Future Capacity Headroom Model

Document 00666
Functional Design Specification

Produced by:	Andy Palmer
Date:	26 February 2013
Version No:	2.1

Distribution for Comment

Reviewer	Role	Contact
Dan Randles		
Rita Shaw		
Tony Noble		
Victor Levi		
Tony McCabe		
Steve Shaw		
Ian Povey		
Geraldine Bryson		
John Waddington		
Paul Stillman		

Document Sign off

Sign-off	Role	Contact	Date
Dan Randles			
Rita Shaw			
Tony Noble			

Document Change Control

Version	Status	Date	Amended by	Description of Change
0.1	Draft	28 May 2012	Andy Palmer	Initial version
0.2	Reviewed	21 June 2012	Andy Palmer	Widespread changes
1.0	Final	4 July 2012	Andy Palmer	New section “Future Requirements”; new Appendix 3.
2.0	For review	11 December 2012	Andy Palmer	New version
2.1	Updated	26 February 2013	Andy Palmer	Minor amendments.

Contents

1 General Information

1.1 Purpose

This document describes the operation of the Future Capacity Headroom Model (FCH), whose user requirements can be found in "Future Capacity Headroom Model - project Overview Paper Version 4.0" dated 24 October 2011. As the FCH relies heavily on the Load Allocation (LA) research and development project funded under the IFI (Innovation Funding Incentive) project No. 259296, some of the information contained in that project's functional design document (Doc 00591) is expanded here. This document provides a reference for the various calculations and algorithms performed by the FCH model and as a starting point for anyone who may become involved in the maintenance or development of the system.

1.2 Scope

This document details LA and FCH processes and algorithms, and inputs and outputs specific to FCH.

1.3 Document References

1. TN-2906-Doc No 00548_Load_Allocation_PID V_1.0.docx
2. Load Allocation Specification and Report V0.3.doc
3. Future Capacity Headroom Model - Project Overview Version 4.0 24 October 11
4. Doc No 00591 Load Allocation 259296 Functional Design Specification v2.2.docx
5. Preview of "ENWL_Draft_Report_15th_April".pdf

   The document by Professor Moriarty of the University of Manchester describing the "Chinese Restaurant Algorithm".

1.4 Acronyms and Abbreviations

Acronym	Description
ARS	Automated Restoration System
arscat	ARS Circuit Attribute Tracking
BSP	Bulk Supply Point
CHP	Combined Heat and Power
CRMS	Control Room Management System
EV	Electric Vehicle
FCH	Future Capacity Headroom (Model)
FLA	Feeder Load Analysis
FSI	FCH Scenario Inputs
GMT	Ground Mounted Transformer
HH	"Half Hour" or "Half Hourly"
HP	Heat Pump
HV	High Voltage
IFI	Innovation Funding Incentive
LA	Load Allocation
ladbss	LA DataBase Sub-System
LIs	Load Indices
LV	Low Voltage
mCHP	Micro CHP
MDI	Maximum Demand Indicator
MPAN	Meter Point Administration Number
OfGEM	Office of the Gas and Electricity Markets
PMT	Pole Mounted Transformer
PV	Photo-Voltaic
RTDB	Real Time DataBase

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

Formatted: Space Before: 0.2 line, After: 0.2 line

2 Introduction

The purpose of FCH is to estimate the counts of overloaded assets in 2015, 2023 and 2031 by combining the current state of the Electricity North West network with predictions about future changes in customers, usage patterns and the uptake of new technologies.

LA calculates loads on all assets for a given period by analysing the entire network, half hour by half hour and then feeder region by feeder region. It uses actual switching conditions to properly represent the network and mitigate the effects of load transfers and fault conditions that would otherwise distort its results.

FCH takes the LA results for the days in which it is interested, applies its algorithms to each region, and produces its own results. The results produced consist of detailed asset results and summaries of various counts of assets, overloads and other information relating to the "Latest" state of the network and that in 2015, 2023 and 2031.

The "Latest" target customers (see 3.2.2.1) are intended to reflect the position at the end of 2011. ladbss (LA DataBase Sub-System) uses figures from the FCH Scenario Inputs (FSI) to realign the number of customers for FCH. Similarly, the 2015, 2023 and 2031 runs have scenario inputs reflecting customer numbers and technology uptake levels predicted for the ends of 2014, 2022 and 2030 respectively.

A simplified representation of the relationship between LA and FCH can be found in Appendix 2: Relationship between LA and FCH.

3 Detailed Description

Load allocation operates as described in 3.3. It produces results for every asset for every HH (Half Hour) for every day. A subset of these results is used as an input into FCH, which then uses them as a starting point for its four runs. These four runs apply various predictions about the future state of the network and create results for the target dates referred to as "Latest", "2015", "2023" and "2031". Run one consists of analysing the current state of the network. The remaining runs consist of a series of stages that apply different predictions to the "Latest" data.

3.1 Data

3.1.1 Assets of Interest

FCH is interested in results for a subset of all asset types, as follows:

1. LV (Low Voltage) ways, at the point where the way exits the distribution substation.
2. HV (High Voltage) feeders, split by whether or not the feeder is directly connected to the feeder breaker (is a "first leg") or not.
3. HV switchgear, split by whether the switch is the breaker for the feeder or not.
4. Primary sites. These are sites identified by the first 6 digits of the CRMS (Control Room Management System) plant reference of feeder breakers. It thus does not include operational groupings of transformers within or between different sites e.g. Spring Garden Street or Ribblesdale.
5. Distribution transformers, split by type (pole- or ground-mounted) and according to their rating.

3.1.2 New Technology of Interest

The types of new technology in which FCH is interested are detailed in the FSI and are as follows:

1. EV (Electric Vehicle) private domestic
2. EV private non-domestic
3. EV public charging
4. Air source HP (Heat Pump) (primarily new build)
5. Ground source HP domestic (primarily retrofit)
6. HP non-domestic
7. PV (Photo-Voltaic) domestic
8. PV non-domestic (at median size in model)
9. Domestic micro CHP (Combined Heat and Power)

3.1.3 Input

FCH requires the following input sources:

1. LA results via ladbss for dtxs, feeders and HV HH demands.
2. Access via ladbss to the data contained in the FSI.
3. Access via ladbss to general LA data.

3.1.4 Output

FCH results are produced as a set of files as follows. With the exception of the log file, each contains rows of tab-separated fields:

1. Asset counts

2. Asset overloads
3. Customer counts split by local authority
4. New technology counts split by local authority
5. New technology counts split by primary site
6. Voltage and harmonic issue counts
7. Primary detailed results
8. Other asset types' detailed results
9. Data from the input spreadsheet
10. Log file output

A more detailed description of the contents of these files is contained in 3.4.5 and screenshots showing the results of importing the output results files into Excel are in Appendix 1: FCH Results Screenshots.

Network Strategy has developed its own formatting for the raw output files, but this is outside the scope of this document.

3.1.5 Internal Model

Both the LA and FCH work on data stored in the internal model. This model is based upon the initial results of the arscat (ARS (Automated Restoration System) Circuit Attribute Tracking) trace.

The output from the arscat trace is a list of nodes, each relating to one end of an asset. Assets that are closed (the majority) appear twice in the list, once for each end. Open assets appear only once because their other end is electrically disconnected and is therefore not part of the region. In order to model the connectivity between the nodes in this otherwise unordered list, each node contains a single backward reference to another node in the list. By following these references, the connections between assets can be determined. However, because this output has only a single reference from each node, it is unable to handle loops in the network. This deficiency results in a loss of connectivity information during the arscat tracing process itself. The outcome of this shortcoming is that an asset has two nodes that should connect to each other but do not, and this is indicative of a non-radial region.

The LA internal model is created from the arscat trace results by adding to it the following:

1. forward indexes for each node to each node that has a backwards index to it,
2. a count of connections for each node,
3. flags, asset and load information for each node,
4. additional nodes to represent the other (primary side) end of feeder breakers,
5. additional node pairs to represent HV HH demands.

3.2 The ladbss Subsystem

The ladbss acts as a buffer between LA or FCH and the LA and CRMS databases. The most important tasks it performs are:

1. To hide the details of the locations of the various input data that is required by LA or FCH.
2. To perform databases accesses efficiently, regardless of when and how the data is required by LA or FCH.
3. To selectively cache data internally to improve performance.
4. To handle the calculation of utilisation factors and ratings for results.
5. To perform the scattering algorithms asynchronously and return results on demand.

3.2.1 Calculation of Ratings and Utilisations

The type of rating, the used rating value and the utilisation factors of every asset are contributors to the summary and detailed results for FCH. The type of rating is categorised by the ladbss into “missing”, “zero”, “cyclic” or “continuous”. An additional category of “missing load” is also possible because the determination of “cyclic” or “continuous” cannot be made without a profile of the load on the asset. Assets with a missing rating or a missing loading will be categorised appropriately and no further calculations performed.

The determination of the rating category and the rating used is summarised in the following table. Conversion between kVA and A is omitted for clarity. The utilisation is the ratio of the peak load to the rating.

<table>
<tr><th>Asset type</th><th>Cyclic rating category if...</th><th>Continuous rating category if...</th><th>Rating used</th></tr>
<tr><td>Distribution transformer</td><td>load exceeds 75% of the peak load for at most 16 of the 48 HH periods</td><td>not cyclic</td><td>“kva_rating” from the CRMS table “TRANSFORMER”</td></tr>
<tr><td>Cable type interconnect whose CRMS “conductor_type” field of “XLPE”</td><td rowspan="2">never</td><td rowspan="2">always</td><td rowspan="2">“ducts” from the CRMS table “INTERCONNECT_RATINGS”</td></tr>
<tr><td>Interconnect connected directly to feeder breaker</td></tr>
<tr><td>Other cable types</td><td>as distribution transformer</td><td>as distribution transformer</td><td>“cyclic” or “direct”, respectively, from the CRMS table “INTERCONNECT_RATINGS”</td></tr>
<tr><td>Overhead line</td><td>never</td><td>always</td><td>“summer” (run month May, June, July, August), “winter” (run month December, January or February) or “spring” (all other run months) from the CRMS table “INTERCONNECT_RATINGS”</td></tr>
</table>

3.2.2 Scattering

Scattering of various types is performed by the ladbss. The purpose of scattering is randomly to allocate missing, surplus or new customers or additional new technology to the network where their actual location is unknown except at a per local authority scale. Results are passed to the main FCH algorithm on demand. All scattering is done on a per-way basis, and is done proportionately to the number of consumers of type domestic or non-domestic (as appropriate to what is being scattered) already existing on the way. In particular, ways that have no consumers originally will not accumulate any later. Domestic customers are those in profile classes 1 or 2. Non-domestic customers are those in profile class 0 or 3 to 8. There are several types of scattering performed, detailed in the following sections, but it should be noted that because all scattering is done on a per-way basis, no customers or new technology are scattered at HV.

3.2.2.1 Missing or Surplus customers

LA models customer numbers according to its latest best data. FCH requires its starting point to be at a fixed point in time, at which it knows the number of customers. Because of this, and because of the problems involved in “snapping” MPANs (Meter Point Administration Numbers) to LV ways, the number of customers known to LA differs from the number that

FCH wishes to use for its "Latest" run. The correct number of customers that FCH requires in "Latest", split into domestic and non-domestic, is provided in FSI, sheet "Stage 2-3 inputs" and tagged "CM1". ladbss achieves the target number of customers required by randomly scattering or removing them from the network before FCH starts, thus ensuring that all phases and all stages are based on the correct number of customers, if not their correct locations. Scattered domestic customers are assumed to be of profile class 1. Scattered non-domestic customers are assumed to be of profile class 3. These assumptions also apply to the following section.

