Mapping customer vulnerability: Methodology

Report to Western Power Distribution

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Contents

1. Introduction

This report outlines the data, data sources, data processing and analysis that were used to map customer vulnerability for Western Power Distribution (WPD).

The work produced three main sets of outputs that: i) identified and mapped individual vulnerabilities; ii) demonstrated the levels of coverage of PSR records for several PSR categories; *and* iii) assessed the vulnerability of substations based on the characterisation of individual households.

The former two of these outputs produced data sets that were matched to spatial information and were used as the basis for creating GIS map package files and high resolution map images. The substation vulnerability assessment also produced a substation level dataset that was provided to WPD.

Section 2 describes the data sources and processes used to identify and map individual indicators of vulnerability. Section 3 demonstrates how extend of PSR coverage (or conversely, the location and extent of gaps in the PSR) was mapped. Finally, Section 4 details the method used to characterise the numbers of vulnerable households connected to (and thus the degree of vulnerability of) WPD substations.

1.1. Use Cases

Early in the project, CSE held meetings with staff from WPD to understand the specific and various needs of the project outputs. One aspect of this was to draw out the different ways in which vulnerability data will be used in WPD's vulnerability engagement work, referred to from here on as 'use cases'. The data set which contained individual indicators of vulnerability was populated with additional 'combined indexes' for these use cases, helping to identify areas with high levels of multiple vulnerabilities. The vulnerability assessment of substations also used these use cases to determine the levels of vulnerability for different perspectives at each substation.

The four main use cases agreed upon at the inception meeting and the way in which the data was used to identify these areas is as follows:

Understanding customer vulnerability for strategic investment decisions

***Requirement*:** To understand which areas of the distribution network should be considered a priority in terms of overall vulnerability and when making asset investment or upgrade decisions.

***Data outputs*:** The study considered the significance of each vulnerable situation, giving priority through a weighted calculation that produced a combined overall index of vulnerability. This index thus highlighted areas with the highest rates of a multitude of vulnerable situations.

Identifying PSR eligibility

***Requirement*:** To understand which areas of the network are most likely to include the highest numbers of people eligible for the PSR.

***Data outputs*:** Using various indicators that directly related to, or were proxies for PSR categories, a combined index was calculated to show the likely rates of PSR eligibility. This was again weighted so that, for example, areas with high number of elderly people or people with disabilities were given particular significance.

Planning responses to planned outages or power cuts

Requirement: To be able to identify which areas will need to be given specific consideration when planning power outages on the network, but also to consider impacts and response to power cuts.

Data outputs: Consideration was given to the vulnerable situations (and the indicators which relate to them) which are most susceptible to a loss of power in the homes and the subsequent impacts on households affected. This resulted in the calculation of a combined index, produced by summing the proportions of people in the different vulnerable situations identified as most critical to this use case. This combined index provides a quick identification of where vulnerability to outages is likely to be most significant. Data from individual vulnerable indicators can then be further explored to ascertain which individual vulnerable situations are most prescient.

Understanding low community resilience

Requirement: A wider consideration of communities' ability to deal with unforeseen adverse situations, particularly natural disasters such as storms and floods.

Data outputs: Consideration was given to a wider set of vulnerable situations (and the indicators which relate to them) which indicate low levels of resilience to events such as natural disasters, drawing on work by Climate Just[1]. This resulted in the calculation of a combined index, produced by summing the proportions of people in the different vulnerable situations identified as most critical. As with the previous use case, once the least resilient areas have been identified, data on indicators for individual vulnerable situations can be further explored to which situations contributed to a particular community having predicted low levels of resilience.

[1] www.climatejust.org.uk/

2. Mapping Vulnerability at Small Areas

2.1. Vulnerability assessment

The initial stage of the work was to derive a set of vulnerable situations relevant to the concerns of a Distribution Network Operator (DNO). Firstly, each of the indicators listed in Ofgem's Customer Vulnerability Strategy[2] was reviewed, whilst also simultaneously considering WPD's vulnerability strategy and aspirations for the project. CSE also evaluated the benefit of using additional vulnerability markers that cover social, environmental and physical infrastructure aspects of vulnerability, and sought to align the different vulnerabilities with some of the use cases describe in the previous section.

The result of this provisional analysis was a finalised list of vulnerability characteristics to be mapped at small areas.

2.2. Data

Running concurrently with the previous work, research was also conducted to check availability and reliability of small area statistics and data that could be used to map indicators of these vulnerable characteristics. This could either be directly related to the characteristics or derived/proxy data that could indicate or point to the prevalence of a certain vulnerability in a given location.

The work for this first stage drew on open-source, robust and updatable datasets that qualified for National Statistics classification. The list of datasets was presented to staff at WPD and a final list of data to be used in the mapping was then agreed between CSE and WPD. The final list of characteristics, related indicators and the data sets and sources from which these indicators were produced is provided in Table 1.

