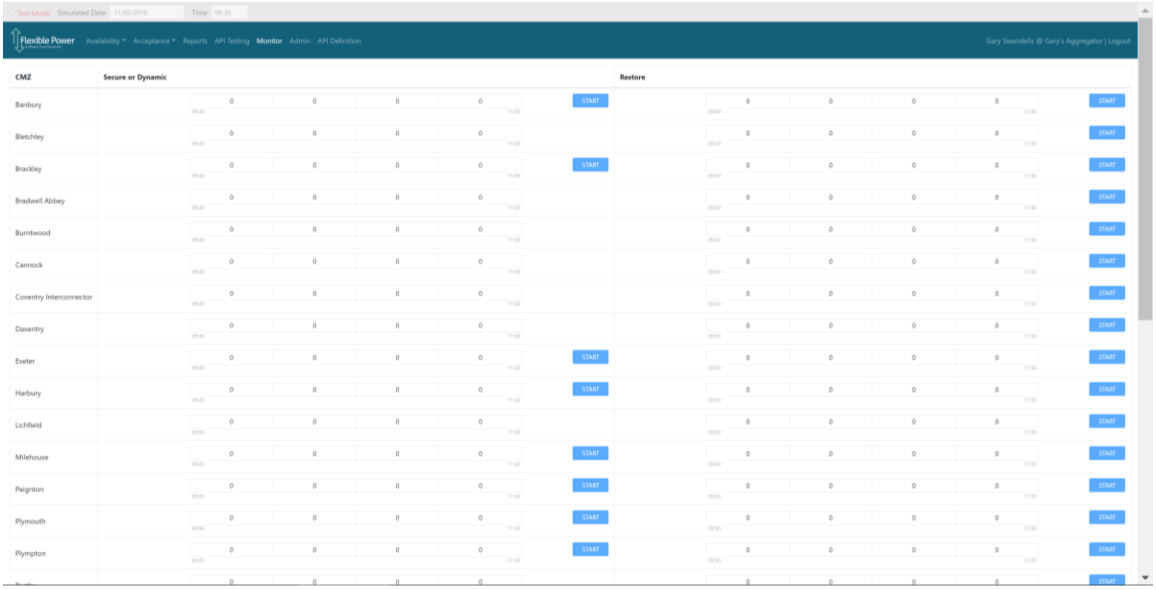


Figure 16 – Monitor screen

Figure 16 also shows that all active zones are listed, and that the first column shows the interaction between the Secure and Dynamic services and that these are mutually exclusive. They were the primary service for each zone and the second column is for the Restore service which is available everywhere. Due to the nature of the Secure service being able to schedule in advance by participants rather than awaiting a dispatch signal from the control room in the event that unexpected conditions occur, the Secure Zones did not require a 'Start' button. The minor vertical columns are to provide a 2-hour rolling forecast in half hour segments as to the available or armed capacity. This was reflected in both the primary services and the Restore service.

While the screens themselves were very simple there is significant complexity behind the system capabilities that were included for the trial. To ensure the participants assets are used appropriately, there was layer of operating logic that was applied without the need for an operator to continue to use the monitor during an event. When a Secure event occurred, the system sent a 15 minute dispatch notification in advance of the scheduled time for the event as well as a cease notification at the end. This would only be sent to participants who had made a declaration and received an arming window. If a Dynamic or Restore event occurred, it would only be triggered when the start button was triggered and it would only be issued to participants who were declared available and could achieve their minimum run duration within the remaining availability window they have declared. When an event was triggered a 15-minute notice was issued and thereafter the system would monitor the operation against the minimum, maximum and weekly maximum run durations. If at any stage these parameters were breached during an event, prior to an operator manually issuing a cease notice, the protection parameters within the system would issue automatically. Similarly, if the operator started an event and then issued a cease prior to the minimum event duration of any participants, it would intercept the cease instruction and delay it until the minimum period had been achieved.

2.5.5 Data Vault and Administration

The Data Vault and administration functions were necessary components of the system in order to ensure it was fully operable for the trials. It was however agreed within the scope of the project that these could be managed by the development team at Kiwi Power rather than developing an interface for WPD to manage directly for the limited number of participants expected during the trial.

There are no screen images for inclusion within the report that show how the administration functions are operated or for the way the system interacts with the data that was received via the API and stored securely within the Data Vault database. The typical Administration functions that we would expect, but not limited to, for transfer internally from development team to WPD would include the ability to;

- Create and delete accounts
- Allocate and edit zones associated with accounts
- Add, edit and delete users within accounts
- Search database by different criteria (location, permissions, account, etc.)
- View, approve and reject batch data received by API and placed in quarantine
- View API endpoint data and error messages
- Send isolated dispatch signals for initial setup and testing
- Edit variables within payments calculations
- Set different payment rates within services / zones
- Clear down any systems error or participants fault warnings
- Clear down any 'emergency withdraw' notices from participants
- Link to 3rd party software such as CRM for managing wider communications requirements

2.5.6 Back Office

As per the previous section, there are limited images that show the reporting systems and logic to reflect the extensive work carried out to create the back-office system. However, the functions that it performs, and the time schedule of the automation associated within the processes can be described. There are visible outputs from the back-office function which extracts data from the vault and processes it to automate most aspects of the settlements process. The outputs generally take the form of reports and invoices provided to participants which are then used to feed into the conventional accounting processes and systems that WPD already use for more conventional payment requirements. The outputs are covered in the following section entitled 'Statements'

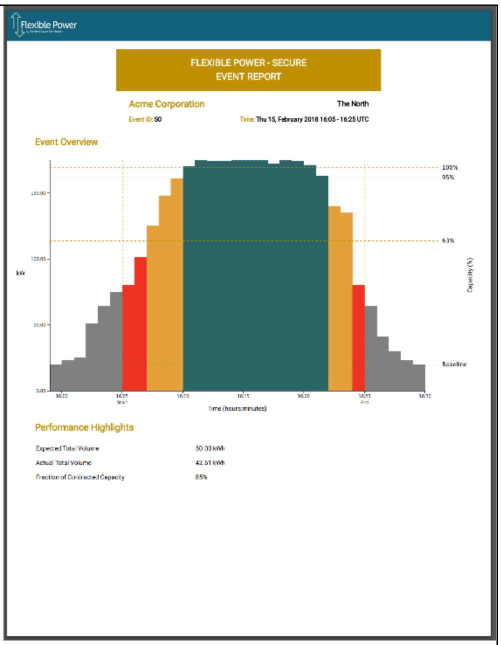
As part of the design process of the three services within the trial was a relatively complex set of payment mechanics, carefully designed to solicit specific types of response from participants that struck a fine balance between incentive and penalty. This was deemed critically important to ensure that participants forecast their reliable capacity with the best possible accuracy and rewarded for providing a good performance during DSR events. But if the penalties are too harsh then participants may not get involved in the first place or abandon a DSR event if they were having any difficulties. The payment mechanics are intended to structure the assessment and payments to address these concerns and provide sufficient incentive to join the program without being unnecessarily complicated so as to be difficult for participants to understand. For more information on the payment mechanics and to understand how these are applied then there are specific documents available.[3]

2.5.7 Settlements processing - Statements & Invoicing

There were three different output documents that were provided to participants in association with their provision of services to Flexible Power;

Event Performance Report[4]

The event performance report was produced immediately following a DSR event. It didn't carry any financial information as its intended audience was the participant's operational staff who were responsible for managing the declarations and assets, etc. associated with Flexible Power. It should provide them with a very quick summary of how well they performed against the expected delivery profile, although the colouring scheme does reflect what is ultimately paid. Grey bars are pre and post event. Green is for each minute at or above 95% delivery. Amber reflects reduced payments and red is where no utilisation is being earned. The performance statements should also contain other relevant data pertaining to the event, such as participant ID, event date, time and total capacity delivered

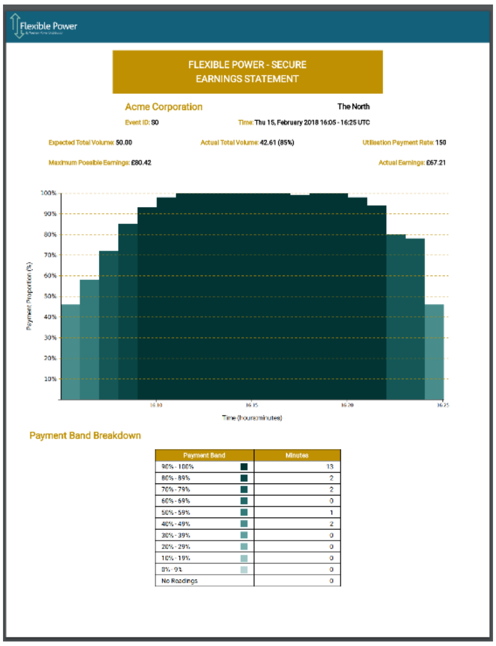


[3]A presentation explaining how the payment mechanisms work. https://www.flexiblepower.co.uk/downloads/52

[4]An example of the performance statement created post a response event. https://www.flexiblepower.co.uk/downloads/64

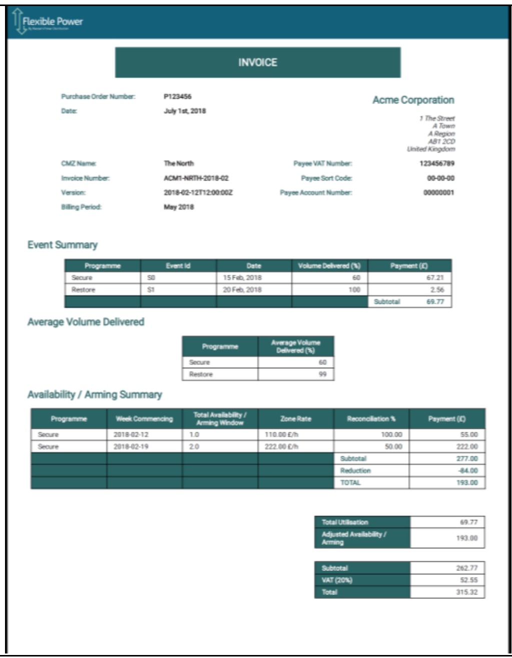
Event Earnings Report[5]

As with the event performance report the event earnings report was created and available shortly after an event has concluded. Again, as with the performance report, the earnings report was developed with a very specific audience in mind. This was likely to be the management of the operational staff or someone with specific financial responsibilities. Within a third party such as an aggregator this could be the accounts department or even an account manager. Their interest was primarily financial and determining what benefit has been achieved, potentially if it can be improved, but also to validate that they are in agreement with the payment they would receive.



Monthly Statement / Invoice

At the end of each month a statement was produced and made available to participants for them to review. It referenced the individual event reports should a participant want detailed breakdowns and any reconciliation applied.
It was prepopulated with all the relevant information for payment purposes so that after approval from the participant it becomes the invoice. Invoices could then be submitted for payment without the need for any further action by the participant.