3.2.2.2 New customers

The numbers of new customers predicted in the three target dates of 2015, 2023 and 2031, split by local authority and whether domestic or non-domestic, are defined in FSI sheet "Stage 2-3 inputs" and tagged "E1". A proportion of these new customers are defined to connect to the network on new distribution transformers and this percentage is defined in FSI sheet "Stage 2-3 inputs" and tagged "C1". The remainder are scattered across existing ways in three passes. The first pass scatters 48% of the total number of new customers in clumps of 12. The second and third passes scatter 16% in clumps of three and 23% singly, respectively. The last figure is approximate - the actual number scattered is the total new customers on existing ways less the number scattered in passes one and two. The scattering is constrained by limiting the increase in customers on any way to 60%. These proportions are based on the number of MPANs connected in different OfGEM (Office of the Gas and Electricity Markets) connections reporting categories, as suggested by Connections from accepted quotations from 1 October 2010 to mid December 2011

3.2.2.3 New Technology

The predictions of the uptake level of all new technology types, split by local authority, are given in FSI sheet "Stage 2-3 inputs" and tagged "U15-1" to "U15-9", "U23-1" to "U23-9" and "U31-1" to "U31-9". The uptake rates are given as a percentage per local authority of domestic or non-domestic customers as appropriate.

1. Existing and new PV installations

   Existing PV installations are defined by their distribution transformer site, with the number of median-sized installations at each site reference supplied as a spreadsheet by Network Strategy. They are scattered at their site across all distribution transformers and their ways in that site proportional to the consumer counts. Each installation unit is scattered independently of other scattered units, for domestic and non-domestic installations separately. If the site is missing, the PV installations destined for it are lost. Existing PV scattering has no effect on the calculations for the "Latest" date as the net change in demand is already taken into account on the feeds to the network. Its purpose is to ensure that the number of scattered PV installations on any way for 2015, 2023 and 2031 is never fewer than any earlier run.

   The scattering of domestic and non-domestic PV installations for 2015, 2023 and 2031 uses the Professor Moriarty "Chinese Restaurant Process". The use of the terms "Median", "Beta" and "Discount" are defined in his paper 'Preview of "ENWL_Draft_Report_15th_April".pdf'. The scattering for 2015, 2023 and 2031 is done using a Beta value of 500 and a Discount value of 80%.

2. Other new technology installations

   These are scattered randomly and linearly across all ways on a per local authority basis. A saturation level (beyond which a way can accumulate no more new technology installations) of 80% is used.

3.3 Standard Load Allocation Phase

The purpose of the LA process is to provide the results that the FCH algorithms will use as a starting point. This process performs most of the calculations referred to in the user requirements as stage 1.

LA will always produce the best possible results despite errors in data.

In the following sections, the terms demand, load, source and sink have these meanings:

1. Demand: a transfer of power into or out of the region whose value is derived during the stage “3.3.4 Application of Initial Demands”.
2. Source: a transfer of power into the region.
3. Sink: a transfer of power out of the region.
4. Load: the actual loading (always +ve) of an asset.

The majority of demands are sinks. The exceptions are HV HH (Half Hourly) demands representing consumers that generate power such as wind farms. The majority of demands derived from FLA (Feeder Load Analysis) data are sources. The exceptions are those whose region is a net exporter of power and feeds its primary rather than vice versa.

LA determines loads on all assets for a given period by analysing the entire network, feeder region by feeder region. Because the connectivity may change from one HH to the next, the entire network is analysed for each individual HH of the run. For dates after the latest data from the state event logs, normal states are used. When operating for a period for which actual switch states are known, the effects of load transfers are removed.

LA works by applying a sequence of stages to each feeder region in turn. A feeder region is selected by using the arscat tracing algorithm to trace connected assets from a distribution transformer, delimited by primary breakers and open points,

The period for which LA will produce results is obtained from the fields “start_date” and “end_date” in the “la_runtime” table in the LA database. The sequence of stages applied is as follows:

1. Create an internal model of a region of the entire network.
2. Identify feeders as being both a primary breaker (by the arscat library) and closed (by the state event logs).
3. Apply FLA readings to those feeders.
4. Apply demands to the region.
5. Scale those demands so that:
   a. The total of sources in the region matches the total of sinks.
   b. Individual sources are modified to match the above calculated power transfer according to their confidences.
   c. Individual sinks are modified to match the above calculated power transfer according to their confidences.
6. Aggregate the demands from each terminus in the region and thereby assign a load to each asset.
7. Output the load associated with each asset.

This is repeated until no further regions can be identified for the HH.

3.3.1 Region Identification

A region is a set of electrically connected assets. The state of the asset in the internal model, and thus its connectivity, is determined by the state event logs. If the date of the run is after the latest state event logs, then normal operating conditions (as determined by the arscat library) are used.

A region is traced from each valid distribution transformer. A valid distribution transformer is one that:

1. exists in the CRMS database table “TRANSFORMERS”, and
2. has not been found in a previously processed region, and
3. does not have a plant reference that begins with the character “9” - the region in which those assets exist is a test network and thus does not represent real assets, and
4. does not have a plant reference that begins with the character “8” - the region in which those assets exist is fed by another DNO (Distribution Network Operator).

A region is delimited by assets meeting one or more of the following criteria:

1. It is a primary breaker, or
2. it is an open asset (as defined by the state event logs or the arscat library), or
3. it is a terminus, with only a single connection.

In particular, open primary breakers act only as open assets for LA. If the region contains any system transformers, the region has been inadequately defined by CRMS and the RTDB (Real Time DataBase). In this case, the region, and all the assets in it, is excluded from further processing.

3.3.2 Feeder Identification

Feeders in the region are identified by the arscat library as being both a primary breaker and by the state event logs as closed. If the number of feeders is greater than 1 then the region is a ring. If not all feeders are in the same CRMS site, then the ring is multi-primary.

3.3.3 Application of FLA Data

This stage applies FLA readings to each identified feeder as a profile covering the period for which LA is being run.

FLA readings for the period being handled by LA are provided by the ladbss for each feeder. Missing or zero readings in the FLA are compensated for by the ladbss by interpolating between valid bounding readings. The quality of these adjusted readings is reduced appropriately. Because the units of the FLA readings are Amperes, the voltage level of the feeder breaker is also read and the calculated kVA values of the feed profile (where kVA = Amperes * voltage level * $\sqrt{3}$) are stored internally.

3.3.4 Application of Initial Demands

This stage applies demands to the internal model. These are obtained from various sources via the ladbss. The applied demands are stored as profiles covering the period for which LA is being run.

The quality of each initial demand is set to the confidence value of the type of source as held in la_parameters “confident” values.

The demands are applied in three stages - profile demands, then flat demands and finally, FLA demands.

1. Profile Demands

   These are demands that are intrinsically profiled - they have 48HH values per day. Any asset is a candidate for an HV HH demand and ladbss gives the demand for any asset. Placement of an HV HH demand creates a new node pair in the internal model that represent an imaginary asset with a CRMS database type of 110. If the asset is a dtx, the demand is connected to the HV side. If the asset is a feeder, the demand is connected to the side more remote from the primary. If the asset is neither, the demand is connected arbitrarily.

   Any dtx may have LV data associated with it, supplied by ladbss. The data may be LV HH profile class 0 customers or counts of customers in profile classes 1 to 8. The former are supplied as a profile. The latter are used to create a profile by multiplying the customer counts for a profile class by the average profile class' profile.

A dtx may have both an LV and HV demand. Both the LV and HV HH profiles may exist but contain only zero values.

2. Flat Demands

   Any dtx that receives no HV or LV demand in the previous stage is given a flat approximation of demand that is converted to a profile. The following flat demands are checked for and applied in the following sequence. Once the dtx has acquired a flat value, the remainder of the checks are omitted.

   a. Any consumer-owned dtx is given a flat value taken from the la_runtime parameter "default_hv_hh_load". However, if there exists in the same region an HV HH demand on an asset with a name that is "like" the name of the consumer-owned dtx, then the placement of the flat load is suppressed. Whether a name is "like" another is the result of a fuzzy comparison that compares the words and tokens that make up the two names. The reason for suppressing these demands is that there exist in the network groups of dtxs with similar names whose demand is aggregated by billing into a single HV HH demand. In this situation, additional demands would be unwanted.
   b. If there exists an MDI (Maximum Demand Indicator) reading for an ENWL-owned dtx, then the flat value used is the MDI value multiplied by the la_runtime parameter "mdi_factor".
   c. If the dtx is ENWL-owned and the dtx has a rating, then the flat value used is the rating multiplied by the la_runtime parameter "pmt_factor" or "gmt_factor" according to whether it is pole or ground mounted. Note that ground-mounted dtxs may have their demand suppressed similarly to consumer-owned dtxs.
   d. If the dtx is ENWL-owned then the flat value is that taken from the la_runtime parameter "default_tx_kVA".

   Having determined a flat value as the best approximation for the demand at the dtx, it is converted into a profile. The profile of the total FLA feeds is used as a base, so the shape of the demand profile matches the feed and is adjusted so that the peak value of the profile matches the flat value.

3. FLA Demands

   FLA readings are considered another source of profiled demands similar to HV HH demands. Where FLA readings are invalid, estimated readings are created by calculating the difference between the total FLA demand and the total non-FLA demand and apportioning the difference between the feeders with invalid FLA.

   FLA readings do not contain power flow direction, so the final stage is to determine the best fit between sources and sinks in the region. Each valid combination of directionality of FLA readings is tested and the combination used whose difference between sinks and sources is least. A valid combination of directionality is one where the direction of power flow is the same for each primary i.e. all feeders in a primary are operating in the same direction.

3.3.5 Scaling of Initial Demands

This stage is only undertaken for regions that have at least one valid feeder.

This stage is performed in three steps for each HH. For scaling to be completely successful, there must be a non-zero source and a non-zero sink for every HH. The steps are:

1. Calculate the throughput for the region by adjusting the sources total and sinks total according to their overall confidence values and power. The total adjusted source and the total adjusted sink are equal to this throughput and to each other.

   F_i is an initial source and F_c is its confidence value

S_i is an initial sink and S_c is its confidence value.

F_t is the total of all sources: $F_t = \sum Fi$

S_t is the total of all sinks: $S_t = \sum Si$

F_w is the total of all sources, weighted by their confidences: $F_w = \sum FiFc$

S_w is the total of all sinks, weighted by their confidences: $S_w = \sum SiSc$

Therefore, the throughput (T) is given by:

$T = (F_w + S_w) / ((F_w / F_t) + (S_w / S_t))$

The following boundary conditions will result in no scaling for the HH:

1. F_t == 0: there is no source to scale
2. S_t == 0: there is no sink to scale

2. Adjust all sources to the throughput according to their confidences. Variability rather than confidence values are used for the calculations. The variability of a demand is a measure of how much change relative to other demands is to be allowed, and is obtained by subtracting the confidence of the demand from 1. Therefore, while confidence is in the range zero (no confidence) to one (certainty), the corresponding variability values are one (completely variable) to zero (no variability allowed).