[2] www.ofgem.gov.uk/publications-and-updates/consumer-vulnerability-strategy

Table 1: List of all vulnerable characteristics and relate indicators that were mapped, and the data sources used

Characteristic	Indicator	Data set	Source of data
Limited personal mobility to respond in case of issues.	Proportion of households who don't own a private car or van	KS404EW - Car or van availability	Census 2011
Living in a remote rural area (IMD profiles)	Distance to key services: GP, school, shop and Post Office	IMD/WIMD/IMD Scotland: Barriers to Access domain	Department for Communities and Local Government, StatsWales, NHS Scotland
Children (under 16)	Proportion of people who are under 16 years old	Lower Super Output Area Mid-Year Population Estimates, 2013	ONS
Young child (Under 5 years)	Proportion of people who are under 5 years old	Lower Super Output Area Mid-Year Population Estimates, 2014	ONS
Age - above pensionable age / 65+	Proportion of people who are above pensionable age	Lower Super Output Area Mid-Year Population Estimates, 2014	ONS
Age - older (75+)	Proportion of people who are 75 years and above	Lower Super Output Area Mid-Year Population Estimates, 2014	ONS
Age (very old 85+)	Proportion of people who are 85 years and above	Lower Super Output Area Mid-Year Population Estimates, 2014	ONS
Numbers on pension credit - low income older adults	Proportion of adults on pension credit	DWP benefits tabulation tool	DWP
Proficiency in English	Proportion of households who don't speak English well or not at all	QS205 - Proficiency in English	Census 2011
Ethnicity	Proportion of people of different ethnic backgrounds (Polish, Urdu, Punjabi, Hindi, Bengali, Somali)	KS201 - Ethnic group	Census 2011
Living in private rented accommodation	Proportion of households living in private rented housing	QS405 – Tenure, Households	Census 2011
Living alone / social isolation - lone parents	proportion of households which are lone parent households	KS105 - Household composition	Census 2011
Living alone / social isolation - single pensioners	Proportion of households which are single pensioners	KS105 - Household composition	Census 2011
Fuel poverty levels	Proportion of households living in fuel poverty	Sub-regional fuel poverty statistics, 2014 / Scotland fuel poverty stats	BEIS

Living in a care home or hospice	Number of people living in a care home	KS405 - Communal Establishment Residents, Medical and care establishment	Census 2011
Full time carers	Proportion of people who provide unpaid care for at least 20 hours a week	QS301 - Provision of unpaid care	Census 2011
Children with disability or health problem	Number of children under 16 in receipt of DLA	DWP benefits tabulation tool	DWP
Health condition or disability that affects day to day activities	Proportion of households who's day to day activities are limited a lot	QS303 - Long-Term Health Problem or Disability	Census 2011
Self-reported poor health	Proportion of people who report that they have bad or very bad health	QS302 - General Health	Census 2011
Mental health	Number of people in reciept of disability benefits for mental health conditions	DWP benefits tabulation tool	DWP
Living in a cold, energy-inefficient home	Proportion of homes with a EPC lodgement that is rated E, F or G	EPC lodgements at LSOA level - Ad-hoc request from National Energy Efficiency Data-framework (NEED) team	BEIS (NEED)
Low levels of educational attainment	Proportion of people without any formal qualifications or the lowest level of qualifications	KS501 - Qualifications and students	Census 2011
Disability benefit claimants	Proportion of people who are claiming disability benefits (ESA, DLA, SDA, Incapacity benefit, etc)	Stat-Xplore DWP benefit statistics	DWP
Low income, lone parents	Proportion of people who are low income parents receiving income support	Stat-Xplore DWP benefit statistics	DWP
Low income - low paid jobs	proportion of people of working age in semi-routine or routine occupations	KS611 - NS-SeC	Census 2011
Long term unemployed or never worked - low income	proportion of people of working age who are long term unemployed or who have never worked	KS611 - NS-SeC	Census 2011
Children in low income households	Proportion of households with dependent children where no adult is in paid employment	KS106EW - Adults not in employment and dependent children and persons with long-term health problems or disability for all households	Census 2011

2.3. Data Processing

2.3.1. Numbers, proportions and ranks

Each data set was processed to determine the both number and proportion of households/people in each of the vulnerable situations. It was then combined using an LSOA spine for each of these small areas in WPD's distribution area. The result was a wide table with a row for each LSOA and a value for each indicator related to the number or proportion of households/people in each of the vulnerable situations listed in Table 1.

Each indicator was ranked in descending order of vulnerability by area to show the LSOAs with the most vulnerable 'scores' for each indicator, as well as allowing comparison across other indicators. (The ranking was derived from the proportion of households/people in vulnerable situations rather than the number of households/people in vulnerable situations to better account for the variation in sizes and populations across LSOAs.)

2.3.2. Use case indexes

The final stage of mapping vulnerability sought to produce a combined 'index of vulnerability' for each of the use cases (see section 1.1), helping to demonstrate those LSOAs which had a combination of high numbers of people in different and multiple vulnerable situations. These indexes were produced by summing the values for each individual indicator of vulnerability. However, for different use cases, each vulnerable situation and related indicator was evaluated in terms of its relevance and significance for each use case. The result of this was a weighting system applied to each indicator separately when producing a combined vulnerability score, so that certain vulnerabilities were promoted and others diminished in the process. Table 2 below shows the weighting system applied to each indicator when compiling the indexes for each use case.

A combined index was not produced for *identifying stakeholder and partner organisations* as it was beneficial to see the breakdown of different vulnerable situations individually.

N.B. There are several older adult related age indicators, and so for several use cases the weightings have been designed so that the total combined weighting factor for percentage of adults over 65, over 75 and over 85 is comparable to the weighting of individual indicators for other vulnerabilities. For example, for 'Strategic network investment', the weighting factors for over 65, over 75 and over 85 are 0.25, 0.35 and 0.4, totalling 1.0.