All of the reports were rendered on-demand using the data contained within the data vault. This prevented any rogue documents circulating and ensures that participants could access an up to date version at any time simply by downloading directly from their portal. If they had an issue with any of the data behind the reports, the API would allow for participants to resubmit any data in a retrospective batch. This would be quarantined until a Flexible Power administrator reviewed, approved and overwrote the record in the data vaults. After this has been completed the revision would be reflected in any future rendering of the reports. This was a vital part of the automated self-billing

[5] An example of the performance statement created post a response event. https://www.flexiblepower.co.uk/downloads/61

process that is outlined in Figure 17. After the monthly statement was created at the end of the month, a participant had up to 14 days to review this in conjunction with the individual event reports. If there are any issues raised the process allowed for a further 14 days to investigate and if necessary revise the data held in the vault and generate new event reports and monthly statement.

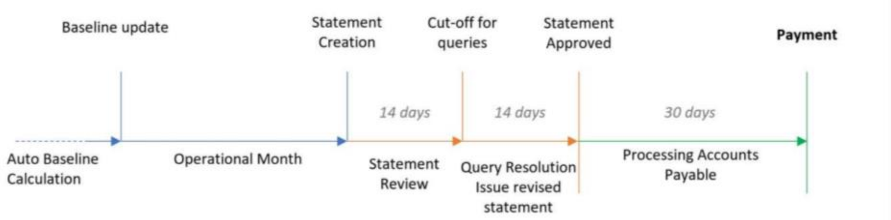


Figure 17 - self-billing automated schedule

At the end of the resolution period, all invoices for that month were then automatically transferred to WPDs accounts department when they were then processed using their regular systems and fulfilling payments on 30 day terms via bank transfer. This whole process was therefore paperless and where interventions were not necessary could be operated automatically within the system.

3 Additional systems and integrations

Alongside the development of the core Collar system, several additional systems and integrations were required. This included the tools needed to facilitate customer recruitment, alongside the direct integrations required to the collar system. These included elements such as processing payments and, or dispatching assets from the main Network Management System (NMS).
The types of integrations are highlighted in Figure 18 below.

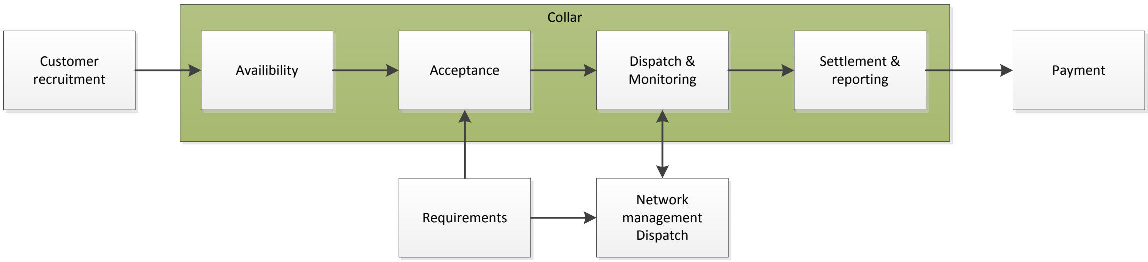


Figure 18: System integrations

3.1 Website

One of the first tools required was the website. This was key to the development of an online presence and the simple transmission of information to and from potential participants.
The detail of the branding design is covered in the Services Report. The key focus of the design was on simplicity and availability of information. This would allow customers to access the information they needed easily as well as reducing the burden on the trial commercial offices.

The website was developed by Solsoft following an initial briefing and amended through the project. Over the course of the project the layout and content of the website changed significantly as the key information to communicate to participants changed, as well as the change in project scope.

The key information to display on the website included is highlighted in Table 5.

Table 5: Website information

Information	How it was displayed
What the services were	Service description
Where they were	Map and postcode checker
What the benefits were	Description and pricing table
How to participate	Process
How to contact us	Email and form
Key documentation	Document library
What Flexible Power was	About Us text

This was originally laid out in a long scrolling website as suggested by Solsoft (see Figure 19). This was then amended to a shorter multipage site to reduce the amount of scrolling needed and to help track usage (see Figure 20).

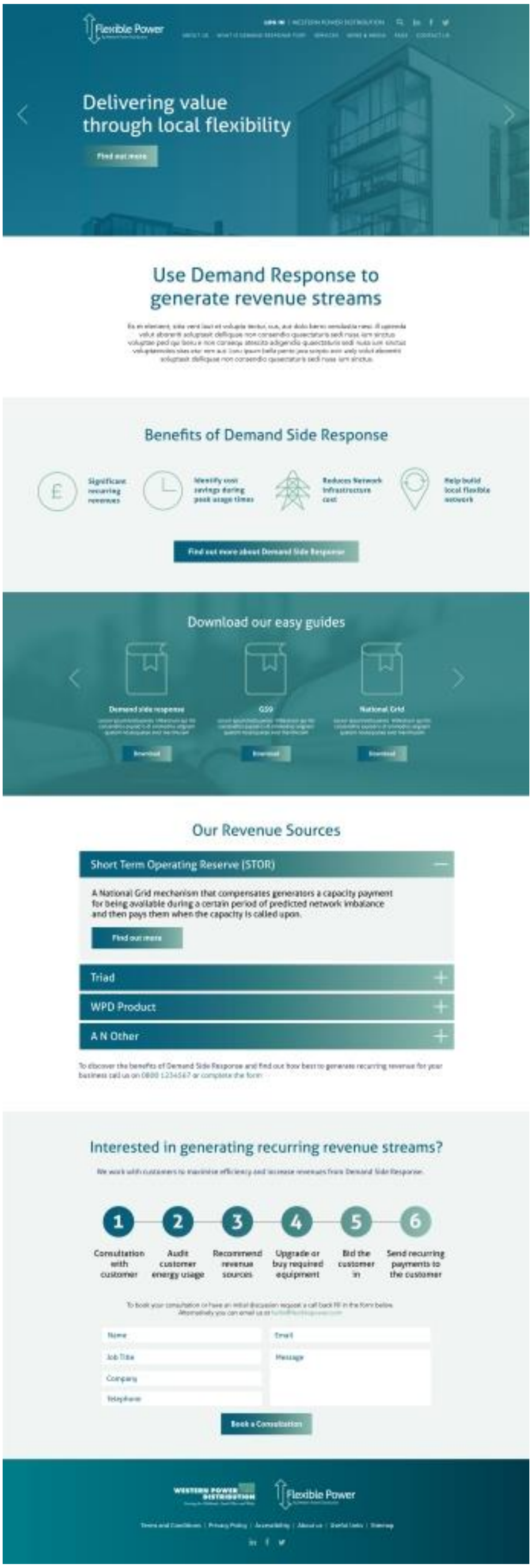


Figure 19: Image of original website

Figure 20: Image of updated website

As the project progressed, feedback from participants was used to amend and improve the information on the website. This included adding the mapping, pricing and process to the home page.

A link to the Collar customer portal was added to the website to ensure participants could access it easily.

3.2 Customer Relationship Management (CRM)

Once potential participants were identified and particularly once any contact was established with Flexible Power, it was important to track their progress through the customer journey and the project.

During the project this was done through a custom-built spreadsheet so as to avoid the delay and expense associated with creating a full scale CRM system which would have been unjustifiable for the size of trial. The spreadsheet understandably highlighted significant limitations, both in terms of data validation, ease of analysis and version control.

Below is the journey of how the CRM requirements evolved over the trial.

Initially the CRM had to capture the basic details of the customer across three main areas:

- Contact information
- Location of the asset
- Site data – relating to capability to comply with the Constraint Management Zone (CMZ)

An an additional “stage notes” section was updated anytime there was any correspondence with the client.

The next section covered the size and use of the asset at a high level check to make sure that all details of the site was known and was a secondary check to make sure that all the parameters to qualify for a CMZ was correct and validated.

The last section was site data and this was to cover information in relation to the actually asset and site, as well as any additional information of what the site asset i.e. is the asset participating in any other National grid schemes.

To track progress with all the information the team added a stage section to cover how we would proceed this was a simple drop-down box of:

- Go
- No go
- Contact made
- First meeting
- Out of zone
- Awaiting information

As this the main source of keeping all the standard information and the softer information, sections were added to keep in line with the primary information that was gathered.

Once Flexible power started to reach out to the public via the webinars and industry press, this information was also captured along with the standard information that is listed above.

With the basic information gathered there was a need to show a more user-friendly version to internal stakeholders and give graphic representation of progression on a weekly basis, there was also additional request to start sub categorise industry sections to see if there were and patterns or trends. This was done through simple Excel graphing.

Once the trail had its first CMZ opened, the above was all reference data and the team needed something more specific that gave a weekly update to internal stakeholders on the clients that had qualified for the CMZ's. The next evolution of the CRM was to simplify the information and focus on clients that have qualified for the CMZ to gather additional information, get the client set up on the flexible power portal so that could declare availability and establish as secure link via the Flexible Power API (see Figure 21). After each stage was completed.

Flexible Power	Latest Associated Documents	Status	Action required
Preparation			
Sign Contract	CM2 Contract 1.1		Sign Contract
Prove Technical compliance	FP Participation Requirements 1.0		Complete form
Establish interface	API Guide 1.2		Build API
Finalise and test			
UAT Portal access	Availability Declaration Guidance 1.0		Send over relevant credentials (email)
Set billing details	Billing details 1.0		Send over completed
API self test	Commissioning and Testing Checklist 1.0		Self test
Commission and Test site	Commissioning and Testing Checklist 1.0		Flexible Power to test API
Go live			
Full portal access	Availability Declaration Guidance 1.0		awaiting UAT tests
Add sites to zones	Availability Declaration Guidance 1.0		awaiting UAT tests
Set intial baseline	Availability Declaration Guidance 1.0		awaiting UAT tests
Complete intial declaration	Availability Declaration Guidance 1.0		awaiting UAT tests

Figure 21: Image of CRM summary tool

This was adapted to go along with the clients that were signed up to the process and a Red - Amber - Green system was implemented to track the progress of cleints on a weekly basis.

A key piece of learning for this process is the requirement for a fully developed CRM tool for any roll out. The project was able to feed into the creation of a detailed specification which WPD used as part of the Flexible Power procurement exercise. Other learning was that excel may be a great tool because of the flexibility, however using this as a CRM was good for the initial part of the trail, however, when requests from stakeholders came over for the team to display more information this posed a few challenges in keeping all the information coherent and simple to display back.

3.3 Operational support

The scheduling of dispatch was given to WPD outage planners to move the role outside of the innovation team and closer to the longer term BaU owners. To support this role, a few simple tools were created to guide them on what was required. The learning would then be used to inform what BaU tools would be required.

The first was a simple spreadsheet defining in detail what each constraint was and where it applied. These were deliberately defined in a simple manner to provide clarity on what was and wasn't relevant.