   F_v is an initial source's variability: $F_v = 1.0 - F_c$

   F_b is the total calibrated source: $F_b = \sum FiFv$

   C_s is the calibrator for all sources: $C_s = (T - F_t) / F_b$

   F_i $becomes\ Fi + Fi * Fv * Cs$

3. Adjust all sinks in a similar way.

The quality of the demands is unchanged by the scaling operation.

3.3.6 Aggregation of Demands

At this stage, the model contains the connectivity of the region and has initial and scaled (if it was possible) demands. The purpose of this stage is to aggregate those demands through the network, assigning a load to each asset whilst so doing.

The process is as follows:

1. Find a terminus in the model. A terminus is a node with only a single connection. The LV side of a dtx, an open asset, an asset with no onward connection and a primary breaker are all termini.
2. Trace from the terminus through connected items, aggregating the initial load as nodes are visited and recording links that have been visited. Stop at any node where a choice of unvisited links is found.
3. Repeat until no more termini are found.

During aggregation, assets that initially have no load on them will acquire a load from one or more nodes. If acquired from a single node, then the quality of the resultant load is the same as that of the originating load. If acquired from two or more, then the resultant quality is the sum of the qualities of the acquired loads weighted proportionally by their respective load values.

3.3.7 Output of Results

LA outputs a value/quality value pair for each asset for each half hour.

3.4 FCH Phase

FCH operates with normal running conditions.

FCH may use a different period of run for each region. This period is defined by the peak day (48 HHs from midnight) for the primary site to which the feeder breaker connects. This data is contained in the FSI, sheet “Stage 5 inputs”, column “Peak Day”. For rings that are connected to different primary sites, the day used as the peak day is arbitrarily chosen from the possible primary sites.

FCH examines each possible dtx in order to trace a region. Any dtx that was excluded by LA will not have any results, so will not be considered by FCH. Furthermore, FCH is not interested in regions that have no valid feeders, nor is it interested in consumer-owned regions. A consumer-owned region is one where each feeder is in the following list of consumer-owned primary sites:

1. 100646: MEDIA CITY PRIMARY
2. 200116: BOLTON WASTE
3. 200210: THE ROCK
4. 300410: ALDERLEY PK PRY
5. 400020: CPS
6. 609913: QUERNMORE PK
7. 205340: PILKINGTON GLASS
8. 211212: PILKINGTON GLASS

3.4.1 Overview

FCH makes four runs. The first is for “Latest”, the latter three model predictions for the years 2015, 2023 and 2031.

Each run begins by tracing a region from a dtx. LA results, supplied by ladbss, are then applied to the FCH internal model and modified to make them more amenable to FCH processing.

The second, third and fourth runs are concerned with predicting the state of the region according to the FSI and are composed of several stages described in the following sections.

The final stage of each run is to aggregate the terminal loads from dtxs, feeders and HV HH demands through the region to produce results for each asset in the region.

3.4.2 Application of Customer Growth

This purpose of this stage is to predict the growth in customer numbers by local authority for 2015, 2023 and 2031.

For each way on each distribution transformer, the ladbss returns the number of new customers, split by those on existing ways and those to be applied to new transformers. The new customers on existing ways are added immediately to the model and marked as being “new” rather than “existing” customers. The remainder are summed by local authority and temporarily stored. When all distribution transformers in the region have been processed, a number of dummy transformers equal to the number of local authorities in the region are created. They are attached in the model to the first CRMS interconnect found from the region’s feeder breaker. New customers categorised by being on new distribution transformers are then added to the dummy distribution transformer for their local authority. The dummy distribution transformers contribute to the loading on the network - effectively only to the feeder breaker and the primary by virtue of their location - but are not included in the results, with the exception of the customer and new technology counts.

3.4.3 Application of Economic and Efficiency Effects

This stage incorporates in the model the effects on the network of customers changing their demands due to predicted economic growth per local authority and an overall prediction of changes in their demands due to efficiency changes.

The relevant parameters are supplied by the ladbss from values originating in FSI sheet “Stage 2-3 inputs” and tagged “E2 and “E3”. Scale factors to be applied to existing customers’ contributions are stored for all combinations of local authority, customer type and year. A set of factors for new customers are similarly calculated by incorporating values tagged “E4”. When the demand for the way and transformer are subsequently calculated for results, the demand contribution of each customer will be multiplied by the factor relevant to the profile class of that customer, the local authority of its dtx and whether the customer is new or existing.

3.4.4 Application of New Technology Uptake

This stage adds counts of the different types of new technology predicted to be in use into the model.

For each way on a distribution transformer, the ladbss returns counts of the different types of new technology that should be associated with it and with the associated dummy transformer. The counts of new technology associated with the existing way are applied directly to the model. The new technology associated with the dummy distribution transformer is applied to the dummy transformer associated with the local authority of the distribution transformer of the way.

When the demand is subsequently calculated for the way and its distribution transformer either during the calculation of thermal overloading or during the calculation of voltage and harmonics issues, the contribution of the new technology applied during this stage is obtained by summing the results of multiplying the used technology profiles by the relevant technology counts.

The profiles used for the new technology types are derived from values in the FSI sheet “Stage 2-3 inputs” in the sections headed “LV Technology power factor, managed load % and clustering (various sources)” and “LV Technology profiles”. The technology diversity to be used is obtained from the field titled “Select technology diversity” and is one of “N” (Non-diverse), “UD” (Unconstrained Diverse), “MD” (Managed Diverse) or “C” (Combined diverse). If the diversity is “N”, “UD” or “MD”, the profiles used for each technology type are taken directly from the profiles tagged by “P1N” to “P9N”, “P1UD” to P9UD” or “P1MD” to “P9MD” respectively. IF the diversity is “C”, the profile used for each technology is derived from a combination of the unconstrained and managed diverse profiles. These are combined, for each technology type, by the factors supplied as percentages, tagged by “T1” to “T9” and labelled “% customers with managed load”. Because the resultant profiles obtained are in units of kW, a power factor for each technology type is obtained from similarly tagged fields labelled “Power Factor” and stored.

The thermal load contributed by the new technology installations is calculated when needed in terms of real and reactive power. However, all other values in the internal model and in output results are in units of kVA at an assumed power factor. This value is obtained from the FSI, sheet “Stage 2-3 inputs”, labelled “Assumed background LV power factor”. This is expected to be unchanged from its value of 0.95. When converting the real and reactive powers into kVA at this assumed power factor there is, therefore, a small loss of accuracy.

3.4.5 Results

At the end of each run of the FCH model on each region, individual results are produced and summary results are accumulated for each asset of interest. An asset is of interest if it is not consumer-owned, not a dummy transformer as created in 3.4.2 and is of a type in the following list:

1. LV ways
2. Distribution transformers
3. Interconnects
4. Switches. These are entities in the following CRMS tables:
    a. "CIRCUITBREAKER"
    b. "CB_WITHDRAWABLE_FEEDER"
    c. "PLAIN_ABSD"
    d. "SWITCH"
    e. “HV_FUSES”
    f. "DISCONNECTOR"
    g. "CB_132_275_400KV"
    h. "OIL_SWITCH"
    i. "SF6_ISOL_132_275_400KV"
    j. "FUSE_SWITCH"
    k. "CB_FREE_STANDING"
    l. "ISOLATOR_132_275_400KV"
5. Primary sites

The output file names are time stamped with the date and time of the FCH run. The fields in the files are separated by tab characters. The following sections describe the contents of the individual output files and explain the derivation of the values in them.

Screenshots resulting from importing the output results files into Excel are in Appendix 1: FCH Results Screenshots.

3.4.5.1 Asset Counts

For each type of asset, a count is recorded of the total number of that type of asset processed. Distribution transformers are split according to whether they are pole- or ground-mounted, and in what band their rating is. Switches are split according to whether they are the feeder breaker or downstream of it. The list of asset types, including their bandings, is as follows:

1. LV ways
2. HV feeders (thermal)
3. HV feeder sections (thermal) - 1st leg
4. HV feeder sections (thermal) - other legs
5. Switchgear on HV feeders at primaries
6. Switchgear on HV feeders - downstream
7. Primaries
8. Distribution subs - GMT (Ground Mounted Transformer)
9. Distribution subs - GMT: Zero or missing rating
10. Distribution subs - GMT: 25kVA or below
11. Distribution subs - GMT: 50kVA (includes 26-50)
12. Distribution subs - GMT: 100kVA (includes 51-100)
13. Distribution subs - GMT: 200kVA (includes 101-200)
14. Distribution subs - GMT: 300kVA (includes 201-315)
15. Distribution subs - GMT: 500kVA (includes 316-600)
16. Distribution subs - GMT: 750 or 800kVA (includes 601-815)
17. Distribution subs - GMT: 1000kVA (includes 816-1200)

18. Distribution subs - GMT: 1500kVA (includes 1200 and above)
19. Distribution subs - PMT (Pole Mounted Transformer)
20. Distribution subs - PMT: Zero or missing rating
21. Distribution subs - PMT: 25kVA or below
22. Distribution subs - PMT: 50kVA (includes 26-50)
23. Distribution subs - PMT: 100kVA (includes 51-100)
24. Distribution subs - PMT: 200kVA (includes 101-200)
25. Distribution subs - PMT: 300kVA (includes 201-315)
26. Distribution subs - PMT: 500kVA (includes 316-600)
27. Distribution subs - PMT: 750 or 800kVA (includes 601-815)
28. Distribution subs - PMT: 1000kVA (includes 816 and above)

These asset counts are accumulated only at the end of run one, from the basic LA results.

A distribution transformer is classified as pole-mounted if the field “mounting” in the CRMS table “TRANSFORMERS” is “POLE”, otherwise it is classified as ground-mounted.

The next 16 columns give the counts of rating categories for each run - Latest, 2015, 2023 and 2031. A check sum is also given to highlight any possible discrepancy and should always be zero. The rating category (cyclic or continuous) is determined by checking the load profile on the asset against its rating, as described in 3.2.1. The next two columns give the number of the asset type with a zero rating and a missing rating (as determined by the data held in CRMS) respectively. The final column is the sum of the previous two figures expressed as a percentage of the total count of the asset type. The value “NaN” appears in this final column when the total asset count is zero, when any percentage would be meaningless.

3.4.5.2 Asset Overloads

Similarly to the asset counts output, this output is also split by asset type. The results are comprised of counts of overloads of each asset type for each of the four runs (Latest, 2015, 2023 and 2031) and the difference in counts between the “Latest” and the other three runs, all repeated for each of three thresholds. The three thresholds are a base threshold percentage of rating, which differs by asset type, a second, higher than the first by 10%, and a third, lower than the first by 10%. The base thresholds are obtained from FSI sheet “Output - thermal loading”. An asset is counted as overloaded when the utilisation factor of the asset (as defined in section 3.2.1) is strictly greater than the threshold.

3.4.5.3 Customer Counts by Local Authority

This output is split by the local authority of the distribution transformer contributing the customer counts. Each local authority has figures for “Latest”, 2015, 2023 and 2031, each being separated into domestic, non-domestic and total. Each distribution transformer is in a local authority area. However, this information is not known for a small number of transformers. These transformers are placed in the imaginary “__UNKNOWN_TX__” authority and the FSI and outputs reflect this.