Table 2: List of indicators of vulnerable characteristics and weighting system applied when producing combined indexes of vulnerability for each use cases

Indicator of vulnerable characteristic	Identifying PSR eligibility weighting	Understanding vulnerability for strategic investment decisions	Planning response to planned outages or power cuts weighting	Understanding low community resilience weighting
Proportion of households who don't own a private car or van		1	1	1
Distance to key services: GP, school, shop and Post Office	0.5	1	1	1
Proportion of people who are under 16 years old				1
Proportion of people who are under 5 years old	2	3	1	1
Proportion of people who are above pensionable age *	0.5	0.25	1	1
Proportion of people who are 75 years and above *	1	0.35	1	1
Proportion of people who are 85 years and above *	1.5	0.4	1	1
Proportion of adults on pension credit	2	1		1
Proportion of households who don't speak english well or not at all	3	1	1	1
Proportion of people of different ethnic backgrounds (Polish, Urdu, Punjabi, Hindi, Bengali, Somali)	1	1	1	
Proportion of households living in private rented housing	1	1		1
proportion of households which are lone parent households	1	2	1	1
Proportion of households which are single pensioners	2	2	1	1

Proportion of households living in fuel poverty				
Number of people living in a care home	3	3	1	
Proportion of people who provide unpaid care for at least 20 hours a week	1	1		1
Number of children under 16 in receipt of DLA	2	1	1	1
Proportion of households who's day to day activities are limited a lot	3	3	1	1
Proportion of people who report that they have bad or very bad health	2	1	1	1
Number of people in reciept of disability benefits for mental health conditions				1
Proportion of homes with a EPC lodgement that is rated E, F or G		1		1
Proportion of people without any formal qualifications				
Proportion of people who are claiming disability benefits (ESA, DLA, SDA, Incapacity benefit, etc)	3	2		
Proportion of people who are on state pension and are over 70	1			
Proportion of people who are low income parents receiving income support		1		
proportion of people of working age in semi-routine or routine occupations		1		1
proportion of people of working age who are long term unemployed or who have never worked		1		1
Proportion of households with dependent children where no adult is in paid employment		1		1

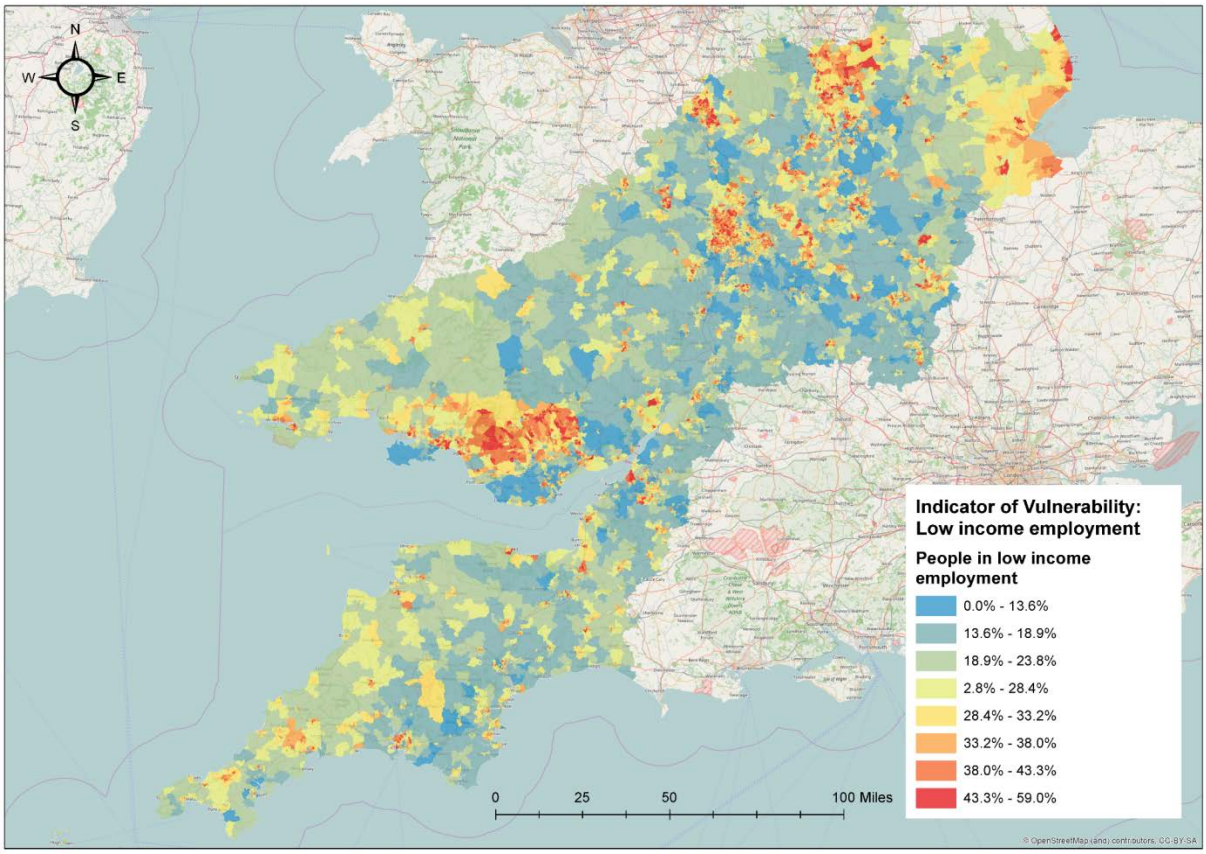
2.4. Mapping Vulnerability at Small Areas: Outputs

The vulnerability mapping analysis produced two key outputs: a data set with scores for the indicators of vulnerability for each of the LSOAs in WPD's distribution areas; and, an ArcGIS map package file.