The second was a simplified forecasting tool based on the output from the previous year. This also included options to artificially reduce the rating of an asset to trigger a requirement to allow for trialling to be conducted. This tool would have required the weekly sending of rating adjustments from the innovation team to create dispatch requirements. To simplify the process, the tool was bypassed and requirements were sent directly in the form of an excel form (see Figure 22).

Requirements forecaster								
Requirements for operational week								
Requirements for week commencing								
							For FP team only	
Secure Requirements								
Location	Date	Day	Start time	End time	Duration (hours)	Trigger	*Expected volume*	*Expected cost*
								0
								0
								0
								0
Dynamic Requirements								
Location	Date	Day	Start time	End time	Duration (hours)	Trigger	*Expected volume*	*Expected cost*
								0
								0
								0
							Total	0

Figure 22: Example of requirement forecaster form.

As part of the service design there was no requirement for service optimisation and so no optimisation tool was developed.

3.4 Link to the Network Management System

Some element s of the Flexible Power services, such as Secure service or acceptance of availability, are pre-emptive and can be done ahead of time. Within this context it is acceptable for designated personnel to interact with a separate system on a separate PC (the collar system). However for services that require live interactions from control engineers this was not deemed acceptable. Their primary tool is the NMS PoF and as such any dispatches that needed the intervention of a control engineer, needed to be enacted through PowerOn Fusion.

WPD's implementation of PowerOn Fusion is based around high cyber security standards and as such is run as a completely segregated system. As such the integration with a cloud based system proved a significant challenge.

Within the trial multiple options we considered with the final implementation based on two back to back pieces of hardware with limited interconnections (see Figure 23). This would allow for the controls required within the project with minimal changes to existing processes. This also allowed for requirements to be further understood to help inform a more enduring solution.

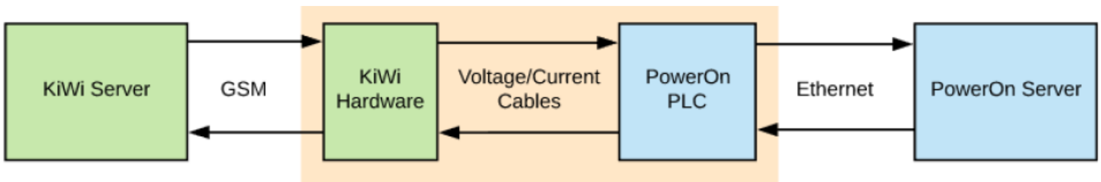


Figure 23: NMS - Collar link overview

For each operational signal required (each dynamic or restore signal), three signals were developed as shown in Table 6.

Table 6: NMS - Collar signal requirements

Type	Logic method	Format	Sent by
Start Dispatch	Pulsed (1 second)	Voltage	WPD

Stop Dispatch	Pulsed (1 second)	Voltage	WPD
Dispatch Status	Latched	Relay	KiWi

This limited information would allow for the start and stop of the assets. Further information may be of value in future, however this would require a different kind of interface.

From a hardware perspective this was implemented on the WPD side via a standard RTU as would be installed in a substation. The Kiwi side involved their Fruit device (their standard control box) alongside a Modbus coupler and digital I/O cards to allow for the volume of physical connections needed. These were interfaced with a number of relays to allow for the connection of the 2 systems.

During the initial installation it was highlighted that the WPD RTU outputted voltages at -54V DC rather than the +48V expected by Kiwi. As such additional optocouplers (to convert from -54V DC to volt free) were installed to allow the signals pushed by the RTU to be accepted.

Alongside the physical install, additional logic was added to PoF to ensure that the signals sent failed safe. When a control engineer started a zone, a start signal would be sent and a timer started. 55 minutes later an alarm would ask the control engineer if they would like to extend the call. If no response was received a stop signal would be sent. This is detailed in Figure 24 below.

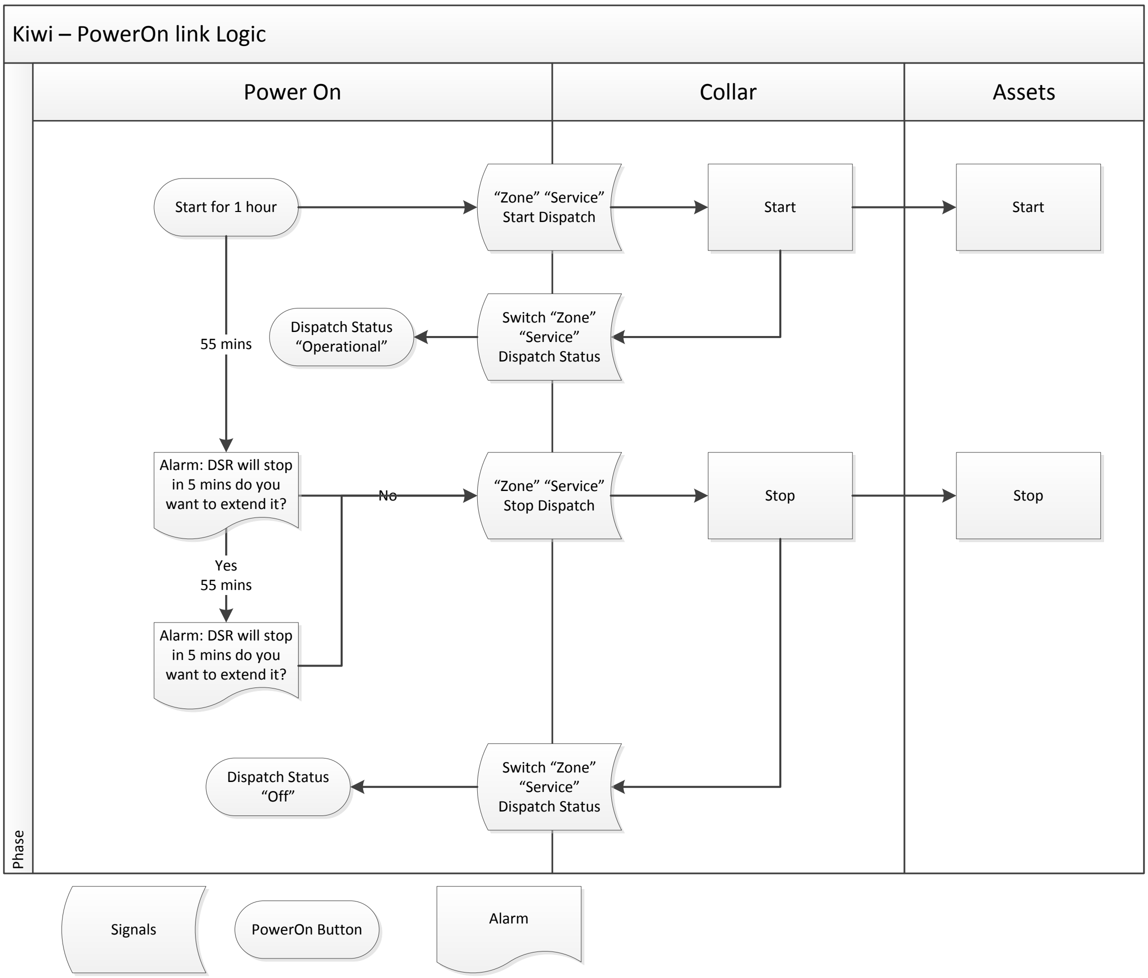


Figure 24: Logic within the NMS

3.5 Contract management

To ensure compliance with obligations on legal documentation retention the project utilised WPD's existing contract management software. Despite the contracting being led by the project team rather than the WPD procurement team this was a relatively simple process. Signed contracts were simply sent to the procurement team to be scanned and uploaded to the system. This approach allowed various compliance issues to be managed with minimal intervention.

3.6 Payments

The final process was to facilitate payments. Settlement and the production of billing was completed within the Collar system, this effectively produced the invoices for participants, however the actual payment of participants needed to be carried out in a separate system. It was decided this should be done via WPD's existing financial management and payment system. This avoided any potential compliance issues.
This was considered as part of the seamless, self-billing approach that we wanted to offer in order to make settlement as easy as possible for participants. The statement that is sent to participants at the end of each month for approval contains all the payment information relating to the participant as well as their event activity for that

month. These were then receipted by the project team and sent to accounts payable for payment. This is shown in Figure 25.

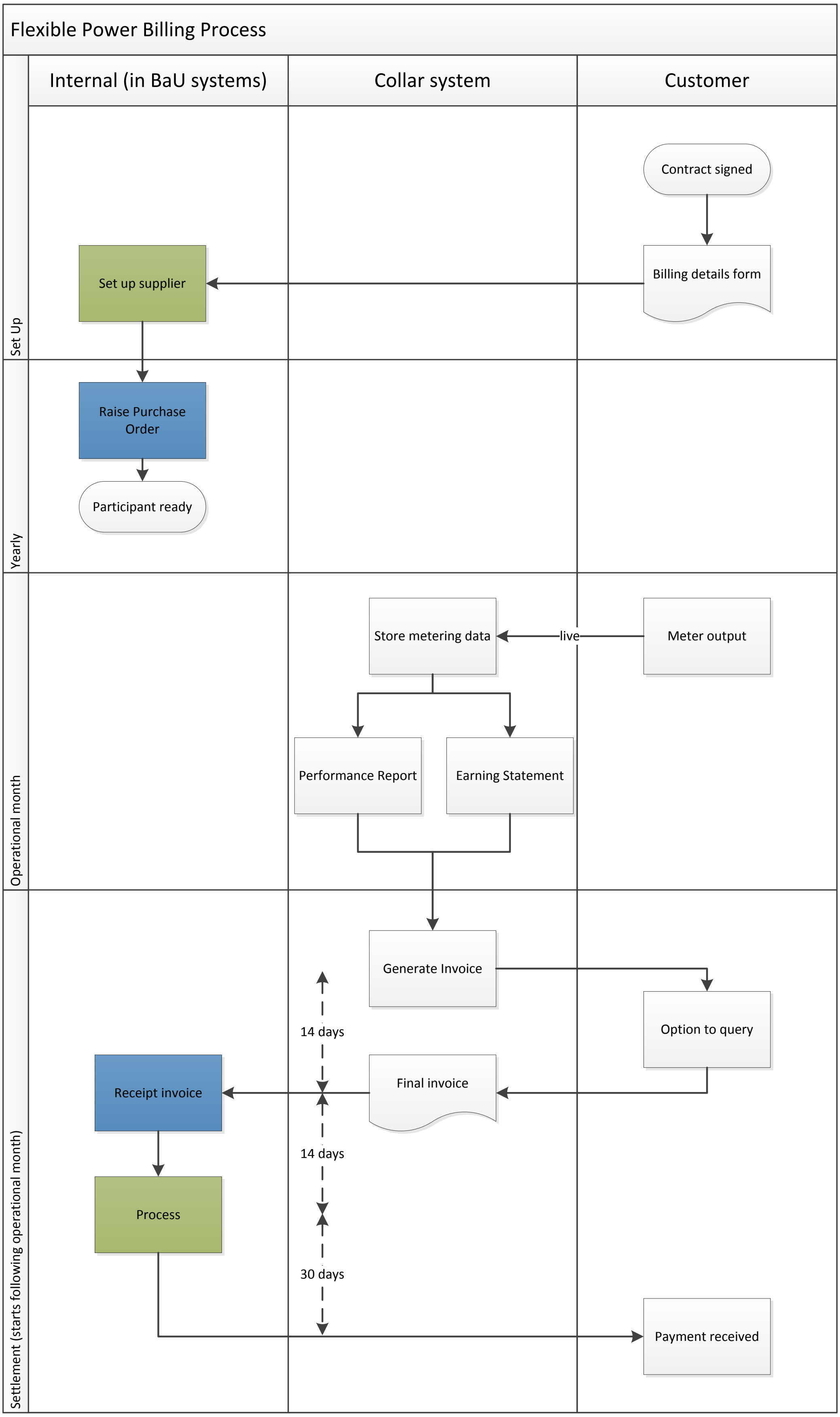


Figure 25: Payment process

4 Data improvement

Previous projects such as FALCON have highlighted the importance of querying and improving the background data held about the network and what is connected to it. As such, the project Entire undertook a number of investigations into the data available in the target area.