3.4.5.4 New Technology Counts by Local Authority

Similarly to the customer counts output, this output is also split by local authority. Each local authority shows the number of each type of new technology predicted to be in place on distribution transformers in that local authority for the years 2015, 2023 and 2031. The nine types are listed in section 3.1.2.

3.4.5.5 New Technology Counts by Primary Site

This output lists the predicted numbers of installations of new technology in 2015, 2023 and 2031, split according to the primary site that feeds the contributing distribution transformer. The new technology types listed are types 1 to 6 in section 3.1.2 i.e. EV and HP that can be expected to add to the primary BSP (Bulk Supply Point) load at peak.

3.4.5.6 Voltage and Harmonic Issue Counts

This output shows the number of assets that may have a voltage or harmonics issue because of the new technology that they are supporting. The assets of interest in this section are distribution transformers and LV ways. Values for thresholds or similar are obtained here via the ladbss from FSI sheet “Output - voltage and harmonics”.

In the following paragraphs, new technology installations are classified as “loading” or “generating”. The loading types are:

1. Electric vehicle private domestic
2. Electric vehicle private non-domestic
3. Electric vehicle public charging
4. Air source heat pump (primary new build)
5. Ground source heat pump domestic (primary retrofit)
6. Heat pump non-domestic

The generating types are:

1. PV domestic
2. PV non-domestic
3. Domestic mCHP

Each asset for each target date (2015, 2023 and 2031) may exceed any of a pair of thresholds for voltage and harmonics for each of a pair of categories of loading or generating new technologies. Two different sets of these four thresholds are obtained according to whether the asset is a distribution transformer or an LV way. Two different sets of these eight thresholds are obtained according to whether the threshold tests are to be made against flat kW or kVA values or against a percentage of the asset’s rating in kVA.

The value to be compared against a threshold is calculated differently depending on whether the threshold relates to loading or generating new technologies. For thresholds relating to loading technologies, the kW load to be compared is calculated as the sum of the product of the peak of the profile of the new technology in kW (see section 3.4.4) and their count. Similarly, the kVA load is calculated as the sum of the product of the peak and the count and the reciprocal of the power factor. For thresholds relating to generating technologies, kW and kVA loads are calculated similarly, except that rather than summing the products, two results are calculated - for PV and mCHP (Micro CHP) - and the maximum used. Loading types are summed because they can reasonably be expected to be used concurrently, whilst PV and mCHP are expected to generate at different times of the day.

Each asset is then checked to determine whether a threshold is breached for each issue type (voltage or harmonics) and each category of new technology (loading or generating). The value used for each check is determined by the field labelled “Threshold to apply” in FSI, sheet “Output - voltage and harmonics”. This field can have several values, each of which results in a different determination of whether the asset breaches the threshold, as follows:

Threshold to apply	Threshold breached if...
kW	kW load > flat threshold for relevant asset type, issue type and technology category
kVA	kVA load > flat threshold for relevant asset type, issue type and technology category
% of cyclic rating	kVA load > percentage threshold for relevant asset type, issue type and technology category multiplied by 100 and divided by the asset rating
kVA and % of cyclic rating	both of the tests "kVA" and "% of cyclic rating" determined a breach

As a result of the above process, the thresholds exceeded are determined for each asset (distribution transformer or LV way), for each target date (2015, 2023 and 2031), for each issue type (voltage or harmonics) and for each category of new technology (loading or generating). The algorithm then proceeds to calculate the breaches for a third pseudo-category of new technology where the asset is also thermally overloaded. Finally, it calculates a third pseudo-category of asset type where, if the asset is an LV way, its parent distribution transformer also breaches the same threshold.

3.4.5.7 Primary Detailed Results

This output lists results for each primary site for "Latest", 2015, 2023 and 2031. Each result lists the primary transformers in the site, input data obtained from FSI and output results for that site for that period. The inputs from FSI sheet "Stage 5 inputs" and repeated here are the peak day, firm capacity and generation correction. The results given are the peak load on that site, the utilisation factor and a set of 48 values showing the load profile on the site for the 48 HH periods throughout the peak day. Because the feeder regions fed from a site are processed randomly, the load on the site is accumulated as each feeder region is processed. Once all regions have been processed, the peak load can be calculated from the total load profile for the site. The utilisation is then calculated as the ratio of the peak load less the generation correction to the firm capacity.

3.4.5.8 Other Asset Types' Detailed Results

These results are produced for each asset of interest for each of the periods "Latest", 2015, 2023 and 2031. A row is produced for each asset for each of the stated periods containing the following fields:

1. The period. This is one of "Latest", 2015, 2023 or 2031.
2. The type of asset, as described in 3.4.5.1. If the asset is an LV way, then the type ("LV ways") is prefixed by the type of its parent distribution transformer.
3. The name of the asset. This is the value of the field "substation" in the CRMS table "TRANSFORMERS" for distribution transformers. For interconnects, it is the value of the field "circuit" in the CRMS table "INTERCONNECTS". If the asset is an LV way, then the name shown is "LV ways" prefixed by the name of its parent distribution transformer.
4. The CRMS plant reference of the asset.
5. The way identifier. If the asset is not an LV way, this field is blank.
6. The units for values in the row. This is always "kVA".
7. The rating of the asset. This is the rating used in determining overload counts used in the overloads summary outputs.
8. The rating type. This is the rating type used when determining rating type counts as listed in the asset counts summary sheet.

9. The peak load. This is the maximum value of the load on the asset during the peak day of its primary.
10. The utilisation factor. This is ratio of the peak load to the rating.
11. The primary site(s). This is the site or sites that contribute to feeding the region in which the asset is. If there is more than one listed, then the asset is in a ring or non-radial region.
12. A set of 48 values showing the load on the asset for the 48 HH periods during the peak day for its feeder.

3.4.5.9 Data from the Input Spreadsheet

This output is produced to show the values obtained from FSI and used by the LA and FCH algorithms.

3.4.5.10 Log File

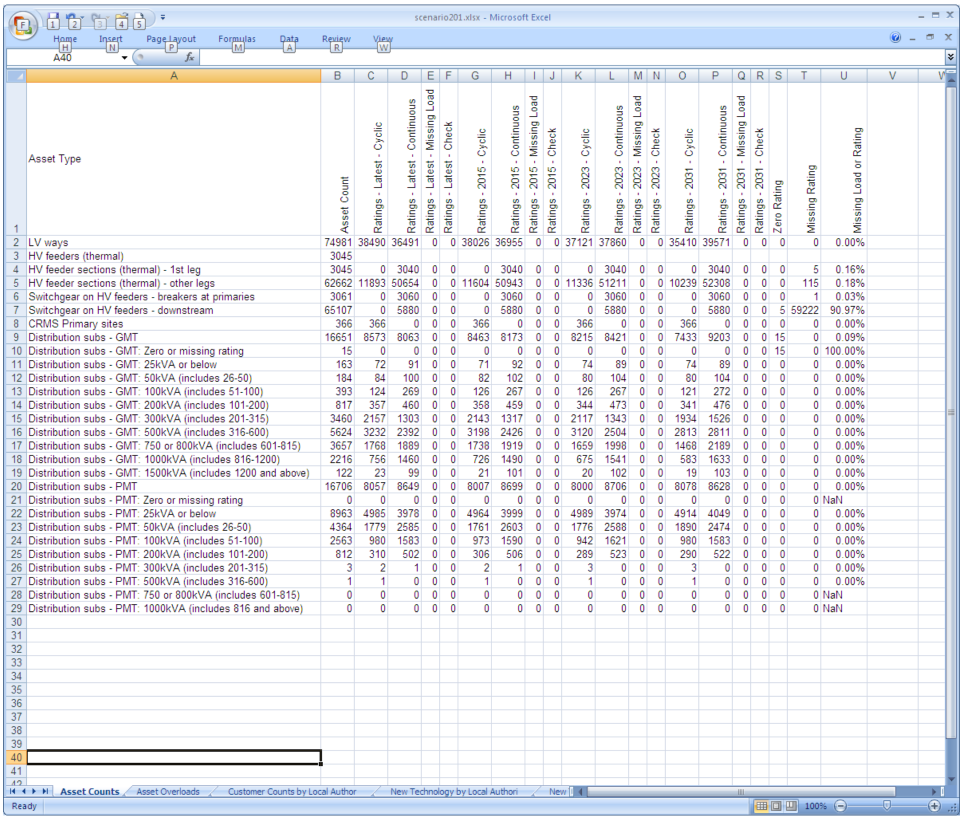
This file records messages from the FCH algorithms.

4 Future Requirements

1. Extend / alter the FCH potentially to include additional low-carbon technology types.
2. Amend the approach for assessing number of interventions for voltage and harmonics issues.
3. Incorporate new adjustment input(s) to FCH to give consistency with the Grid and Primary baseline forecast.
4. Incorporate thermal rating / overloads of HV switches.
5. Review baseline customer numbers in model – partially addressed under data quality issues in IFI load allocation project - confirm inclusion of customers at HV and at distribution subs as being included for customer counts, allocation of new low-carbon technology, and aggregation of load.
6. Review approach to clustering of new connections and new technology
7. Review the allocation of existing PV to network using data from DGdatabase
8. Create new output files, including 2031 run and overloads classified by load indices (LIs) (The definitions of LIs for secondary network assets are to be confirmed).

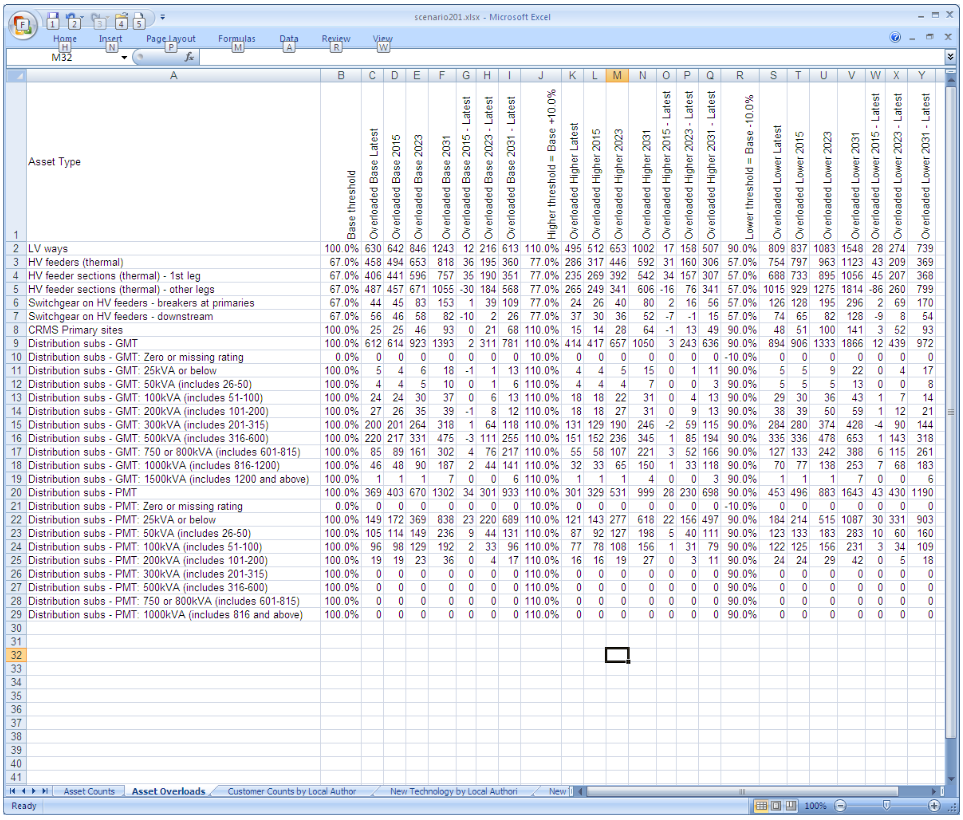
Appendix 1: FCH Results Screenshots

This section shows the results of importing the FCH output results files into Excel and performing some minor formatting adjustments, generally to the header row and column size.