2.4.1. Data

The data set was a wide table with a row for each LSOA in WPD's area and a value representing the proportion of households/people in each of the vulnerable situations listed and described in Table 1. This data set also included combined vulnerability indexes for four of the use cases described in section 1.1.

Figure 1: Map image of taken from GIS map file showing proportion of people in low income employment in the WPD distribution areas (red = high proportion of people, blue = low proportions of people)



2.4.2. Maps

The data set was used to produce an ArcGIS map package file for the WPD's distribution areas. These contained map layers for each of the individual indicators of vulnerability as well as the combined indexes of vulnerability for four of the use cases described in section 1.1. High resolution map images of each individual indicator and combined index of vulnerability was also produced from this map file and provided to WPD.

An example map for the vulnerability indicator which shows the ***number of people in low income employment*** is provided above in Figure 1.

3. Assessing levels of PSR coverage

A second aspect of the analysis sought to understand the level to which WPD's Priority Service Register (PSR) includes the total potential number of eligible people or households. The aim of the exercise was to identify and map the areas of the WPD distribution regions where there exist the most significant gaps in terms of eligibility versus existing records. This section describes the data sources and the processing used to conduct this analysis.

3.1. Data processing

3.1.1. Processing WPD PSR data

CSE were provided with PSR records at address level files detailing the categories under which people were registered on the PSR. The total list of categories and the number of records for each category are shown in Table 3.

It is not possible to represent all the PSR categories at small statistical geographies, as data which covers all individual PSR categories at LSOA level is not available. However, a total of six PSR categories covering 65% of all records on the PSR were included in the analysis. These were summarised into three distinct categories to align with data sets available at LSOA level. The three categories were elderly people/people over 60, people with disabilities, and foreign language speakers. The disability assessment combines four categories in the PSR that are related to impaired mobility ("Disabled", "Stair Lift", "Bath Hoist", "Restricted Movement"), as shown in Table 4.

Table 3: Categories and corresponding numbers of records on WPD's PSR

PSR category	Summary category	Number of PSR records	Proportion of PSR records
19 - restricted movement	Physical disability or restrictions	493,896	17%
15 - disabled		312,818	11%
12 - stair lift		46,810	2%
13 - bath hoist		10,510	0%
14 - elderly (60 plus)	Over 60	1,343,887	45.99%
17 - foreign language speaker	Foreign language speaker	12,380	0.42%
08 - blind	*Blind or partially sighted*	*22595*	*0.77%*
09 - partial sighted		*91,069*	*3.12%*
10 - deaf	*Deaf or hearing impaired*	*34,226*	*1%*
11 - hearing impaired		*140,813*	*5%*
20 - dementia	*Dementia*	*44,193*	*2%*
03 - kidney dialysis	*None*	*5552*	*0.19%*
18 - learning difficulties		*59,979*	*2%*
07 - other medical dependency on	*Other*	*121,413*	*4.16%*

electricity			
21 - other		*59,919*	*2%*
01 - nebuliser		*29,091*	*1%*
02 - heart/lung machine		*4,758*	*0.16%*
04 - oxygen concentrator	*Respiratory condition*	*56,043*	*1.92%*
05 - ventilator		*4,292*	*0%*
06 - apnoea monitor		*13,410*	*0%*
16 - speech difficulties	*Speech difficulties*	*11,935*	*0%*
90 - transient	*Transient*	*2,348*	*0%*
All categories		**2,921,937**	**100%**

Table 4: Summary PSR categories included in the PSR coverage mapping

Included in mapping coverage	Summary PSR category	Number of PSR records	Proportion of PSR records	overall proportion of records
Included in coverage	Physical disability or restrictions	864,034	30%	76%
	over 60	1,343,887	46%	
	Foreign language speaker	12,380	0.4%	
Not included in coverage	*Blind or partially sighted*	113,664	4%	*24%*
	Deaf or hearing impaired	175,039	6%	
	Dementia	44,193	2%	
	None	65,531	2%	
	Other	181,332	6%	
	Respiratory condition	107,594	4%	
	Speech difficulties	11,935	0.4%	
	Transient	2,348	0.1%	
All records		**2,921,937**	**100%**	

3.1.2. Matching PSR categories with spatial data

Using postcodes provided in the WPD PSR data, the number of records in each of the summarised PSR categories were aggregated to LSOA using external data derived from the ONS Postcode Directory[3].

The estimation of the PSR coverage for *Elderly (60+)* PSR records was perform by comparing the number of these records with ONS mid population statistics (available by LSOA) which are disaggregated by all ages (1 – 90+), and thus was used to estimate the total number of people in each LSOA who are 60 or over.

[3] www.ons.gov.uk/methodology/geography/geographicalproducts/postcodeproducts

The assessment of PSR coverage of people with physically limiting conditions was assessed by comparing the sum of the number of *disabled*, *stair lift*, *bath hoist* and *restricted movement* records on the PSR with external data at LSOA level for people who have limiting long term health conditions that restrict their activities a lot.

To determine how effective the current PSR is at capturing people who don't speak English, a comparison was made with the numbers of people identified as *foreign language speaker* in the PSR with information about people who have little or no English from Neighbourhood Statistics at LSOA level.