4.1 Reclaiming unused Agreed Supply Capacities (ASC)

The first element investigated was the potential for the reclaiming of unused ASCs for demand customers. Most large demand customers have ASCs governing the maximum import they are allowed to draw from the network. In many cases these are not fully utilised. However, they must be factored into network design studies as they could be taken up by customers. Demand customers pay a £/kVA charge for the reservation of this capacity. As such an assessment of utilisation was carried out with letters sent out to relevant customer in the target area (potential reclaims of over 10% of ASC with a minimum reclaim of 200kW) informing them of their current usage versus their reserved capacity as well as the potential savings possible by relinquishing such capacity. These letters were designed to trigger customers to reassess their agreements, whilst reminding them of the implications of doing so (see Appendix C). Where interest was registered, a variation agreement was sent out to formalise the reduction in capacity. As part of this process 153 letters were sent out with 2 sites replying directly relinquishing 2.1MW of capacity. Larger customers were followed up with phone calls resulting in 6 further responses delivering a further 5.1MW of capacity.
Of the companies actively called, approximately 30% were holding/leasing companies with limited interest in reducing ASCs, 30% actively wanted to keep their ASCs and the rest were still in the process of finding the right person to make the decision.
Several challenges arose as part of the process including the wording of the letters, to ensure the correct balance between informing customers of the potential benefits whilst ensuring they were aware of the potential risks. In addition, the data used to identify the sites and send the letters was poor, with extensive work required to collate workable addresses for each customer. Finally, once contacted, identifying key decision makers proved challenging. However despite these challenges, the process returned 7.2MW of capacity with no ongoing costs.

A similar process was undertaken across the business as part of the response to Ofgem's Quicker and More Efficient Connections consultation. WPD contacted customers with embedded generation who had not during any period of 12 consecutive months exceeded 75% of the Maximum Export Capacity and asked them to relinquish capacity. Some capacity was recovered; however this was relatively small considering the sample size. This is primarily due to the limited financial incentive to relinquish capacity as there is no (or very limited if charged through the EHV Distribution Charging Methodology), capacity charge.
Since this exercise WPD has committed to reviewing new cases of export underutilisation on a three-month rolling basis, returning to each of our four licence areas on an annual basis.

4.2 Generator Audit

Building on the learning from the FALCON project, where generators were identified that did not align with WPD records, an audit of the generation within the area was carried out. This was originally going to coincide with a push for participant recruitment; however following the project review this was delayed to the end of the project.

The purpose of the audit was to verify that the information held by WPD on what was connected to the system was correct.

The audit targeted generators between 150kW and 1MW. Any smaller was deemed of limited materiality whilst larger would have been covered by the existing program of Rate of Change of Frequency (ROCOF) communications.

As such 52 sites we contacted with an initial letter (example in Appendix D). A follow up letter was also issued to sites that did not respond. In total 24 responses were received with no causes for concern raised. Follow up discussions are underway for some sites which have unused capacity.

4.3 Value of DNO data

As part of the project review, the potential value of the data help by DNOs for the targeting of flexibility recruitment was highlighted by Ofgem. Whilst this data was not used within the trial to target customers, an action was taken to investigate the potential value and how it could be unlocked.

As the project progressed this was identified as being investigated by the Open Networks project under Work stream 1, Product 8 the System Wide Resource Register. As part of the 2018 work this developed the framing for a register for generation assets and connections. This did not investigate the value of a register of flexible demand assets. As such the project did some informal consultation with relevant trade bodies to understand the appetite and value for the potential to expand the register to cover flexible demand assets. The results highlighted the requirement for this to be addressed through further industry work as representatives of asset owners and potential aggregators had differing views on the value of such a register.

5 Learning Generated

5.1 Known limitations

As part the system design and implementation, various trade-offs were made to balance the requirements for generation of learning whilst limiting the costs of such learning to end customers. As such there are some known limitations to the systems such as the limited integration with PoF, or the all or nothing acceptance. These should be investigated in further work, however any solutions must continue to weigh up the benefits of increased functionality versus the additional cost that must be borne.

5.1.1 Forecasting and optimisation

The provision of forecasting and service optimisation was not directly provided within the project as this was the focus of WPD's EFFS project. The focus of projectEntire was on how procure services rather than the development of processes to determine what to procure. As such the trials requirements were developed to help prove operational reliability, mimicking expected requirements rather than a full forecasting system. In addition no optimisation was carried out. As mentioned previously all participants were dispatched identically to avoid the requirement for optimisation. The topic of optimisation is large and learning from project Entire has fed into the EFFS project and wider adoption of optimisation as part of BaU.

5.1.1 Meritocracy

To simplify the customer proposition the services were developed with fixed prices. This intentionally limited any available meritocracy within the trial, pushing the dispatch of all available assets within a zone for any dispatch. Due to this design the capability to disaggregate acceptance and dispatch was not added to the system build scope.

5.1.2 Limited NMS link

As mentioned in section 3.4, the link between Collar and the NMS is limited, allowing for the simple transmission of a start and stop signal between the two. In future, more information will need to be transmitted between the systems. This could include the volume of DSR being provided and future availability. However this must build on the learning generated on the reliability of metering data provided as well as the cyber security implications of increased linkages.

5.1.3 Admin functions

The addition of new participants to Collar and the assessment of data provision were conducted exclusively by Kiwi Power as part of the trial. This limited the development work required for the limited volumes within the trial. This also allowed for fluidity in the process as it was being tested. Going forward additional functions will be needed to allow WPD to manage new participant additions to the portal, as well as the monitoring and troubleshooting of the API.

5.2 Learning generated

5.2.1 RTU output voltage

During the initial installation it was highlighted that the WPD RTU outputted voltages at -54V DC rather than the +48V expected by Kiwi. As such additional optocouplers (to convert from -54V DC to volt free) were installed to allow the signals pushed by the RTU to be accepted.

5.2.2 API

The API interface was implemented as a new technology for which there was no prior examples within the industry to base this upon. It therefore required to be simple set up and secure enough to address any cyber security concerns with participants. This was initially met with some concern by participants due to lack of experience in setting up but with access to the UAT environment to develop and test they all succeeded within a reasonable timescale.

5.2.3 Cloud Computing

The use of a cloud computing approach enabled the low cost development of system that would not require any proprietary hardware to operate the service. The control console only required to be a web connected PC and participants would only require a minimum of a web connected PC to administer as well as some form of web connected device to send and receive asset signals. The system was developed and deployed in just over a year and can be further enhanced and developed centrally, with no specific need for hardware changes to any of its users.

5.2.4 Software Change Control

Change control affected the way that we deploy new software enhancements. In addition to the Production and UAT environments which participants have access to there is a third which is only accessible internally and used for system development. This environment is called DEV. Initially we would migrate the entire DEV software version to UAT then PROD whenever a new feature was to be released. This unfortunately meant that there were a couple of minor incidents where there were conflicts between completed features and those still in development, restricting the ability to move new features across. The developers therefore introduced a system where each feature was given its own toggle switch that could enable and disable it, and ensured that we didn’t have to wait for all features under development to be completed before migration.

5.2.5 Participant Portal

The portal facilitates the opportunity for participants to interact, largely on a self-service basis. It provides a central point where all information that they require is located. The process of declaring capacity and receiving notifications of running requirements are operated consistently around a weekly schedule. Actions occur without the need for participants to submit in an attempt to minimise the operating burden placed upon them. This principle is also applied to the monthly billing cycle which is automated an only requires participants to take action in the event they wish to raise a query.

5.2.6 Document management

The systems capabilities require to be supported closely in conjunction with documentation. The document library contains several guides for the many aspects of the service but amongst these is the contract, which due to the performance based service, requires to encompass many variables. Keeping the documentation updated with the service developments is vital. Change management procedures are therefore vital and the web site is used to make the most current versions publicly available.

5.2.7 Baseline Limitations

The principle that has been developed for the baseline was originally based on a concept where it may have to be done manually. For this reason, it involved the capture of data for the first 3 weeks of the month, still allowing sufficient time to analyse and publish revised baselines prior to the start of the following month. During the trial it was demonstrated that we can automate this process within the system and therefore we don’t require to limit the data collection to the unusual arrangement of just the 3 weeks.

The time of day from which the readings were utilised was intended to reflect the periods of highest expected consumption, which was assumed would reflect the times when flexibility would be most frequently required. It was also expected that this would in turn coincide with the periods during which participants would potentially have the highest baseline and therefore at its most generous in terms of potential earnings. While this is to a large extent true of the majority of sites, we did encounter examples where this was not applicable and actually limited some potential participants from offering capacity at any time. This was generally the case in scenarios where a participant reduced demand and increased generation to avoid demand or sell generation during Distribution Use of System (DUoS) red periods and peak charging tariffs for electricity.

5.3 Potential for development

5.3.1 Disaggregation

This will be a vital development in order to elevate the systems from its ‘trials’ capability to a fully functioning enterprise system. This will require a series of changes to the control console and back office in order to schedule, manage and fulfil billing for. This relates to the meritocracy and will also require the updating of contracts and procurement processes in order to comply with guidance.

5.3.2 Optimisation

Related to the disaggregation, it will be likely that the control room operators will require some assistance at making decisions on how best to construct the best configuration of participant capacity in order to get the best results. This may be optimised using various criteria such as reliability, fairness of value allocation or lowest cost. While it is not anticipated that this functionality will be developed within Flexible Power Systems, it will be necessary to integrate with external resources to allow them to carry this out.