	Asset Type	Asset Count	Ratings - Latest - Cyclic	Ratings - Latest - Continuous	Ratings - Latest - Missing Load	Ratings - Latest - Check	Ratings - 2015 - Cyclic	Ratings - 2015 - Continuous	Ratings - 2015 - Missing Load	Ratings - 2015 - Check	Ratings - 2023 - Cyclic	Ratings - 2023 - Continuous	Ratings - 2023 - Missing Load	Ratings - 2023 - Check	Ratings - 2031 - Cyclic	Ratings - 2031 - Continuous	Ratings - 2031 - Missing Load	Ratings - 2031 - Check	Zero Rating	Missing Rating	Missing Load or Rating
2	LV ways	74981	38490	36491	0	0	38026	36955	0	0	37121	37860	0	0	35410	39571	0	0	0	0	0.00%
3	HV feeders (thermal)	3045																			
4	HV feeder sections (thermal) - 1st leg	3045	0	3040	0	0	0	3040	0	0	0	3040	0	0	0	3040	0	0	0	5	0.16%
5	HV feeder sections (thermal) - other legs	62662	11893	50654	0	0	11604	50943	0	0	11336	51211	0	0	10239	52308	0	0	0	115	0.18%
6	Switchgear on HV feeders - breakers at primaries	3061	0	3060	0	0	0	3060	0	0	0	3060	0	0	0	3060	0	0	0	1	0.03%
7	Switchgear on HV feeders - downstream	65107	0	5880	0	0	0	5880	0	0	0	5880	0	0	0	5880	0	0	5	59222	90.97%
8	CRMS Primary sites	366	366	0	0	0	366	0	0	0	366	0	0	0	366	0	0	0	0	0	0.00%
9	Distribution subs - GMT	16651	8573	8063	0	0	8463	8173	0	0	8215	8421	0	0	7433	9203	0	0	15	0	0.09%
10	Distribution subs - GMT: Zero or missing rating	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	100.00%
11	Distribution subs - GMT: 25kVA or below	163	72	91	0	0	71	92	0	0	74	89	0	0	74	89	0	0	0	0	0.00%
12	Distribution subs - GMT: 50kVA (includes 26-50)	184	84	100	0	0	82	102	0	0	80	104	0	0	80	104	0	0	0	0	0.00%
13	Distribution subs - GMT: 100kVA (includes 51-100)	393	124	269	0	0	126	267	0	0	126	267	0	0	121	272	0	0	0	0	0.00%
14	Distribution subs - GMT: 200kVA (includes 101-200)	817	357	460	0	0	358	459	0	0	344	473	0	0	341	476	0	0	0	0	0.00%
15	Distribution subs - GMT: 300kVA (includes 201-315)	3460	2157	1303	0	0	2143	1317	0	0	2117	1343	0	0	1934	1526	0	0	0	0	0.00%
16	Distribution subs - GMT: 500kVA (includes 316-600)	5624	3232	2392	0	0	3198	2426	0	0	3120	2504	0	0	2813	2811	0	0	0	0	0.00%
17	Distribution subs - GMT: 750 or 800kVA (includes 601-815)	3657	1768	1889	0	0	1738	1919	0	0	1659	1998	0	0	1468	2189	0	0	0	0	0.00%
18	Distribution subs - GMT: 1000kVA (includes 816-1200)	2216	756	1460	0	0	726	1490	0	0	675	1541	0	0	583	1633	0	0	0	0	0.00%
19	Distribution subs - GMT: 1500kVA (includes 1200 and above)	122	23	99	0	0	21	101	0	0	20	102	0	0	19	103	0	0	0	0	0.00%
20	Distribution subs - PMT	16706	8057	8649	0	0	8007	8699	0	0	8000	8706	0	0	8078	8628	0	0	0	0	0.00%
21	Distribution subs - PMT: Zero or missing rating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NaN
22	Distribution subs - PMT: 25kVA or below	8963	4985	3978	0	0	4964	3999	0	0	4989	3974	0	0	4914	4049	0	0	0	0	0.00%
23	Distribution subs - PMT: 50kVA (includes 26-50)	4364	1779	2585	0	0	1761	2603	0	0	1776	2588	0	0	1890	2474	0	0	0	0	0.00%
24	Distribution subs - PMT: 100kVA (includes 51-100)	2563	980	1583	0	0	973	1590	0	0	942	1621	0	0	980	1583	0	0	0	0	0.00%
25	Distribution subs - PMT: 200kVA (includes 101-200)	812	310	502	0	0	306	506	0	0	289	523	0	0	290	522	0	0	0	0	0.00%
26	Distribution subs - PMT: 300kVA (includes 201-315)	3	2	1	0	0	2	1	0	0	3	0	0	0	3	0	0	0	0	0	0.00%
27	Distribution subs - PMT: 500kVA (includes 316-600)	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0.00%
28	Distribution subs - PMT: 750 or 800kVA (includes 601-815)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NaN
29	Distribution subs - PMT: 1000kVA (includes 816 and above)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NaN

Figure 3.4.5.1-a: Asset Counts



Asset Type	Base threshold	Overloaded Base Latest	Overloaded Base 2015	Overloaded Base 2023	Overloaded Base 2031	Overloaded Base 2015 - Latest	Overloaded Base 2023 - Latest	Overloaded Base 2031 - Latest	Higher threshold = Base +10.0%	Overloaded Higher Latest	Overloaded Higher 2015	Overloaded Higher 2023	Overloaded Higher 2031	Overloaded Higher 2015 - Latest	Overloaded Higher 2023 - Latest	Overloaded Higher 2031 - Latest	Lower threshold = Base -10.0%	Overloaded Lower Latest	Overloaded Lower 2015	Overloaded Lower 2023	Overloaded Lower 2031	Overloaded Lower 2015 - Latest	Overloaded Lower 2023 - Latest	Overloaded Lower 2031 - Latest
LV ways	100.0%	630	642	846	1243	12	216	613	110.0%	495	512	653	1002	17	158	507	90.0%	809	837	1083	1548	28	274	739
HV feeders (thermal)	67.0%	458	494	653	818	36	195	360	77.0%	286	317	446	592	31	160	306	57.0%	754	797	963	1123	43	209	369
HV feeder sections (thermal) - 1st leg	67.0%	406	441	596	757	35	190	351	77.0%	235	269	392	542	34	157	307	57.0%	688	733	895	1056	45	207	368
HV feeder sections (thermal) - other legs	67.0%	487	457	671	1055	-30	184	568	77.0%	265	249	341	606	-16	76	341	57.0%	1015	929	1275	1814	-86	260	799
Switchgear on HV feeders - breakers at primaries	67.0%	44	45	83	153	1	39	109	77.0%	24	26	40	80	2	16	56	57.0%	126	128	195	296	2	69	170
Switchgear on HV feeders - downstream	67.0%	56	46	58	82	-10	2	26	77.0%	37	30	36	52	-7	-1	15	57.0%	74	65	82	128	-9	8	54
CRMS Primary sites	100.0%	25	25	46	93	0	21	68	110.0%	15	14	28	64	-1	13	49	90.0%	48	51	100	141	3	52	93
Distribution subs - GMT	100.0%	612	614	923	1393	2	311	781	110.0%	414	417	657	1050	3	243	636	90.0%	894	906	1333	1866	12	439	972
Distribution subs - GMT: Zero or missing rating	0.0%	0	0	0	0	0	0	0	10.0%	0	0	0	0	0	0	0	-10.0%	0	0	0	0	0	0	0
Distribution subs - GMT: 25kVA or below	100.0%	5	4	6	18	-1	1	13	110.0%	4	4	5	15	0	1	11	90.0%	5	5	9	22	0	4	17
Distribution subs - GMT: 50kVA (includes 26-50)	100.0%	4	4	5	10	0	1	6	110.0%	4	4	4	7	0	0	3	90.0%	5	5	5	13	0	0	8
Distribution subs - GMT: 100kVA (includes 51-100)	100.0%	24	24	30	37	0	6	13	110.0%	18	18	22	31	0	4	13	90.0%	29	30	36	43	1	7	14
Distribution subs - GMT: 200kVA (includes 101-200)	100.0%	27	26	35	39	-1	8	12	110.0%	18	18	27	31	0	9	13	90.0%	38	39	50	59	1	12	21
Distribution subs - GMT: 300kVA (includes 201-315)	100.0%	200	201	264	318	1	64	118	110.0%	131	129	190	246	-2	59	115	90.0%	284	280	374	428	-4	90	144
Distribution subs - GMT: 500kVA (includes 316-600)	100.0%	220	217	331	475	-3	111	255	110.0%	151	152	236	345	1	85	194	90.0%	335	336	478	653	1	143	318
Distribution subs - GMT: 750 or 800kVA (includes 601-815)	100.0%	85	89	161	302	4	76	217	110.0%	55	58	107	221	3	52	166	90.0%	127	133	242	388	6	115	261
Distribution subs - GMT: 1000kVA (includes 816-1200)	100.0%	46	48	90	187	2	44	141	110.0%	32	33	65	150	1	33	118	90.0%	70	77	138	253	7	68	183
Distribution subs - GMT: 1500kVA (includes 1200 and above)	100.0%	1	1	1	7	0	0	6	110.0%	1	1	1	4	0	0	3	90.0%	1	1	1	7	0	0	6
Distribution subs - PMT	100.0%	369	403	670	1302	34	301	933	110.0%	301	329	531	999	28	230	698	90.0%	453	496	883	1643	43	430	1190
Distribution subs - PMT: Zero or missing rating	0.0%	0	0	0	0	0	0	0	10.0%	0	0	0	0	0	0	0	-10.0%	0	0	0	0	0	0	0
Distribution subs - PMT: 25kVA or below	100.0%	149	172	369	838	23	220	689	110.0%	121	143	277	618	22	156	497	90.0%	184	214	515	1087	30	331	903
Distribution subs - PMT: 50kVA (includes 26-50)	100.0%	105	114	149	236	9	44	131	110.0%	87	92	127	198	5	40	111	90.0%	123	133	183	283	10	60	160
Distribution subs - PMT: 100kVA (includes 51-100)	100.0%	96	98	129	192	2	33	96	110.0%	77	78	108	156	1	31	79	90.0%	122	125	156	231	3	34	109
Distribution subs - PMT: 200kVA (includes 101-200)	100.0%	19	19	23	36	0	4	17	110.0%	16	16	19	27	0	3	11	90.0%	24	24	29	42	0	5	18
Distribution subs - PMT: 300kVA (includes 201-315)	100.0%	0	0	0	0	0	0	0	110.0%	0	0	0	0	0	0	0	90.0%	0	0	0	0	0	0	0
Distribution subs - PMT: 500kVA (includes 316-600)	100.0%	0	0	0	0	0	0	0	110.0%	0	0	0	0	0	0	0	90.0%	0	0	0	0	0	0	0
Distribution subs - PMT: 750 or 800kVA (includes 601-815)	100.0%	0	0	0	0	0	0	0	110.0%	0	0	0	0	0	0	0	90.0%	0	0	0	0	0	0	0
Distribution subs - PMT: 1000kVA (includes 816 and above)	100.0%	0	0	0	0	0	0	0	110.0%	0	0	0	0	0	0	0	90.0%	0	0	0	0	0	0	0