Table 5 summarises the PSR categories and the corresponding LSOA data used to make a comparison between existing PSR records and estimated total eligible numbers.

Table 5: Summary PSR and corresponding LSOA data used to compare PSR records with PSR eligibility criteria

PSR category	Summarised PSR category	Corresponding LSOA data
14 - elderly (60 plus)	Over 60	People over 60 years (ONS)
19 - restricted movement **15 - disabled** **12 - stair lift** **13 - bath hoist**	Physical disabilities or restrictions	People whose activities are limited a lot (Census)
17 - foreign language speaker	Foreign language speaker	People who cannot speak English well or at all (Census)

3.2. Calculating PSR coverage

The previous processes resulted in a table comprising the number of records for each of the three summarised PSR categories, plus corresponding socio-demographic statistics on the numbers of people likely to eligible for the PSR via these categories.

The final stage was to then calculate the difference in these two data points in each LSOA. For each individual category and the corresponding socio-demographic statistics, this was performed using a two-step calculation to produce an index which measured the extent of the gap between eligibility and PSR coverage.

An example of this calculation, assessing the extent of coverage of the *Elderly (60+)* category, is shown below, where '*PSR over 60*' refers to *Elderly (60+)* category, and the ONS statistics on the number of people over 60 is referred to as '*ONS over 60*'.

The calculation of the extent of coverage of the *Elderly (60+)* PSR category was then calculated as follows:

$$\textbf{Population weighted PSR gap in coverage index for } \boldsymbol{Elderly}\ \textbf{(60 +)} = \left(\frac{ONS\ over\ 60 - PSR\ over\ 60}{ONS\ over\ 60}\right)$$

This was then converted in to a normalised index (with a value of between 0 and 1) by dividing all population weighted indexes with the maximum value for the population weighted index across the whole WPD distribution area, as follows:

$$\textbf{Index: Gap in coverage of the Over 60 age group on PSR} = \frac{\text{population weighted PSR gap in coverage index for } Elderly\ (60+)}{\max(\text{population weighted PSR gap in coverage index for } Elderly\ (60+))}$$

The same calculation was performed for foreign language speakers and people registered as having physical disabilities to create two further indexes:

- **Index: Gap in coverage of people not speaking English**
- **Index: Gap in coverage of people with physical disabilities**

Finally, a combined index was calculated to estimate an overall coverage of all PSR records by combining the number of records for all three categories, and summarising the socio-demographic statistics on all three. Thus two further statistics were calculated:

Total number of PSR records (using categories for which comparable statistic are available at LSOA level) – a summation of the six PSR categories of *elderly (60+)*, *disabled*, *stair lift, bath hoist, restricted movement* and *foreign language speaker*.

Estimate of total number of persons eligible for the PSR – a summation of statistics for the numbers of *people over 60 years* (ONS), *people whose activities limited a lot* (Census), and p*eople who cannot speak English well or at all* (Census)

The final overall PSR gap index was then calculated:

$$\textbf{Population weighted overall PSR gap index} = \left(\frac{\text{Estimate of total persons eligible for PSR } - \text{Total PSR records}}{\text{Estimate of total persons eligible for PSR}}\right)$$

This was then converted in to a normalised index by dividing all population weighted indexes with the maximum value for the population weighted index across the WPD distribution area, as follows:

$$\textbf{Overall PSR gap index} = \frac{\text{Population weighted overall PSR gap index}}{\max(\text{Population weighted overall PSR gap index})}$$

Finally, all LSOAs were then ranked by each of the indexes to allow an easy process of identifying which LSOAs had the lowest estimated coverage, both overall and for the individual categories assessed.

3.3. Assessing levels of PSR coverage: Outputs

The PSR coverage analysis produced two key outputs: a data set recording the index and rank of each LSOA in WPD's distribution areas; and, maps of the data provided in high resolution map image files and a ArcGIS map package file.

3.3.1. Data

The data set contained the information provided in Table 6 for each LSOA in WPD's distribution area.

Table 6: Field names and descriptions of data showing levels of PSR coverage by LSOA.

Field Name	Field Description
LSOA code	ONS code for each LSOA
LSOA name	ONS name for each LSOA
Overall PSR gap index	An estimation of the extent to which the existing WPD PSR covers those eligible to be included on the register. The index is weighted to account for the total number of eligible people and normalised between 0 and 1; a score of 1 represents the lowest level of coverage, and 0 the highest level of coverage.
Overall PSR gap rank	Ranking of LSOAs based on the 'Overall PSR gap index', with those with the highest ranking being the LSOAs with the lowest coverage (i.e. the LSOA with a rank of 1 has the lowest level of potential coverage).
Index: Gap in coverage of the Over 60 age group on PSR	An estimation of the extent to which the existing WPD PSR covers those eligible to be included on the register, through being over 60 years of age. The index is weighted to account for the total number of people over 60 in each LSOA and normalised between 0 and 1; a score of 1 represents the lowest level of coverage, and 0 the highest level of coverage.
Rank: Gap in coverage of the Over 60 age group on PSR	Ranking of LSOAs based on the 'Index: Gap in coverage of the Over 60 age group on PSR', with those with the highest ranking being the LSOAs with the lowest coverage (i.e. the LSOA with a rank of 1 has the lowest level of potential coverage).
Index: Gap in coverage of people with physical disabilities	An estimation of the extent to which the existing WPD PSR covers those eligible to be included on the register, through having a disability. The index is weighted to account for the total number of people with a long term limiting health condition in each LSOA and normalised between 0 and 1; a score of 1 represents the lowest level of coverage, and 0 the highest level of coverage.
Rank: Gap in coverage of people with physical disabilities	Ranking of LSOAs based on the 'Index: Gap in coverage of people with physical disabilities', with those with the highest ranking being the LSOAs with the lowest coverage (i.e. the LSOA with a rank of 1 has the lowest level of potential coverage).
Index: Gap in coverage of people not speaking English	An estimation of the extent to which the existing WPD PSR covers those eligible to be included on the register, through not speaking English. The index is weighted to account for the total number of people who don't speak English in each LSOA and normalised between 0 and 1; a score of 1 represents the lowest level of coverage, and 0 the highest level of coverage.
Rank: Gap in coverage of people not speaking English	Ranking of LSOAs based on the 'Index: Gap in coverage of people not speaking english', with those with the highest ranking being the LSOAs with the lowest coverage (i.e. the LSOA with a rank of 1 has the lowest level of potential coverage).