5.3.3 Variable Pricing

The current pricing is determined upon savings that can be achieved, largely through delaying the costs of expensive capital upgrades. This ultimately means there is a cost threshold above which capital upgrades become more economically attractive. Therefore there is a ceiling for the price that a DNO should pay to contract flexibility and that is the starting price that can be offered to the market as a published price. This is then effective up until a point where a DNO has a liquid market and is offered a greater capacity than it requires. Once there is a liquid market for DNO flexibility services, then other pricing options could be explored. For example, one option might be that participants are required to submit a bid with their tender to provide lower price at which they would still be willing to contract. An auction would then be processed with all successful contracts being awarded at the highest clearing price. The systems will need to allow for pricing to be allocated on a zone by zone basis, and reflect this in the back office settlements as and additional variable. This is in effect and extension of the disaggregation development work.

5.3.4 Enhanced account management systems

Several system issues such as missing metering data were only identified accidentally, or by participants. Proactive highlighting of such issues would allow for more active account management to limit both the technical and reputational risks associated.

5.3.5 CRM

A key element for further development is the use of a more developed CRM tool. This would increase the ability to track participants through the process and allow for more complex recruitment analysis. As part of the transition to BaU, a new CRM tool has been scoped.

5.3.6 Wider Industry Sharing

As the dialogue within the industry has increased and gained momentum it has become apparent that the work being carried out by WPD has a very direct relevance to other DNOs and a great deal of learning has already been shared both directly and via the Open Networks project. With all DNOs faceingthe challenge of developing their own flexibility programmes there is a clear opportunity to extend the sharing beyond the knowledge and gain greater value from Project Entire by facilitating access for other DNOs to the developed technology. Collaboration meetings have been arranged with all DNOs to demonstrate the capabilities and open Flexible Power for use by any who wish to adopt it. By sharing the ownership of the complete service, including technical systems Flexible Power can reduce overall costs of operating flexibility for the industry and therefore cost to customers.

5.3.7 Baseline revisions

The development so far have indicated a wide range of options that could be considered by utilising the metering data we are collecting coupled with more complex algorithms to calculate them. It may be the case that more than one baseline methodology will be developed to maximise the opportunities for participants to declare their flexibility. This is likely to be required as we encounter different types of flexibility from different types of participants such as domestic clusters, EV Smart Charging or even intraday markets.

5.3.8 Future Architecture

With these services having been developed on a Cloud Computing principle it brings many benefits including scalability and addressing the communications between participants and central control it does also establish new challenges. The architecture therefore has to be considered in conjunction with wider policies for system design and operations. This is particularly true should the link between Collar and the NMS by strengthened. This architecture must balance the ease and simplicity of communication provided by the wider cloud based APIs, versus the increase security risk.

5.3.9 Wider Market Integration

Flexible Power has been very specifically designed as a tool set for the management of new relationships and encompassing many of the functionality challenges of supporting such services. There can only be a single system in the control room to operate the functional aspects but it is also recognised that with a growing number of opportunities within an increasingly distributed energy market, there may be other developments with which Flexible Power will require to interact. Currently the services are based upon commercial providers on a week-ahead basis but Flexible Power has been designed with a view to enabling further development which may include domestic flexibility or integration with wider flexibility platforms.

6 Contact

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

Future Networks Team
Western Power Distribution,
Pegasus Business Park,
Herald Way,
Castle Donington,
Derbyshire
DE74 2TU
Email: wpdinnovation@westernpower.co.uk

Glossary

Abbreviation	Term
ASC	Agreed Supply Capacity
API	Application Programing Interface
AWS	Amazon Web Services
BaU	Business as Usual
CMZ	Constraint Management Zone
CRM	Customer Relationship Management
DDoS	Denial of Service
DNO	Distribution Network Operator
DNS	Domain Name Server
DSR	Demand Side Response
DUoS	Distribution Use of System
ESO	Electricity System Operator
FALCON	Flexible Approaches for Low Carbon Optimised Networks
GUI	Graphical User Interface
HTTPS	Hypertext Transfer Protocol Secure
IAM	Identify and Access Management
IP	Internet Protocol
JVM	Java Virtual Machine
NMS	Network Management System
ROCOF	Rate of Change of Frequency
SCADA	Supervisory Control and Data Acquisition
SGC	Smart Grid Consultancy
SSL	Secure Sockets Layer
SQL	Structured Query Language
STOR	Short Term Operating Reserve
SYNC	Solar Yield Network Constraints
UAT	User Acceptance Testing
URL	Uniform Resource Locator
WPD	Western Power Distribution

Appendix A

6.1 Outstation (LOT A)

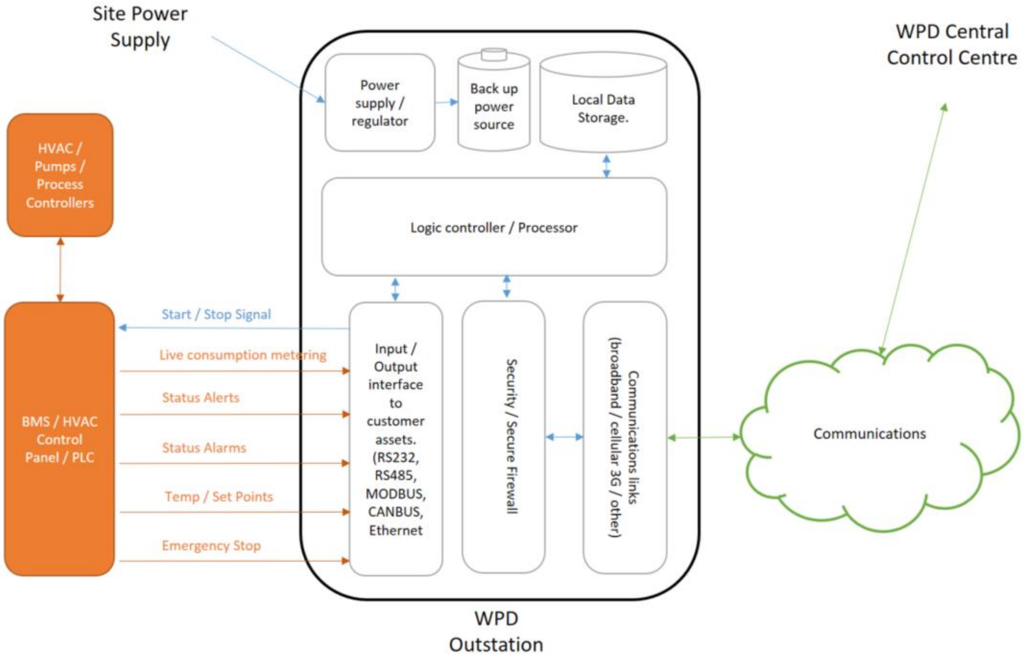


Figure 26 – Proposed Outstation Architecture

The Outstation is the onsite device interfacing signals from both the site asset and the upstream Central Control system. It should the ability to interface with energy consuming, generation and storage type assets and their according control systems / metering. The interface will allow the upstream control room to monitor all of the relevant status signals from third party sites in a standardised form, and support a limited number of instruction signals that will start and stop DSR events.

Downstream Communications

The Outstation must be able to connect 'downstream' to an array of customer asset types. It must be developed with integration versatility that can support a wide range of interfaces, connection types and protocols. A few such examples are listed below; *(also see Figures 2 & 3):*

- ***Asset Types***
  - Generators
  - BMS (Building Management Systems)
  - Scada systems
  - HVAC (Heating Ventilation & Air Conditioning)
  - Pumps
  - Energy Storage / Battery
- ***Connections Types***
  - RJ45
  - Serial (RS-232 & RS-485)

  - Volt Free contacts
  - USB
- ***Protocols***
  - Canbus
  - Modbus
  - PLC
  - BACnet

Depending on the asset being controlled, it will be necessary to monitor a range of different operating parameters. Most of these should be available from the control systems to which it is interfacing; however, there may be a few exceptions where additional devices are necessary.

Status Parameters (Generators)

- Fuel Level
- Operating mode / start mode (manual / auto / off)
- Live Metering output
- For example, a generator should be able to provide a starter battery status, inhibit switches and even a live metering output. It may however require a separate sensor added to measure the available fuel supply. HVAC, Pumps or BMS controls will often not include a <1 min meter reading and in many cases this will need to be acquired at the site settlement / supply point if energy reductions are being achieved from several assets.

The asset being interfaced should retain all of its primary control and protection functions; the outstation will simply interface with the existing control panels and request actions (such as starting or stopping). The outstation must also be able to pick up existing (or even additional) statuses and metering to allow the Central Control Facility full visibility of the asset.

For example: in the case of a generator the outstation would not supersede the existing controls. The generator control panel would retain all controls as well as G59 and engine management protection. This allows the site to remain reliable and safe. Any alerts from these should operate to protect the site and the asset in the first instance. The outstation will simply request that the generator control panel starts / ceases operation and receives status signals and metering data.

For ongoing fault diagnosis and enhanced support to the site it would be beneficial to obtain additional information from the generator control panel. These are not mandatory but it would be advantageous if the outstation could receive enhanced information and relay back any notifications of;

- Under / Over Voltage
- Under / Over Frequency
- RoCoF (Rate of Change of Frequency)
- Vector Shift
- Loss of Mains
- Low Oil Pressure
- Short Circuit
- Overload Protection

- Engine over-speed
- Water Temperature
- Battery Voltage
- Fuel Level

Note: If frequency support services are to be considered as a future commercial opportunity it would be desirable to ensure that the unit either has embedded or scope to retrofit a real time frequency sensor so any fast responding assets could be enabled at a later date. This is not mandated within the scope of the trial.

Upstream Communications

The 'upstream' requirement will remain relatively consistent across the majority of installations as they will each be communicating back to WPD's new Central Control Facility. This will have a standardised set of requirements for incoming outstation signal / data parameters which are monitored for individual performance analysis and aggregated to report results into operating groups. Greater details of these specifications are contained in the section for LOT B - Central Control

Upstream communications should be maintained in 'real-time' or close to 'real-time' in order to support the commercial and contractual requirements defined by the service operators. This will be WPD's own constraint alleviation service in some instances, but will also include National Grid Balancing Services portfolio. Multiple options should be available to each outstation for the communications including but not limited to;

- Cellular data (3G or 4G)
- Dedicated Fixed line broadband
- Corporate LAN/WAN access
- UHF Radio

To ensure resilience it would be preferred that where there is economic justification from larger capacity sites that an outstation includes a primary and secondary communications method.

The minimum frequency granularity of communications from the outstation to the CCF is 1 min intervals but can be provided at higher rates up to and including continuous live streaming.