Figure 3.4.5.2-b: Asset Overloads

Local Authority Name	Latest - Domestic	Latest - Non-domestic	Latest - Total	2015 - Domestic	2015 - Non-domestic	2015 - Total	2023 - Domestic	2023 - Non-domestic	2023 - Total	2031 - Domestic	2031 - Non-domestic	2031 - Total
ALLERDALE	44892	5158	50050	45363	5201	50564	47037	5298	52335	54718	5617	60335
BARROW	33038	2127	35165	33279	2144	35423	34984	2183	37167	48649	2317	50966
BLACKBURN	59623	4954	64577	60236	4990	65226	62788	5081	67869	75943	5410	81353
BLACKPOOL	67289	6622	73911	67645	6661	74306	70223	6780	77003	91541	7266	98807
BOLTON	121577	7868	129445	122901	7929	130830	129742	8076	137818	171859	8577	180436
BURNLEY	40160	3071	43231	40413	3095	43508	41247	3153	44400	44837	3351	48188
BURY	81222	5182	86404	82034	5221	87255	86209	5317	91526	111948	5654	117602
CARLISLE	49106	5057	54163	50014	5098	55112	53986	5193	59179	75313	5509	80822
CHESHIRE EAST	60292	5364	65656	61178	5410	66588	65397	5512	70909	89548	5839	95387
CHORLEY	45448	3249	48697	46115	3274	49389	49294	3335	52629	67504	3541	71045
COPELAND	32160	2614	34774	32731	2624	35355	35098	2669	37767	47309	2914	50223
CRAVEN	7818	1256	9074	7954	1268	9222	8696	1292	9988	13495	1367	14862
EDEN	24583	4201	28784	24826	4238	29064	26535	4318	30853	40235	4570	44805
FYLDE	35921	3078	38999	36259	3105	39364	38709	3164	41873	58951	3348	62299
HIGH PEAK	38429	3084	41513	39067	3108	42175	42077	3166	45243	59354	3364	62718
HYNDBURN	36054	3008	39062	36415	3033	39448	38114	3090	41204	47881	3274	51155
LANCASTER	60718	5510	66228	61920	5554	67474	67288	5657	72945	96657	6005	102662
MANCHESTER	217359	18839	236198	223053	18984	242037	246745	19335	266080	368988	20543	389531
OLDHAM	93950	6260	100210	94882	6305	101187	99850	6421	106271	131212	6835	138047
PENDLE	31805	2584	34389	32171	2606	34777	34181	2655	36836	47179	2811	49990
PRESTON	59181	5489	64670	59873	5523	65396	63145	5623	68768	81940	6022	87962
RIBBLE VALLEY	24098	2658	26756	24645	2682	27327	26915	2733	29648	38619	2890	41509
ROCHDALE	90709	6174	96883	91425	6221	97646	94799	6337	101136	114219	6730	120949
ROSSENDALE	30903	2540	33443	31508	2563	34071	34018	2612	36630	46954	2764	49718
SALFORD	107684	7605	115289	109559	7666	117225	118774	7808	126582	173272	8281	181553
SOUTH LAKELAND	53060	7167	60227	53809	7231	61040	58303	7367	65670	89736	7794	97530
SOUTH RIBBLE	47363	3071	50434	48144	3098	51242	51317	3156	54473	67425	3342	70767
ST HELENS	22211	1167	23378	22407	1176	23583	23331	1198	24529	28643	1271	29914
STOCKPORT	127004	8661	135665	128592	8734	137326	136606	8898	145504	185285	9429	194714
TAMESIDE	98476	6300	104776	99866	6346	106212	106456	6463	112919	144263	6873	151136
TRAFFORD	95340	7751	103091	97123	7822	104945	105752	7970	113722	156149	8426	164575
WARRINGTON	9763	841	10604	9928	848	10776	10746	864	11610	15620	916	16536
WEST LANCASHIRE	41101	3468	44569	41596	3499	45095	43656	3565	47221	54279	3774	58053
WIGAN	139370	8222	147592	141113	8286	149399	149405	8440	157845	196958	8965	205923
WYRE	48974	4122	53096	49845	4154	53999	54468	4232	58700	83651	4491	88142
__ UNKNOWN TX __	17	4	21	17	4	21	18	4	22	25	4	29
Totals	2176698	174326	2351024	2207906	175701	2383607	2355909	178965	2534874	3220159	190084	3410243

Figure 3.4.5.3-c: Customer Counts by Local Authority

Local Authority Name	2015 - EV private domestic	2015 - EV private non-domestic	2015 - EV public charging	2015 - Air source HP (primarily new build)	2015 - Ground source HP domestic (primarily retrofit)	2015 - HP non-domestic	2015 - PV domestic	2015 - PV non-domestic (at median size in model)	2015 - Domestic micro CHP
ALLERDALE	136	111	1	454	109	229	241	54	0
BARROW	23	18	1	66	17	129	72	0	0
BLACKBURN	126	102	1	120	30	219	347	3	0
BLACKPOOL	101	82	1	135	34	398	147	11	0
BOLTON	394	344	32	246	61	349	300	3	0
BURNLEY	61	49	1	81	20	81	131	10	0
BURY	360	280	31	164	41	230	206	5	0
CARLISLE	140	119	4	226	50	224	303	0	0
CHESHIRE EAST	458	363	4	611	147	324	333	3	0
CHORLEY	175	141	8	208	46	144	219	3	0
COPELAND	76	61	1	66	16	116	110	4	0
CRAVEN	36	28	0	79	8	33	55	0	0
EDEN	136	110	8	248	60	186	336	7	0
FYLDE	163	129	1	72	18	186	210	9	0
HIGH PEAK	168	148	1	175	19	137	158	0	0
HYNDBURN	40	34	1	73	18	79	95	28	0
LANCASTER	217	176	1	279	62	244	243	17	0
MANCHESTER	379	338	36	1003	111	1139	272	110	0
OLDHAM	256	201	30	189	47	164	150	29	0
PENDLE	51	41	0	64	16	68	110	2	0
PRESTON	155	126	1	269	60	331	201	27	0
RIBBLE VALLEY	155	125	1	247	59	70	194	20	0
ROCHDALE	247	206	31	183	46	162	243	13	0
ROSSENDALE	85	68	1	63	16	113	136	2	0
SALFORD	243	201	31	220	54	460	217	0	0
SOUTH LAKELAND	247	208	1	538	129	318	448	6	0
SOUTH RIBBLE	192	157	6	216	48	136	268	37	0
ST HELENS	43	34	0	45	11	52	31	0	0
STOCKPORT	1233	992	34	257	64	521	593	34	0
TAMESIDE	190	161	30	200	50	165	135	11	0
TRAFFORD	1000	778	30	194	48	470	163	10	0
WARRINGTON	43	34	0	20	5	51	41	0	0
WEST LANCASHIRE	204	165	1	186	41	91	133	5	0
WIGAN	410	329	31	282	70	364	1145	5	0
WYRE	255	203	1	225	50	108	252	14	0
__ UNKNOWN TX __	0	0	0	0	0	0	0	0	0
Totals	8198	6662	362	7704	1681	8091	8238	482	0

Local Authority Name	2023 - EV private domestic	2023 - EV private non-domestic	2023 - EV public charging	2023 - Air source HP (primarily new build)	2023 - Ground source HP domestic (primarily retrofit)	2023 - HP non-domestic	2023 - PV domestic	2023 - PV non-domestic (at median size in model)	2023 - Domestic micro CHP
ALLERDALE	1599	1331	119	1882	211	1483	241	54	0
BARROW	252	213	21	525	35	786	72	0	0
BLACKBURN	1401	1211	115	941	62	1422	347	3	0
BLACKPOOL	1137	978	94	1053	70	2437	147	11	0
BOLTON	4687	4124	416	1947	129	2260	300	3	0
BURNLEY	687	583	56	618	41	632	131	10	0
BURY	3923	3338	382	1293	87	1489	206	5	0
CARLISLE	1620	1421	133	4319	108	1454	303	0	0
CHESHIRE EAST	5156	4361	412	5230	295	1988	333	3	0
CHORLEY	2005	1691	171	1976	99	934	219	3	0
COPELAND	876	737	66	1401	69	752	110	4	0
CRAVEN	423	342	31	696	17	258	55	0	0
EDEN	1574	1316	131	2123	119	1209	336	7	0
FYLDE	1823	1551	145	1548	78	1139	210	9	0
HIGH PEAK	2092	1768	146	1683	84	887	158	0	0
HYNDBURN	468	407	39	572	38	618	95	28	0
LANCASTER	2449	2103	195	2690	135	1584	243	17	0
MANCHESTER	4466	4027	441	9870	247	6960	272	110	0
OLDHAM	2780	2400	285	1498	100	1283	150	29	0
PENDLE	570	494	48	513	34	531	110	2	0
PRESTON	1724	1498	139	2526	126	2024	201	27	0
RIBBLE VALLEY	1789	1505	140	2154	121	547	194	20	0
ROCHDALE	2749	2464	291	1422	95	1267	243	13	0
ROSSENDALE	966	828	78	1361	34	732	136	2	0
SALFORD	2734	2401	287	4741	120	2804	217	0	0
SOUTH LAKELAND	2927	2493	222	4664	262	2063	448	6	0
SOUTH RIBBLE	2212	1878	185	2052	103	883	268	37	0
ST HELENS	462	402	38	350	23	335	31	0	0
STOCKPORT	13865	7265	1159	5463	274	3200	593	34	0
TAMESIDE	2237	1925	233	1597	106	1292	135	11	0
TRAFFORD	11041	9309	955	4231	105	2869	163	10	0
WARRINGTON	488	410	38	430	21	311	41	0	0
WEST LANCASHIRE	2288	1963	180	1740	87	717	133	5	0
WIGAN	4587	3941	431	5977	149	2363	1145	5	0
WYRE	2881	2429	225	4358	108	846	252	14	0
__ UNKNOWN TX __	1	2	0	1	0	1	0	0	0
Totals	92939	75109	8047	85445	3792	52360	8238	482	0