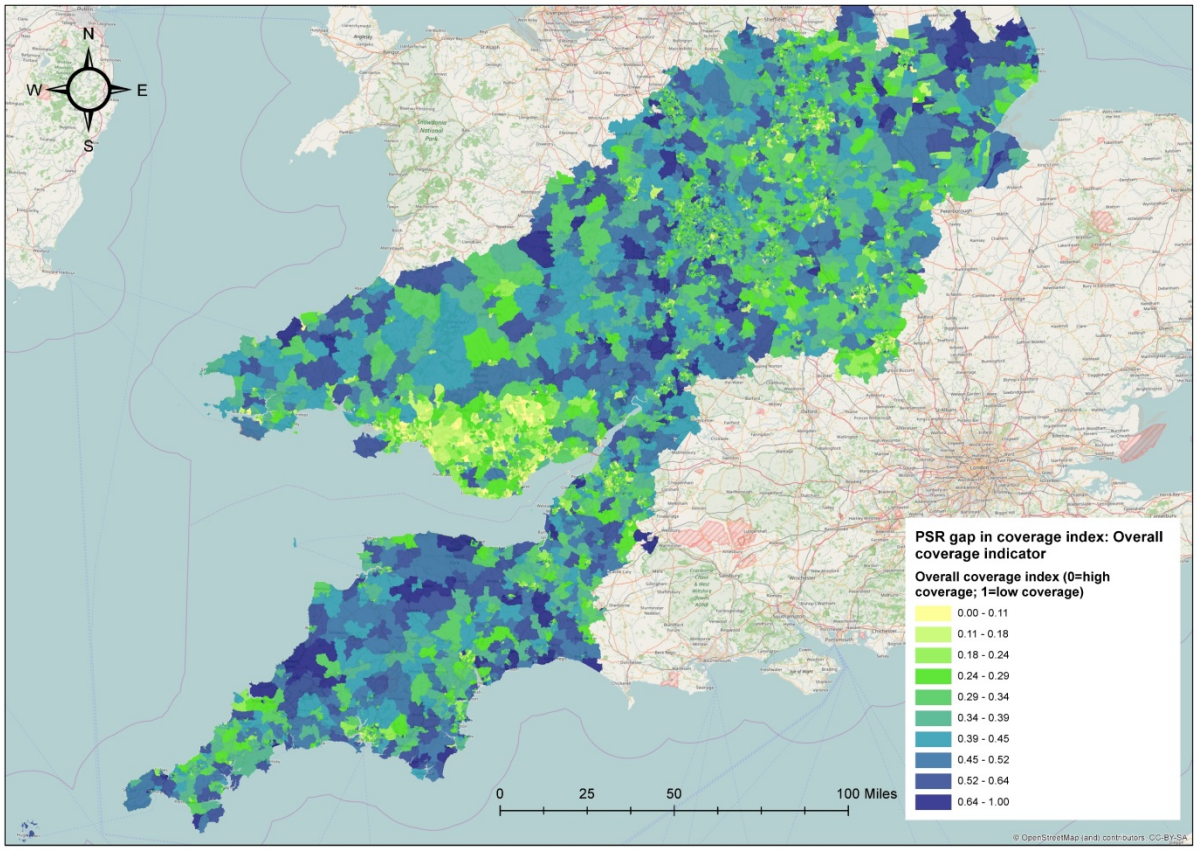
3.3.2. Maps

The data set was used to produce a ArcGIS map package file and high resolution map images of the PSR coverage index across the WPD distribution area. These contained for map layers for the following data:

- Overall PSR gap index
- Index: Gap in coverage of the Over 60 age group on PSR
- Index: Gap in coverage of people with physical disabilities
- Index: Gap in coverage of people not speaking English

An example map for the ***Index: Gap in coverage of people with physical disabilities*** is provided below in Figure 2.

Figure 2: Map image of PSR gap index for overage coverage of eligible households



4. Vulnerability Assessment of WPD Substations

4.1. Data sources

4.1.1. Mosaic segmentation data (Experian)

On behalf of WPD, CSE purchased Mosaic Public Sector classification data from Experian[4] at address level for all LSOA areas within WPD's distribution areas.

Mosaic divides the UK population into 15 'Groups' and 66 more detailed 'Types'. It uses over 400 data variables classify UK households based on their demographic characteristics, lifestyles and behaviour. It uses more than 450 data variables from a combination of Experian proprietary, public and trusted third party sources - including research findings and behavioural data.