There will be two operational states that the system must communicate under. The first of these is its 'holding' state during which it is not being utilised for a DSR event but must continually update its state of readiness or availability for dispatch. This will be done based on the 'Dead Man's Handle' (DMH) principle. Each outstation will have a series of asset parameters that it must check in order to establish the satisfactory state of the remote asset. These will be checked at a maximum expired interval of 1 minute and communicate this back to the CCF. If the outstation has the ability to embed some low-level intelligence, then a single arbitrary signal can be transmitted stating a confirmation of the positive site readiness state

Examples of the parameters that require to be communicated are:

For Generators

- Auto / Manual start switch position
- Battery health
- Fuel Level
- Manual Override / Inhibit Switch
- Run status
- Metered output
- G59 inhibit status
- Pre-heaters
- System Warnings / Alarms

For Battery / Storage

- Charge level
- Manual Override / Inhibit Switch
- Operating status
- State of Charge
- Metered intake / output
- G59 inhibit status
- System Warnings / Alarms

Load Reduction (Pump / HVAC / Chillers)

- Operating Set Points
- Current state in relation to set points
- Projected volume or reduction and duration of available DSR
- System Warnings / Alarms
- Metered Load

The second operating state is that of delivery. During this condition it is necessary that the site has its 'alerts' and 'alarms' closely monitored to ensure that the asset isn't likely to suffer any faults and that metering of the output is fed back to the CCF where it can be monitored and reported to any third parties if required.

Resilience

The outstation device is expected to be powered by either a standard UK 3 pin power source or a fixed power connection with a fused pole switch. This should be located in such a manner as to minimise risk of accidental interruption or tampering. This may also be enhanced by an option for small back up power capability to minimise the loss of data or operating configurations in the event of power loss.

As generators will often be located in external enclosures or plant rooms, the outstation must either be a robust device in its own right or capable of being mounted in a ruggedized casing that will ensure that it remains operational in spite of

- Wide temperature operating range
- High humidity
- Vibration and noise

Some data storage capability is necessary to record the site status and any metering information in the event that there is any failure in the upstream communications. This will be beneficial for any post-failure diagnosis and ensure data integrity for metering audits should communications failures occur during a DSR event.

Local processing capability would also be preferred alongside the data storage. Again, this would allow the site to remain operational in the event that communications to the site were lost in any way.

The outstation should also include a manual inhibit switch that the site can use to isolate the DSR service capability in the event of emergency. This could be a physical switch on the outstation or accessible via their own operational systems such as BMS or Scada if appropriate.

Security

The device must be able to demonstrate a reasonable level of physical security and a high level of cyber/data security.

The physical security aspect should accord with the resilience principals set out earlier. It should be robust, but also that this shouldn't afford an easy point of infiltration to the WPD systems upstream.

Cyber security is also vital in order to ensure the integrity of the response as well as the customer assets. There must be no easy opportunity for undesired access to the systems that could result in malicious interference or data theft.

6.2 Central Control Facility (LOT B)

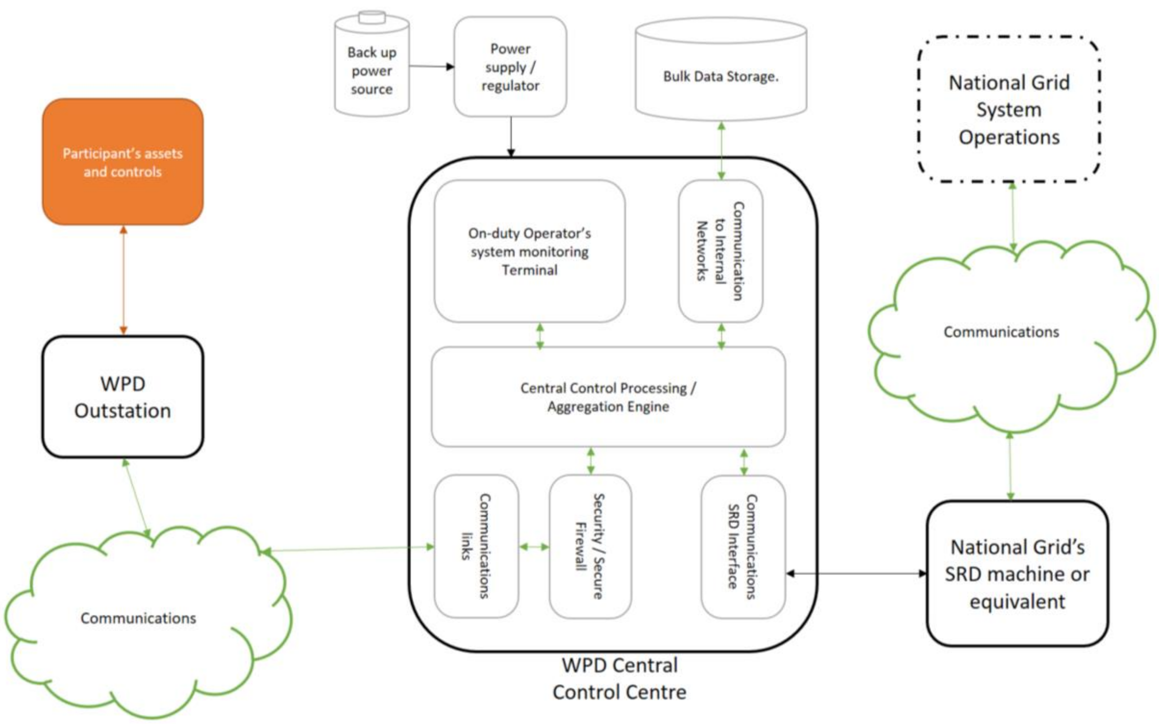


Figure 27 – Proposed Central Control Architecture

The CCF (Central Control Facility) will be located in parallel to WPD's existing control room facilities located in the Midlands and be the main point from which DSR services are operated. The intention with the CCF is to provide not just the ability to start and stop the demand response capability at customer sites, but also take much of the burden of monitoring and operating and automate these within system logic. It will achieve this through devolving much of the understanding and customisation relating to the sites to the local outstation operating the DMH principal, leaving the CCF to monitor a limited range of alerts and alarms when an outstation encounters an issue. On the basis that sites are available the CCF will be able to send a limited number of simple instructions for the outstation to relay to the assets, such as start and cease a DSR event. Parameters within the asset controller owned by the site will still manage the asset during the event, with the outstation merely monitoring the status and meter outputs.

Downstream Communication to Assets

While the Outstation must have a wide range of communication types and protocols in order to allow it to integrate with potential participant assets, the CCF only needs to communicate with Outstations. It is therefore reasonable to limit the downstream communications to compatibility with Outstation which will provide the versatility to integrate with a broad range of assets types and controls.

Examples of the parameters that require to be communicated are:

For Generators

- Auto / Manual start switch position
- Battery health
- Fuel Level
- Manual Override / Inhibit Switch
- Run status
- Metered output
- G59 inhibit status
- Pre-heaters
- System Warnings / Alarms

For Battery / Storage

- Charge level
- Manual Override / Inhibit Switch
- Operating status
- State of Charge
- Metered intake / output
- G59 inhibit status
- System Warnings / Alarms

Load Reduction (Pump / HVAC / Chillers)

- Operating Set Points
- Current state in relation to set points
- Projected volume or reduction and duration of available DSR
- System Warnings / Alarms
- Metered Load

The second operating state is that of delivery. During this condition it is necessary that the site has its 'alerts' and 'alarms' closely monitored to ensure that the asset isn't likely to suffer any faults and that metering of the output is fed back to the CCF where it can be monitored and reported to any third parties if required.

It is expected that the primary method of Outstation / CCF communications will take place over a secure communications network with sufficient bandwidth and low latency. Then main interface for the CCF should have a high level of reliability as it is critical to maintain the status update link in order to meet the terms of commercial arrangements into which the sites will be participating. It is therefore desirable to include a secondary connection from an alternative supplier and potentially even using alternative technology so as to reduce risk from single point of failure such as physical line damage or disruption at the local phone exchange.

Upstream Communications

The CCF needs to be capable of and compatible with the upstream links necessary for third party DSR programmes such as those operated by National Grid for balancing services. It is therefore mandatory that any tender respondent is able to confirm that their solution includes this ability. In particular, to aggregate outstation data and present this to third parties in a manner that complies with service contracts. E.g. STOR (Short Term Operating Reserve) includes the provision of a specific device known as an SRD[6] (Standing Reserve Dispatch) machine.

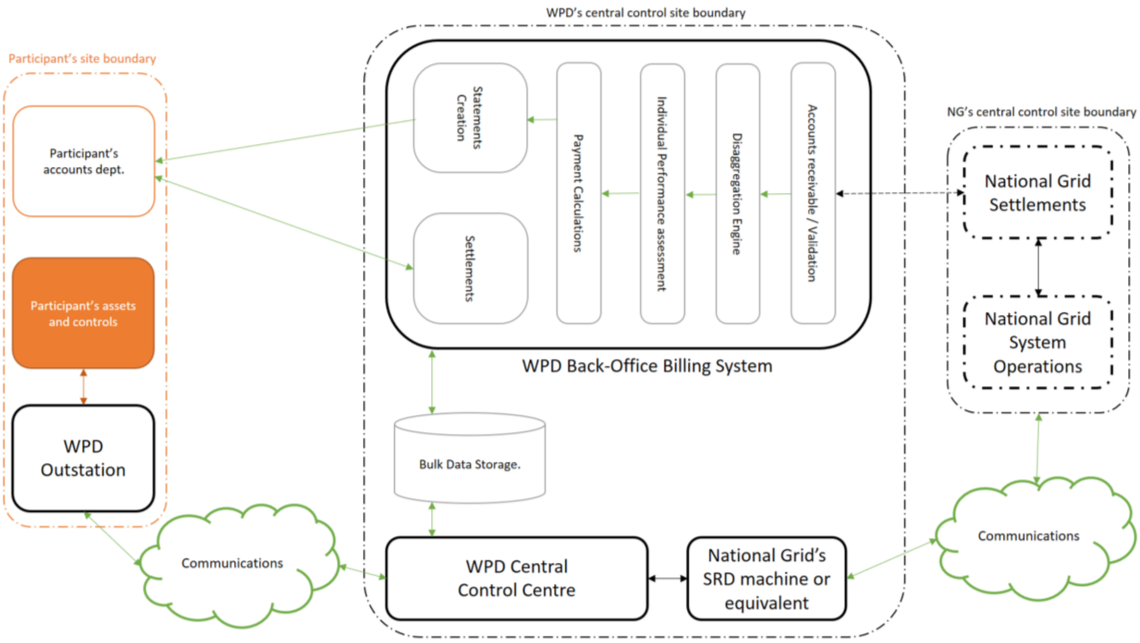


Figure 28 – Proposed Architecture for overall system

Operation

[6] Details of the National Grid SRD and the interface spec can be downloaded https://www.nationalgrid.com/sites/default/files/documents/SRD%20Interface%20Technical%20Reference%20May%202016.pdf

The outstation will provide a high frequency of status signals updates confirming that of all the key parameters are correct for assumed availability. *(see figures 2 & 3)*
The CCF will then check the current status against any site-specific checklist that ensures the state of readiness to respond to a DSR dispatch notice. The site checklist will be established during initial site audits and recorded in the CCF as the site operational profile. This will also be reflected in the commercial terms and contracts with the participant. If at any stage the site status is negative or communications links are lost the CCF should immediately record and be able to flag the event to the on-duty operator. *(see figure 4)*

In a normal state when the remote outstations are reporting no issues the CCF will aggregate the confirmation of availability signals with their operational groups. This will be recorded locally as well as reported upstream to third party programme providers that require it.