Local Authority Name	2031 - EV private domestic	2031 - EV private non-domestic	2031 - EV public charging	2031 - Air source HP (primarily new build)	2031 - Ground source HP domestic (primarily retrofit)	2031 - HP non-domestic	2031 - PV domestic	2031 - PV non-domestic (at median size in model)	2031 - Domestic micro CHP
ALLERDALE	11841	8914	125	7004	788	3460	241	54	0
BARROW	2151	1428	22	2335	156	1835	72	0	0
BLACKBURN	10595	4434	121	3645	243	3332	347	3	0
BLACKPOOL	9236	6626	99	4392	293	5754	147	11	0
BOLTON	38550	27556	439	8251	550	5284	300	3	0
BURNLEY	4735	2749	59	2153	144	1476	131	10	0
BURY	31883	4621	402	5373	358	3482	206	5	0
CARLISLE	13925	4601	141	19280	482	3393	303	0	0
CHESHIRE EAST	43789	29154	433	22927	1286	4626	333	3	0
CHORLEY	17020	11290	180	8638	433	2181	219	3	0
COPELAND	7278	5032	72	6058	303	1794	110	4	0
CRAVEN	4043	1165	32	3454	86	602	55	0	0
EDEN	14452	3880	139	10300	580	2815	336	7	0
FYLDE	17025	2749	152	7545	377	2651	210	9	0
HIGH PEAK	18220	11808	153	7598	380	2071	158	0	0
HYNDBURN	3696	2673	41	2298	153	1441	95	28	0
LANCASTER	21610	4931	205	12369	618	3699	243	17	0
MANCHESTER	41290	16662	464	47231	1181	16270	272	110	0
OLDHAM	22656	5568	299	6300	420	3008	150	29	0
PENDLE	4930	2318	52	2264	151	1237	110	2	0
PRESTON	13946	10088	148	10489	525	4770	201	27	0
RIBBLE VALLEY	15695	10039	148	9887	556	1272	194	20	0
ROCHDALE	20788	5539	306	5482	365	2961	243	13	0
ROSSENDALE	8193	2275	82	6010	150	1702	136	2	0
SALFORD	24572	6772	297	22203	557	6559	217	0	0
SOUTH LAKELAND	27531	16664	233	22972	1292	4801	448	6	0
SOUTH RIBBLE	18245	12528	193	8631	431	2059	268	37	0
ST HELENS	3561	1049	40	1375	92	783	31	0	0
STOCKPORT	116415	79469	1221	23717	1186	7471	593	34	0
TAMESIDE	18819	5618	246	6929	461	3024	135	11	0
TRAFFORD	99545	6877	1003	19987	499	6674	163	10	0
WARRINGTON	4383	2739	40	2000	100	726	41	0	0
WEST LANCASHIRE	17739	13155	192	6947	350	1658	133	5	0
WIGAN	37658	26536	454	25211	630	5522	1145	5	0
WYRE	26855	3706	237	21413	535	1976	252	14	0
__ UNKNOWN TX __	6	4	0	3	0	2	0	0	0
Totals	792876	361217	8470	382671	16711	122371	8238	482	0

Figure 3.4.5.4-d: New Technology Counts by Local Authority

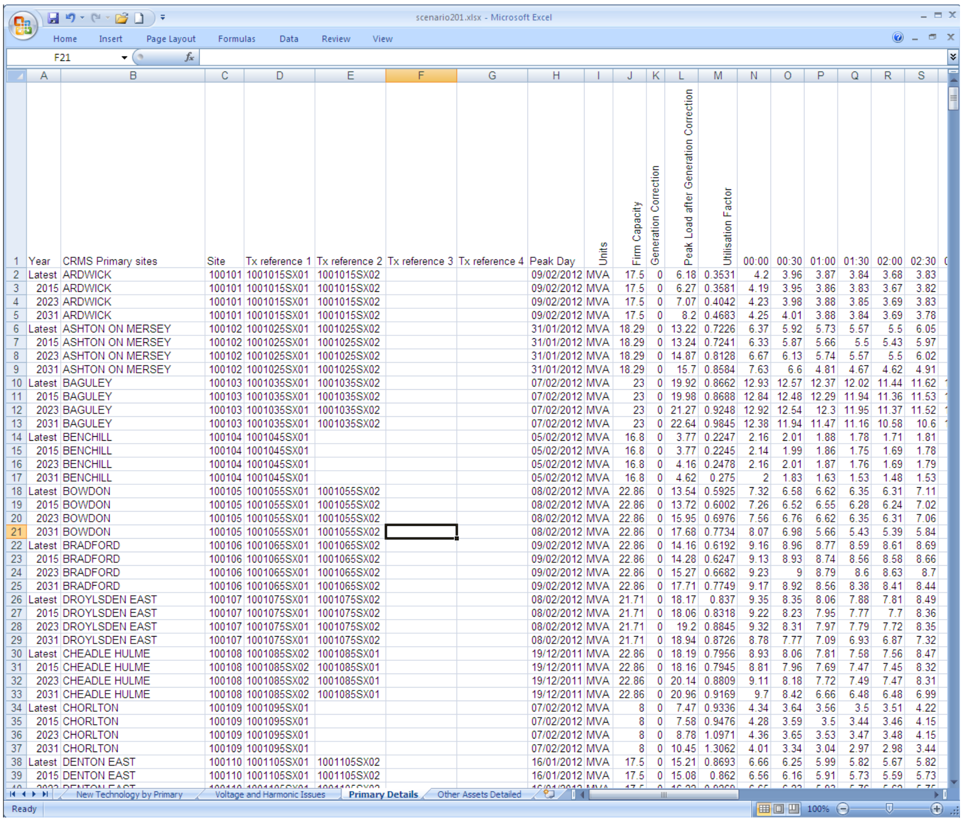
	Site	CRMS Primary sites	2015 - EV private domestic	2015 - EV private non-domestic	2015 - EV public charging	2015 - Air source HP (primarily new build)	2015 - Ground source HP domestic (primarily retrofit)	2015 - HP non-domestic	2023 - EV private domestic	2023 - EV private non-domestic	2023 - EV public charging	2023 - Air source HP (primarily new build)	2023 - Ground source HP domestic (primarily retrofit)	2023 - HP non-domestic	2031 - EV private domestic	2031 - EV private non-domestic	2031 - EV public charging	2031 - Air source HP (primarily new build)	2031 - Ground source HP domestic (primarily retrofit)	2031 - HP non-domestic
2	100101	ARDWICK	3	5	1	3	0	13	24	57	9	61	4	105	225	224	8	271	11	216
3	100102	ASHTON ON MERSEY	129	38	1	17	3	21	1058	346	59	419	8	145	9592	361	48	1967	39	351
4	100103	BAGULEY	20	7	0	47	5	18	215	58	10	385	9	116	1749	271	7	1767	48	269
5	100104	BENCHILL	6	2	0	12	2	4	54	16	2	133	6	29	557	71	2	653	21	69
6	100105	BOWDON	83	62	4	15	5	47	858	642	87	305	10	303	7876	684	94	1615	30	667
7	100106	BRADFORD	3	6	0	17	1	21	75	78	11	168	4	140	667	340	12	791	24	335
8	100107	DROYLSDEN EAST	22	11	0	28	5	19	264	165	22	230	18	131	2380	476	16	1056	49	288
9	100108	CHEADLE HULME	93	69	2	24	4	31	1087	470	65	421	24	226	9087	497	98	1852	75	482
10	100109	CHORLTON	4	9	1	27	1	23	133	75	4	257	1	130	1099	306	9	1222	42	300
356	609910	BURROW BECK	27	9	0	33	6	20	289	189	15	276	12	136	2382	416	19	1341	71	302
357	609912	CATTERALL WATER WKS	4	10	0	6	2	6	81	76	7	137	1	30	750	120	10	565	18	54
358	609915	YEALAND	5	2	0	8	1	2	53	50	3	76	2	25	435	96	1	359	25	69
359	609918	TRIMPELL (CONS)	2	3	0	4	1	3	34	32	0	43	0	14	286	62	3	174	10	47
360	609919	CLAUGHTON	5	8	0	9	1	5	61	60	3	63	3	43	609	136	7	336	14	98
361	609920	PREESALL	34	27	0	23	4	19	305	359	34	482	13	137	3129	550	27	2418	51	298
362	609958	MELLING	2	7	0	3	2	8	33	76	14	41	0	64	316	178	6	180	10	131
363	609961	FLAT LN	8	7	0	18	1	8	93	100	7	166	5	75	919	7883	8	768	23	145
364	609962	SETTLE	6	4	0	13	1	8	98	83	5	174	6	60	1075	291	7	962	32	158
365	609963	BENTHAM	12	6	0	17	3	12	118	73	5	186	1	56	1046	270	9	883	17	140
366	609964	INGLETON	6	5	0	20	0	3	63	60	8	97	5	49	632	219	5	502	12	107
367	609965	HELWITH BRIDGE	4	5	0	8	3	3	41	40	7	73	0	21	350	116	3	308	6	64
368	668005	_UNKNOWN_	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
369		Totals	8198	6662	362	7704	1681	8091	92939	75109	8047	85445	3792	52360	792876	361217	8470	382671	16711	122371

Figure 3.4.5.5-e: New Technology by Primary Site

Note that rows 11 to 355 have been hidden.

	A	B	C	D	E	F	G	H	I	J
1	Count number of assets above threshold	2015 - LV way	2015 - Dist sub	2015 - LV way on Dist sub above threshold	2023 - LV way	2023 - Dist sub	2023 - LV way on Dist sub above threshold	2031 - LV way	2031 - Dist sub	2031 - LV way on Dist sub above threshold
2	Above Voltage threshold for EV and HP	99	561	31	3682	7159	3023	16291	19087	15733
3	Above Voltage threshold for EV and HP (and the same asset also thermally overloaded)	44	104	4	541	1245	265	1091	2612	671
4	Above Voltage threshold for PV or mCHP	5	6	3	5	6	3	5	6	3
5	Above Harmonics threshold for EV and HP	7	238	1	955	2979	632	7040	12919	6458
6	Above Harmonics threshold for EV and HP (and the same asset also thermally overloaded)	6	53	1	365	918	181	993	2544	610
7	Above Harmonics threshold for PV or mCHP	0	2	0	0	2	0	0	2	0

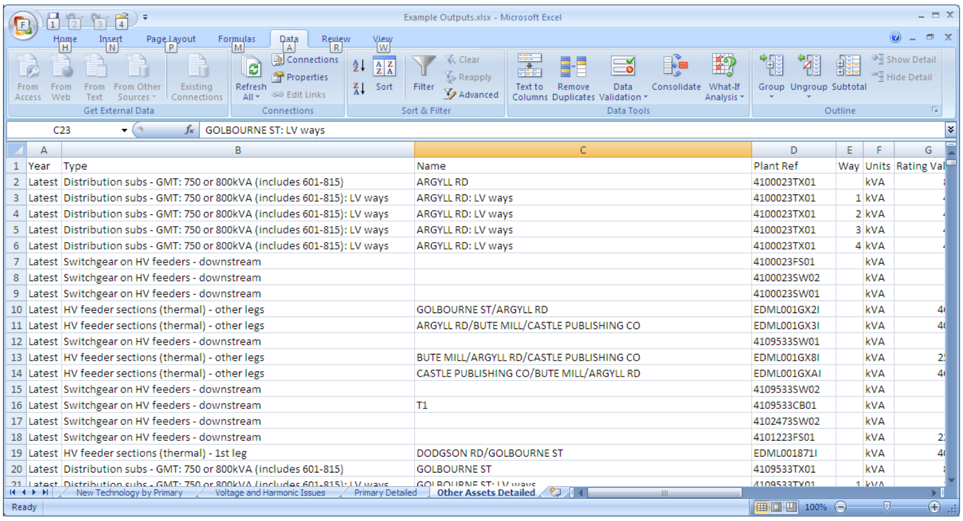
Figure 3.4.5.6-f: Voltage and Harmonic Issue Counts