Furthermore, Experian provides access to its 'Mosaic Audience' allows users to build up a profile of any subset of the population by picking from a list of characteristics, and converts this to a set of Mosaic Types which helps to better understand the lifestyles of these households, including potential vulnerable situations.

CSE used this Mosaic Audience tool and a series of known and identified vulnerable characteristics to produce a subset of the Mosaic Types which were found to be living in some of the vulnerable situations identified in other aspects of the work. The descriptions of the Mosaic types also allowed an understanding of the levels of vulnerability of each type so that each Mosaic Type could be further considered in terms of exposure to various vulnerable situations.

4.2. Address matching

WPD also provided CSE with anonymised address level data for all MPANs in the WPD regions, including information on the unique substation ID to which each MPAN was connected.

CSE then adapted a Sorting Office API designed by Open Addresses[5] that processed and uniformly restructured address details from the MPAN data into a common format, aligned with AddressBase Premium[6] data (which CSE were sub-licenced to use as part of the project). The two sets of data, WPD MPANs and AddressBase Premium, were then joined on common address terms. AddressBase Premium data contains several unique property reference numbers, including a *unique delivery point reference number* (UDPRN), which is also the main unique property identifier in Experian Mosaic data. Thus, once MPAN data was matched with AddressBase Premium data, Experian Mosaic data could also be joined to MPAN data.

The result was an address level data set that contained all WPD MPANs, Substation ID, UPDRNs and the Mosaic Type for the household at which the MPAN was registered.

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[4] www.experian.co.uk/marketing-services/products/mosaic/mosaic-in-detail.html
[5] alpha.openaddressesuk.org/developers/sortingoffice
[6] www.ordnancesurvey.co.uk/business-and-government/products/addressbase-premium.html

4.3. Mosaic Analysis

The final stage in the vulnerability assessment of each WPD substation was to take the outputs from the address matching stage (a dataset summarising the count of each of the 66 Mosaic Types connected to each substation) and summarise the number of each of the Mosaic Type identified as being vulnerable. This process was repeated four times, once for each of the use cases described in (Section 1.1) with a weighting applied to different Mosaic types based on the information known about each Type and the results of the analysis using the 'Mosaic Audience' tool.

Details of each of the Mosaic Types selected as having vulnerable characteristics is shown in Table 7, with some summary of the vulnerable characteristic of each group. Also shown in Table 7 is the weighting factor applied to each Mosaic Type for each calculation of vulnerability. An example calculation for assessing substation vulnerability score for the use case '**vulnerability for strategic investment decisions'** and using the derived weighting system is provided below:

Vulnerability for Strategic Investment index weighted =

(*Number of F23 Solo Retirees* * 2 +
Number of F24 Bungalow Haven * 0 +
Number of G26 Far-Flung Outposts * 2 +
Number of G27 Outlying Seniors * 3 +
Number of G28 Local Focus * 2 +
Number of I38 Asian Heritage * 1 +
Number of L49 Disconnected Youth * 2 +
Number of L50 Renting a Room * 1 +
Number of M54 Childcare Squeeze * 2 +
Number of M55 Families with Needs * 3 +
Number of N57 Seasoned Survivors * 1 +
Number of N58 Aided Elderly * 3 +
Number of N59 Pocket Pensions * 2 +
Number of N60 Dependent Greys * 3 +
Number of N61 Estate Veterans * 3 +
Number of O62 Low Income Workers * 0 +
Number of O63 Streetwise Singles * 2 +
Number of O64 High Rise Residents * 3 +
Number of O65 Crowded Kaleidoscope * 2 +
Number of O66 Inner City Stalwarts * 1)
/
(Total number of PROFILE CLASS 1 & 2 MPANs on substation)

The resulting weighted index number for each use case was then converted into a normalised index – a value between 0 and 1 whereby a score of 0 was awarded to the least vulnerable substation and a score of 1 to the most vulnerable substation. Finally, each substation was ranked in order of descending vulnerability.

Table 7: List of the 21 MOSAIC types used in the analysis to determine vulnerability at substation level and the weighting applied to each type for each of the four use cases

MOSAIC type	Key characteristics	Weight applied for vulnerability for strategic investment decisions	Weight applied when identifying PSR eligibility	Weight applied to planning responses to planned outages or power cuts*	Weight applied to understanding low community resilience*
F23 Solo retirees	Very low fixed incomes. Very old (81+). Very limited internet or smart phone usage. Manage bills by switching off devices.	2	0	1	1
F24 Bungalow Haven	Mainly 66+; <15k HH income; rural; state pension and may receive pension credit. Some use of internet and smart phone. Relatively good health for age.	0	1	0	0
G26 Far-flung outposts	Number of risk factors for low PSR uptake amongst eligible HH. Isolated communities, with low uptake of benefits other than pension. Generally ageing, with smaller numbers families with younger children. Self-reported COPD and depression. Poor broadband access.	2	2	1	1
G27 Outlying pensioners	Pensioner HH in isolated locations - may include HH with poor health who may be particularly vulnerable if not on PSR in case of power cut. Remote locations, <15k HH income, self-reported COPD, limiting long term condition, care provider, 66-70 age bands. Infrequent users of internet, dislike marketing approaches.	3	3	1	1
G28 Local focus (rural families)	Families in rural communities with children <5. Below average income, with low benefits uptake, struggling on income. May include some PSR eligible families with <5 age children. Otherwise, not likely to be PSR.	2	1	1	1