The aggregation ability involves:

- Allocation and transfer of individual assets to groups
- Mapping of contractual terms / performance requirements to groups
    - Response time
    - Group delivery capacity
    - Min / Max run duration
- Flagging of assets that don't meet the group performance requirements (speed, duration)
- Withdrawal of groups from service when individual asset status prevents group meeting contracted terms / performance requirements
- Optimisation of available assets to meet group requirements
- Duty sharing of assets to distribute usage if operating de-rated capacity
- Live meter aggregation and reporting

The data generated from all the status reporting, alerts, alarms and metering will also be necessary for access by the back-office systems which will be responsible for providing

- retrospective performance assessments
- aggregated data to generate payment information to invoice for services provided
- disaggregated data for fair distribution of payments to participants based on actual results
- create customer's monthly statements with details of availability / utilisation and dispatched events
- flag performance issues for customer performance reviews / account management
- structure the storage of and manage the data repository to make data easy to interrogate

In the event that communications issues result in disruption of live data collection, then the CCF must flag this and automate the retrospective collection from local storage within the outstation, prior to overwriting or disposal. Responsibility for this could be initiated by either the outstation or CCF on either a push or pull basis.

As with the upstream communications from the outstation, there is not a defined specification for the structure of the data storage that must be accessed by the back-office system (LOT C). Interested respondents will be invited to express any restrictions or preferences as to how the CCF will deal with data records or communications so as to demonstrate ability to integrate seamlessly.

In order to ensure that the CCF itself is ready and in a satisfactory state including the presence of a trained operator, there must be a timed alert to check this. After a defined period of inactivity has elapsed the CCF will generate an alert that must be acknowledged and acknowledged by the on-duty operator. This should be simple but change slightly in terms of the required response to ensure that the operator is not just present but alert and observant to any potential issues.

Resilience
The resilience of the CCF should be regarded similarly to that of other internal IT resources typically located in a critical environment such as the control room. It shall be maintained behind a UPS and backup power provision and the environment will not be subject to harsh environmental conditions. The CCF system should however be designed to ensure that all data is regularly backed up and that is operated on a system with redundancy that prevents it being subject to any single component failure, whether that is a PC, communications link or similar.
The respondent must be able to demonstrate their ability to support the solution with the appropriate resources for the duration of up to a three-year operational trial.

Security
The CCF may be physically hosted within a WPD building, most likely in parallel with and existing control room facility in the Midlands where conventional operations currently take place. The conventional control capabilities operate on a closed network with dedicated communications methods which result in very little risk of malicious attacks or attempts to breach security measures. The CCF trial system will be run in parallel and therefore avoid any perceived risks to existing operations.

Instructions will be passed manually between the control room when WPD requires to utilise the DSR resources for the purposes managing any constraints or other capacity related conditions on the distribution network. CCF will have direct interfaces into the customer’s sites via the outstation as well as upstream to programme operators such as National Grid. The security arrangements must be such that it is not deemed possible for any unauthorised access to be obtained that would allow visibility of any systems that would allow access to unencrypted data or the ability to simulate instructions to assets.

6.3 Back Office (LOT C)

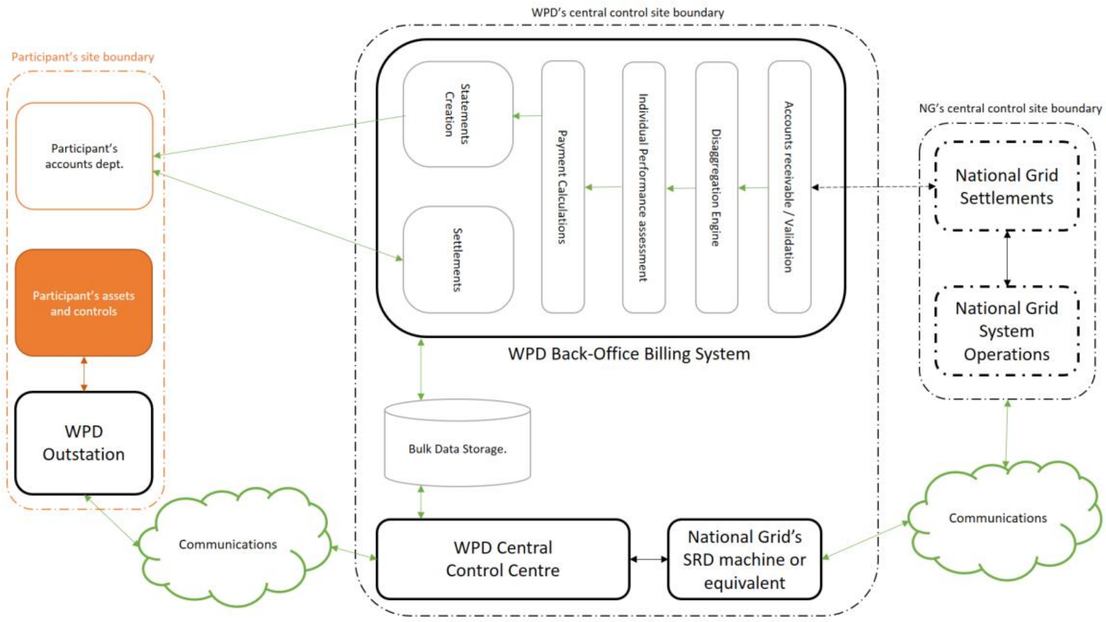


Figure 29 – Proposed Back-Office Architecture

The purpose of the Back Office Systems is to retrospectively administer all the collected performance data and allow WPD to process all the commercial activity associated with the service operation. This will enable analysis of the data, perform account management reports, monthly statements and disaggregate third party payments.

Service Capabilities

The system will need to enable

- Payment calculations for each participant within each service they are enrolled
- Event performance breakdown for every dispatch, flagging any occasions of underperformance for each participating asset
- Applying variable parameters to each customer asset based upon contracted requirements
    - Capacity
    - Response time
    - Min / Max duration
    - Availability including approved exclusions
- Retaining customer contact details, historical performance, key interactions and service operation parameters for each site / asset
- Production of monthly performance statements with minimal levels of manual intervention
- Production of monthly customer statements with minimal levels of manual intervention
- Aggregation of customer performance data to variable groups to invoice or provide bill validation to third party DSR programmes
- Disaggregation of third-party service payments and allocation payments to customer assets based on actual performance data.
- Calculation of customer service charges based on a variable percentage or revenue share, specific to each site.

In addition to the internal WPD programme requirements the Back Office System must also incorporate the capability to aggregate customers in line with third party DSR programmes. The system should be developed in order that as a base capability it would facilitate participation in;

- TRIAD / TNUoS avoidance
- National Grid STOR (Short Term Operating Reserve)
- Capacity Market
- Demand Side Balancing Reserve (DSBR)
- Demand Turn Up (DTU)

It would be advantageous if a provider can also ensure that there is adequate scope for the addition of further services to be integrated or alteration of base capabilities in line with any third-party programme updates.

Data Aggregation

The outstations will manage the relationship between customers' assets and CCF which will in turn store the data for access by the Back Office systems. The data will need to be accessed as individual customers and assets for the purposes of assessing individual purposes but also aggregated together to determine the performance out to any external service programmes. These programmes will typically not wish to see any individual performance data and will need to assess the overall impact of DSR assets grouped together. There will however be instances where this is not the case and the systems have to be developed to manage this in an equitable manner.

- If all assets perform as desired, then the disaggregation of the payments for DSR services are relatively simple and will reflect a direct proportional allocation of revenues.
- If one or more participants within a group underperform to an extent that the overall group underperforms then revenue will be produced and penalties could potentially be applied. Under such circumstance the bulk of the reduction should be attributed to the site(s) responsible.
- If one or more participants within a group underperform but the overall group still meets its objectives due to the over performance of other group members, then any reductions or penalties will be avoided. Under such circumstance the site that covered the shortage should also see a reallocation of the revenues from the underperforming site.

In addition to the requirements for aggregating performance to bill out to third parties and disaggregating payments back to participants there will be the requirement to develop the payment systems for WPD's internal requirements. It is likely that these will be based upon the service models trialled within previous innovation trials and will be used to incentivise participants to change demand at times of need. During the initial phase of project trials this will be targeting the reduction of annual peak demand and will be subject to an internal billing process. There may also be further propositions that would need to be integrated.

Security

The device must be able to demonstrate a reasonable level of physical security and a high level of cyber / data security.

The Cyber Security is vital in order to obtain policy approval by WPDs IR (Information Resources) department who have strict policies in order to preserve the integrity and security of all data systems. Although the DSR system will be developed on a standalone basis and not integrate with any current core systems we will still require to ensure that there is no easy opportunity for undesired access to the systems that could result in malicious interference or data theft.

The billing system should not need any live links directly to outside environments and therefore vulnerabilities should be limited through separation of the infrastructure. It may however be the case that some tender respondents would wish to offer a customer portal where online billing and statements are accessed rather than employ a paper based systems. In such instances it will be necessary to demonstrate that this approach does not result in any increased risk of either a data protection or operational system breach.

Data Repository

The collection and retention of customer data is a vital component of the back-office systems. The data will be collected and used for operational purposes through the mechanisms specified in the outstation and CCF tenders. The back-office system will then receive the data from the CCF by either a continuous stream or batch file as the data processing only requires to be retrospective as part of a monthly billing cycle.

The data will be accessed to produce a monthly performance record and a financial statement that will be used for the settlements process. Following the data processing for the monthly cycles the data should then be retained for a minimum of 2 years.