I38 Asian Heritage	Asian families with high number <5 may not be aware of PSR eligibility. May include elderly parents with poor health, who may not be picked up in PSR. Includes lower income households, low paid working and job seekers.	1	1	1	0
L49 Disconnected Youth	Low income <£19k. No car ownership. High mobility (<1yr, 1-3yrs)	2	0	1	1
L50 Renting a Room	Long term unemployed. Private rented.	1	0	0	0
M54 Childcare squeeze	High number children <5. Low income HH/high deprivation. Unlikely to fit any other category for PSR eligibility. Low level qualifications, routine or semi-routine occupations. High hh bills and childcare costs. Use smart phones. Worse health than average.	2	1	1	1
M55 Families with needs	High number children <5. Low income HH/high deprivation. Unlikely to fit any other category for PSR eligibility. Includes BAME HH. Low car ownership. Includes lone parents. Low levels education and semi-routine, routine work or unemployed.	3	1	1	1
N57 Seasoned survivors	Lowest income band. Includes very elderly. Not necessarily health issues. Dependent on state benefits. Mostly in 70s & 80s.	1	1	1	1
N58 Aided Elderly	Very elderly (90+); require care, may live alone, many single females. Live in specialist accommodation with on-site assistance. Thrifty.	3	0	1	1
N59 Pocket pensions	Lowest income band. Includes very elderly. Health conditions & high levels of unpaid care.	2	2	1	1

N60 Dependent greys	Lowest income band. Includes very elderly. Health conditions & high levels of unpaid care. High levels of deprivation. May live alone. Receive disability related benefits.	3	3	1	1
N61 Estate veterans	Lowest income band. Includes very elderly - on average 75+. Living alone. Health conditions & high levels of unpaid care. High levels of deprivation. Long term social renters. State pension, careful with money. Don't use internet. Prefer face to face or postal.	3	3	1	1
O62 Low income workers	Older people. High levels unpaid care. Poor health. May include BAME HH. May have low awareness PSR. Prefer postal or face to face.	0	1	1	1
O63 Streetwise Singles	Combines a number of vulnerabilities around health, low income and low qualifications.	2	0	0	1
O64 High rise residents	Older people. High numbers <5. Vulnerable to poor health. May include BAME HH. May have low awareness PSR. Very low environmental awareness. Mixed use of internet.	3	2	1	1
O65 Crowded kaleidoscope	Ethnic minority HH with high numbers <5. Unlikely to fit other PSR criteria. Unlikely to be aware of PSR eligibility. High risk urban fuel poverty. Use internet.	2	1	1	0
O66 Inner City stalwarts	Mainly single households ageing (55+). Social rented flats. Generally poor health, smokers. Pensions or low incomes / benefits. Newspapers / TV.	1	3	1	1

4.4. Vulnerability Assessment of WPD Substations: Outputs

The main output from this part of the analysis was a data set provided in an Excel spreadsheet containing vulnerability information at substation level. The core fields in the dataset are summarised below in Table 8. In addition, the spreadsheet contained the counts of each Mosaic Type and the characteristics of the main LSOA within which the substation was located.

Table 8: Main data fields and descriptions provided in the 'WPD-substation-vulnerability-assessment.xlsx' spreadsheet.

Field	Description
SUPPLY_POINT_NAME	Substation Name
SUPPLY_POINT_UDB	Substation Unique Identifier
Total number of addresses	Total number of MPAN addresses with Profile Class 1 or 2, provided to CSE.
Address match proportion	Proportion of Experian addresses matched to MPAN addresses, and thus with MOSAIC characteristics
Vulnerability for Strategic Investment index weighted	Vulnerability for Strategic Investment: Weighted number of occurrences of vulnerable MOSAIC types (highest number = most vulnerable)
Vulnerability for Strategic Investment index weighted normalised	Vulnerability for Strategic Investment: Normalised Weighted number of occurrences of vulnerable MOSAIC types (0 = least vulnerable, 1 = most vulnerable)
Vulnerability for Strategic Investment index rank	Vulnerability for Strategic Investment: Ranking of substations (1 = most vulnerable)
PSR Eligibility index weighted	PSR Eligibility: Weighted number of occurrences of vulnerable MOSAIC types (highest number = most vulnerable)
PSR Eligibility index weighted normalised	PSR Eligibility: Normalised Weighted number of occurrences of vulnerable MOSAIC types (0 = least vulnerable, 1 = most vulnerable)
PSR Eligibility index rank	PSR Eligibility: Ranking of substations (1 = most vulnerable)
Outages and Power Cut Vulnerability index weighted	Outages and Power Cut Vulnerability: Weighted number of occurrences of vulnerable MOSAIC types (highest number = most vulnerable)
Outages and Power Cut Vulnerability index weighted normalised	Outages and Power Cut Vulnerability: Normalised Weighted number of occurrences of vulnerable MOSAIC types (0 = least vulnerable, 1 = most vulnerable)
Outages and Power Cut Vulnerability index rank	Outages and Power Cut Vulnerability: Ranking of substations (1 = most vulnerable)
Low Community Resilience index weighted	Low Community Resilience: Weighted number of occurrences of vulnerable MOSAIC types (highest number = most vulnerable)
Low Community Resilience index weighted normalised	Low Community Resilience: Normalised Weighted number of occurrences of vulnerable MOSAIC types (0 = least vulnerable, 1 = most vulnerable)
Low Community Resilience index rank	Low Community Resilience: Ranking of substations (1 = most vulnerable)

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