Appendix B Example Reports

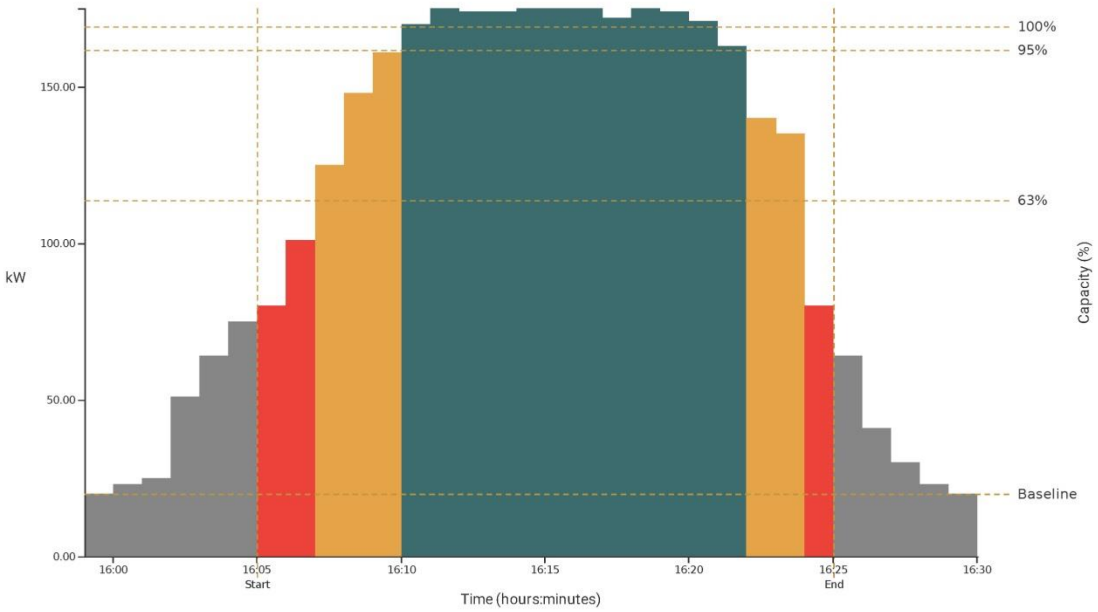
Flexible Power
By Western Power Distribution

FLEXIBLE POWER - SECURE
EVENT REPORT

Acme Corporation | **The North**

Event ID: S0 | Time: Thu 15, February 2018 16:05 - 16:25 UTC

Event Overview



Performance Highlights

Expected Total Volume	50.00 kWh
Actual Total Volume	42.61 kWh
Fraction of Contracted Capacity	85%

Flexible Power
By Western Power Distribution

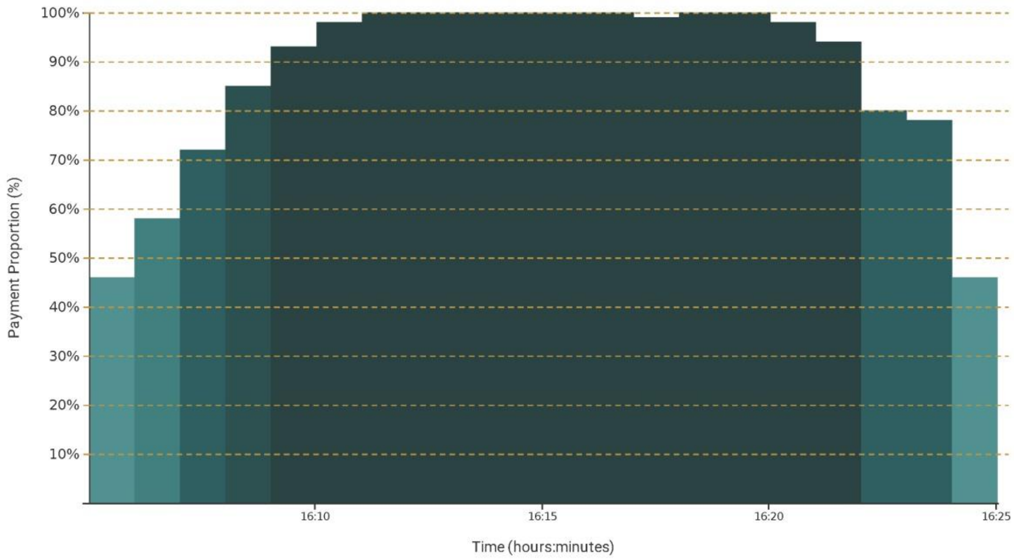
FLEXIBLE POWER - SECURE EARNINGS STATEMENT

Acme Corporation — The North

Event ID: S0 — Time: Thu 15, February 2018 16:05 - 16:25 UTC

Expected Total Volume: 50.00 — Actual Total Volume: 42.61 (85%) — Utilisation Payment Rate: 150

Maximum Possible Earnings: £80.42 — Actual Earnings: £67.21



Payment Band Breakdown

Payment Band	Minutes
90% - 100%	13
80% - 89%	2
70% - 79%	2
60% - 69%	0
50% - 59%	1
40% - 49%	2
30% - 39%	0
20% - 29%	0
10% - 19%	0
0% - 9%	0
No Readings	0

Appendix C Unused ASC letter

XXXXX

Western Power Distribution
Herald Way
Pegasus Business Park
DE74 2TU

e-mail: wpdpolmids@westernpower.co.uk
Date: 12 May 2017

Dear Sir/Madam,

PROPOSED VARIATION TO THE MAXIMUM SITE IMPORT CAPACITY

Connection Site: XXX
MPAN: XXXXX
Connection Agreement: XXXX

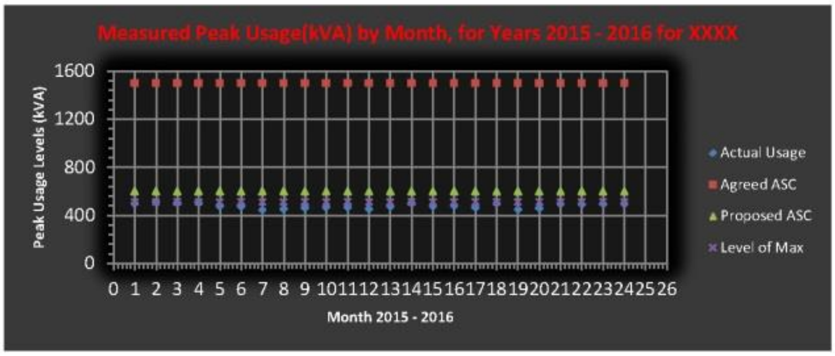
We are currently reviewing utilisation of import capacities in your area and have identified that the utilisation at your site is consistently below your contracted agreed supply capacity.

I would like to take this opportunity to highlight that the capacity charge element of your DUoS charges is based on your contracted capacity. As such reviewing your contracted capacity may allow you to reduce your costs. Your rates for 2016-2017 were 4.09 p/kVA/day.

The information below highlights some analysis on your usage that we would like to share with you. This covers your usage and agreed import capacity from 2015 and 2016, as such very recent changes may not be reflected.

Agreed Maximum Import Capacity	1500 kVA

	2015	2016
Maximum Import (kVA)	511	500
% of Agreed Import Capacity	34	33



Based on the above, we have calculated a suggested new Maximum Import Capacity (MIC) requirement of: 600kVA, which is based on a 10% uplift on your maximum usage over 2015 and 2016. **We highly recommend you review this figure in line with your future plans for the site and an assessment of your capacity requirements, and seek advice from your electrical contractor as required.**

This revised MIC could have provided a potential saving of £13435.7 in 2016. Please note, however, that:

(a) any savings in our charges will be passed on to your supplier – **the implications on your bills of a reduced MIC, and the extent to which such savings will be passed on from your supplier to you, should be discussed with your supplier**;

(b) the potential savings outlined above are also based on our charges for 2016-2017,

and as a result any future savings cannot be guaranteed.

More details on future charging can be found on the WPD website: https://www.westernpower.co.uk/About-us/Our-system/Use-of-System-Charges.aspx

Please note that if you agree to revise your MIC, **the old higher MIC will no longer be available for your connection**. If you subsequently exceed the revised MIC, you will be liable to penalty charges as a result of this. The exceeded portion of the capacity will be charged at the excess capacity charge p/kVA/day rate based on the difference between the MIC and the actual capacity used. This will be charged for the full duration of the month in which the breach occurs. In addition, should you require an increase in capacity in the future, then you will be required to submit a modification application to us – we cannot guarantee that any such increase will be available in the future without network reinforcement work being required at an additional cost to you.

If you would like to reduce your MIC please contact us at wpdpolmids@westernpower.co.uk. To reduce your MIC you will need to sign and return a Variation Agreement. A draft variation agreement has been attached. Your Connection Agreement will be varied, in accordance with the terms of the variation, with effect from the date of signature by us of the Variation Agreement (the "Variation Date").

If you would like further information regarding this change or wish to discuss the level of capacity you require, please do not hesitate to contact us using the following email address: wpdpolmids@westernpower.co.uk.

Yours faithfully

Appendix D Generator Audit letter

To Whom it May concern
Facilities Manager
«Company_Name»
«Customer_Address_1»
«Customer_Address_2»
«Customer_Address_3»
«Customer_Address_4»
«Customer_Address_5»
«Customer_Address_6»

Western Power Distribution
Herald Way
Pegasus Business Park
DE74 2TU

e-mail:
wpdconnectionpolmids@westernpower.co.uk
Date: «Now»

Dear Sir/Madam,

Embedded Generation Review

Connection Site: «Site_Name1»
Postcode: «site_postcode»
Associated MPAN(s): «MPAN»
Connection Agreement: «Connection_Agreement_ID»

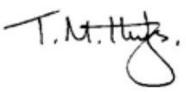
As part of the transition to a smart, flexible energy system we are we are looking to review and update our records of embedded generation connected to our network. This will help us run a more efficient, coordinated and economic electricity distribution network

Our current records indicate the potential presence of generation at your site.

As such we ask that you provide us with the information in Appendix 1 with regards to your site at «Site_Name1».

Please fill in the required details and return them in the free post envelope provided. Alternatively email the information to wpdconnectionpolmids@westernpower.co.uk. If you have any questions relating to the process, please contact the email above.

We thank you in advance for your cooperation



Tim Hughes
Connection Policy Manager
Western Power Distribution

Embedded Generation Review: Appendix 1

Site: «Site_Name1»
Postcode:«site_postcode»
MPAN(s): «MPAN»
Connection Agreement ID: «Connection_Agreement_ID»

Contact Details
Please update your contact information.

Customer contact telephone number:…………………………………………………………………………………….

Customer contact email:……………………………………………………………………………………………………

Generator Details
Please fill in one column per generator on site. If you have more than 3 generators on site please fill in another copy of appendix 1.

	Generator 1	Generator 2	Generator 3
Generation unit name[1]			
Installed generation capacity	………. kW	………. kW	………. kW
Generation unit type (please circle the appropriate response)	Biomass CHP Diesel Gas Hydro Landfill Gas PV Storage Waste Incineration Wind Other	Biomass CHP Diesel Gas Hydro Landfill Gas PV Storage Waste Incineration Wind Other	Biomass CHP Diesel Gas Hydro Landfill Gas PV Storage Waste Incineration Wind Other
Generation unit manufacturer and type[2]			
Operation type (please circle the appropriate response)	Long term parallel Short term parallel Stand-by	Long term parallel Short term parallel Stand-by	Long term parallel Short term parallel Stand-by

[1] An identifier to distinguish the generators. For example CHP Unit 1 or Main Standby generator
[2] The specific unit purchased from a manufacturer. For example SMA STP25000TL or Perkins AP400S