	Year	CRMS Primary sites	Site	Tx reference 1	Tx reference 2	Tx reference 3	Tx reference 4	Peak Day	Units	Firm Capacity	Generation Correction	Peak Load after Generation Correction	Utilisation Factor	00:00	00:30	01:00	01:30	02:00	02:30
2	Latest	ARDWICK	100101	1001015SX01	1001015SX02			09/02/2012	MVA	17.5	0	6.18	0.3531	4.2	3.96	3.87	3.84	3.68	3.83
3	2015	ARDWICK	100101	1001015SX01	1001015SX02			09/02/2012	MVA	17.5	0	6.27	0.3581	4.19	3.95	3.86	3.83	3.67	3.82
4	2023	ARDWICK	100101	1001015SX01	1001015SX02			09/02/2012	MVA	17.5	0	7.07	0.4042	4.23	3.98	3.88	3.85	3.69	3.83
5	2031	ARDWICK	100101	1001015SX01	1001015SX02			09/02/2012	MVA	17.5	0	8.2	0.4683	4.25	4.01	3.88	3.84	3.69	3.78
6	Latest	ASHTON ON MERSEY	100102	1001025SX01	1001025SX02			31/01/2012	MVA	18.29	0	13.22	0.7226	6.37	5.92	5.73	5.57	5.5	6.05
7	2015	ASHTON ON MERSEY	100102	1001025SX01	1001025SX02			31/01/2012	MVA	18.29	0	13.24	0.7241	6.33	5.87	5.66	5.5	5.43	5.97
8	2023	ASHTON ON MERSEY	100102	1001025SX01	1001025SX02			31/01/2012	MVA	18.29	0	14.87	0.8128	6.67	6.13	5.74	5.57	5.5	6.02
9	2031	ASHTON ON MERSEY	100102	1001025SX01	1001025SX02			31/01/2012	MVA	18.29	0	15.7	0.8584	7.63	6.6	4.81	4.67	4.62	4.91
10	Latest	BAGULEY	100103	1001035SX01	1001035SX02			07/02/2012	MVA	23	0	19.92	0.8662	12.93	12.57	12.37	12.02	11.44	11.62
11	2015	BAGULEY	100103	1001035SX01	1001035SX02			07/02/2012	MVA	23	0	19.98	0.8688	12.84	12.48	12.29	11.94	11.36	11.53
12	2023	BAGULEY	100103	1001035SX01	1001035SX02			07/02/2012	MVA	23	0	21.27	0.9248	12.92	12.54	12.3	11.95	11.37	11.52
13	2031	BAGULEY	100103	1001035SX01	1001035SX02			07/02/2012	MVA	23	0	22.64	0.9845	12.38	11.94	11.47	11.16	10.58	10.6
14	Latest	BENCHILL	100104	1001045SX01				05/02/2012	MVA	16.8	0	3.77	0.2247	2.16	2.01	1.88	1.78	1.71	1.81
15	2015	BENCHILL	100104	1001045SX01				05/02/2012	MVA	16.8	0	3.77	0.2245	2.14	1.99	1.86	1.75	1.69	1.78
16	2023	BENCHILL	100104	1001045SX01				05/02/2012	MVA	16.8	0	4.16	0.2478	2.16	2.01	1.87	1.76	1.69	1.79
17	2031	BENCHILL	100104	1001045SX01				05/02/2012	MVA	16.8	0	4.62	0.275	2	1.83	1.63	1.53	1.48	1.53
18	Latest	BOWDON	100105	1001055SX01	1001055SX02			08/02/2012	MVA	22.86	0	13.54	0.5925	7.32	6.58	6.62	6.35	6.31	7.11
19	2015	BOWDON	100105	1001055SX01	1001055SX02			08/02/2012	MVA	22.86	0	13.72	0.6002	7.26	6.52	6.55	6.28	6.24	7.02
20	2023	BOWDON	100105	1001055SX01	1001055SX02			08/02/2012	MVA	22.86	0	15.95	0.6976	7.56	6.76	6.62	6.35	6.31	7.06
21	2031	BOWDON	100105	1001055SX01	1001055SX02			08/02/2012	MVA	22.86	0	17.68	0.7734	8.07	6.98	5.66	5.43	5.39	5.84
22	Latest	BRADFORD	100106	1001065SX01	1001065SX02			09/02/2012	MVA	22.86	0	14.16	0.6192	9.16	8.96	8.77	8.59	8.61	8.69
23	2015	BRADFORD	100106	1001065SX01	1001065SX02			09/02/2012	MVA	22.86	0	14.28	0.6247	9.13	8.93	8.74	8.56	8.58	8.66
24	2023	BRADFORD	100106	1001065SX01	1001065SX02			09/02/2012	MVA	22.86	0	15.27	0.6682	9.23	9	8.79	8.6	8.63	8.7
25	2031	BRADFORD	100106	1001065SX01	1001065SX02			09/02/2012	MVA	22.86	0	17.71	0.7749	9.17	8.92	8.56	8.38	8.41	8.44
26	Latest	DROYLSDEN EAST	100107	1001075SX01	1001075SX02			08/02/2012	MVA	21.71	0	18.17	0.837	9.35	8.35	8.06	7.88	7.81	8.49
27	2015	DROYLSDEN EAST	100107	1001075SX01	1001075SX02			08/02/2012	MVA	21.71	0	18.06	0.8318	9.22	8.23	7.95	7.77	7.7	8.36
28	2023	DROYLSDEN EAST	100107	1001075SX01	1001075SX02			08/02/2012	MVA	21.71	0	19.2	0.8845	9.32	8.31	7.97	7.79	7.72	8.35
29	2031	DROYLSDEN EAST	100107	1001075SX01	1001075SX02			08/02/2012	MVA	21.71	0	18.94	0.8726	8.78	7.77	7.09	6.93	6.87	7.32
30	Latest	CHEADLE HULME	100108	1001085SX02	1001085SX01			19/12/2011	MVA	22.86	0	18.19	0.7956	8.93	8.06	7.81	7.58	7.56	8.47
31	2015	CHEADLE HULME	100108	1001085SX02	1001085SX01			19/12/2011	MVA	22.86	0	18.16	0.7945	8.81	7.96	7.69	7.47	7.45	8.32
32	2023	CHEADLE HULME	100108	1001085SX02	1001085SX01			19/12/2011	MVA	22.86	0	20.14	0.8809	9.11	8.18	7.72	7.49	7.47	8.31
33	2031	CHEADLE HULME	100108	1001085SX02	1001085SX01			19/12/2011	MVA	22.86	0	20.96	0.9169	9.7	8.42	6.66	6.48	6.48	6.99
34	Latest	CHORLTON	100109	1001095SX01				07/02/2012	MVA	8	0	7.47	0.9336	4.34	3.64	3.56	3.5	3.51	4.22
35	2015	CHORLTON	100109	1001095SX01				07/02/2012	MVA	8	0	7.58	0.9476	4.28	3.59	3.5	3.44	3.46	4.15
36	2023	CHORLTON	100109	1001095SX01				07/02/2012	MVA	8	0	8.78	1.0971	4.36	3.65	3.53	3.47	3.48	4.15
37	2031	CHORLTON	100109	1001095SX01				07/02/2012	MVA	8	0	10.45	1.3062	4.01	3.34	3.04	2.97	2.98	3.44
38	Latest	DENTON EAST	100110	1001105SX01	1001105SX02			16/01/2012	MVA	17.5	0	15.21	0.8693	6.66	6.25	5.99	5.82	5.67	5.82
39	2015	DENTON EAST	100110	1001105SX01	1001105SX02			16/01/2012	MVA	17.5	0	15.08	0.862	6.56	6.16	5.91	5.73	5.59	5.73

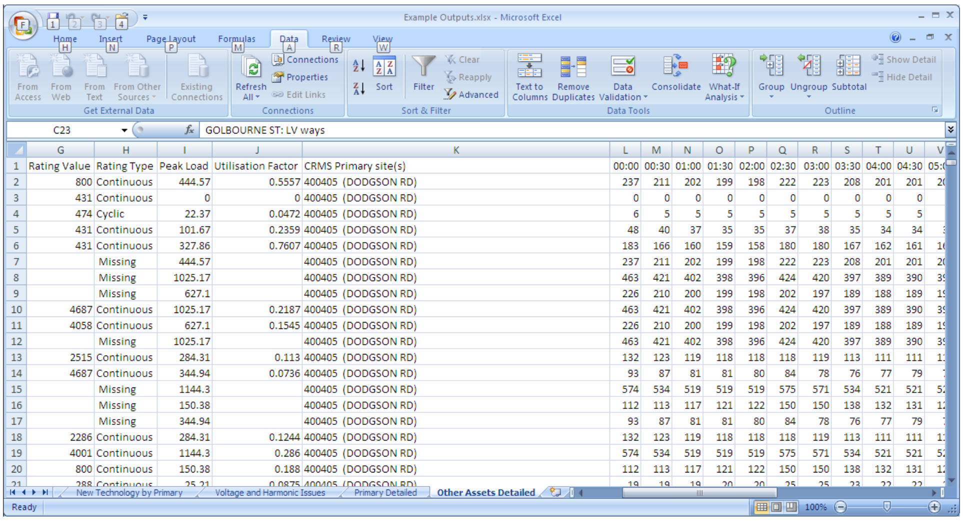
Figure 3.4.5.7-g: Primary Detailed Results

Note that only a subset of the output is shown.



	Year	Type	Name	Plant Ref	Way	Units
1	Year	Type	Name	Plant Ref	Way	Units
2	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815)	ARGYLL RD	4100023TX01		kVA
3	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815): LV ways	ARGYLL RD: LV ways	4100023TX01	1	kVA
4	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815): LV ways	ARGYLL RD: LV ways	4100023TX01	2	kVA
5	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815): LV ways	ARGYLL RD: LV ways	4100023TX01	3	kVA
6	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815): LV ways	ARGYLL RD: LV ways	4100023TX01	4	kVA
7	Latest	Switchgear on HV feeders - downstream		4100023FS01		kVA
8	Latest	Switchgear on HV feeders - downstream		4100023SW02		kVA
9	Latest	Switchgear on HV feeders - downstream		4100023SW01		kVA
10	Latest	HV feeder sections (thermal) - other legs	GOLBOURNE ST/ARGYLL RD	EDML001GX2I		kVA
11	Latest	HV feeder sections (thermal) - other legs	ARGYLL RD/BUTE MILL/CASTLE PUBLISHING CO	EDML001GX3I		kVA
12	Latest	Switchgear on HV feeders - downstream		4109533SW01		kVA
13	Latest	HV feeder sections (thermal) - other legs	BUTE MILL/ARGYLL RD/CASTLE PUBLISHING CO	EDML001GX8I		kVA
14	Latest	HV feeder sections (thermal) - other legs	CASTLE PUBLISHING CO/BUTE MILL/ARGYLL RD	EDML001GXAI		kVA
15	Latest	Switchgear on HV feeders - downstream		4109533SW02		kVA
16	Latest	Switchgear on HV feeders - downstream	T1	4109533CB01		kVA
17	Latest	Switchgear on HV feeders - downstream		4102473SW02		kVA
18	Latest	Switchgear on HV feeders - downstream		4101223FS01		kVA
19	Latest	HV feeder sections (thermal) - 1st leg	DODGSON RD/GOLBOURNE ST	EDML001871I		kVA
20	Latest	Distribution subs - GMT: 750 or 800kVA (includes 601-815)	GOLBOURNE ST	4109533TX01		kVA

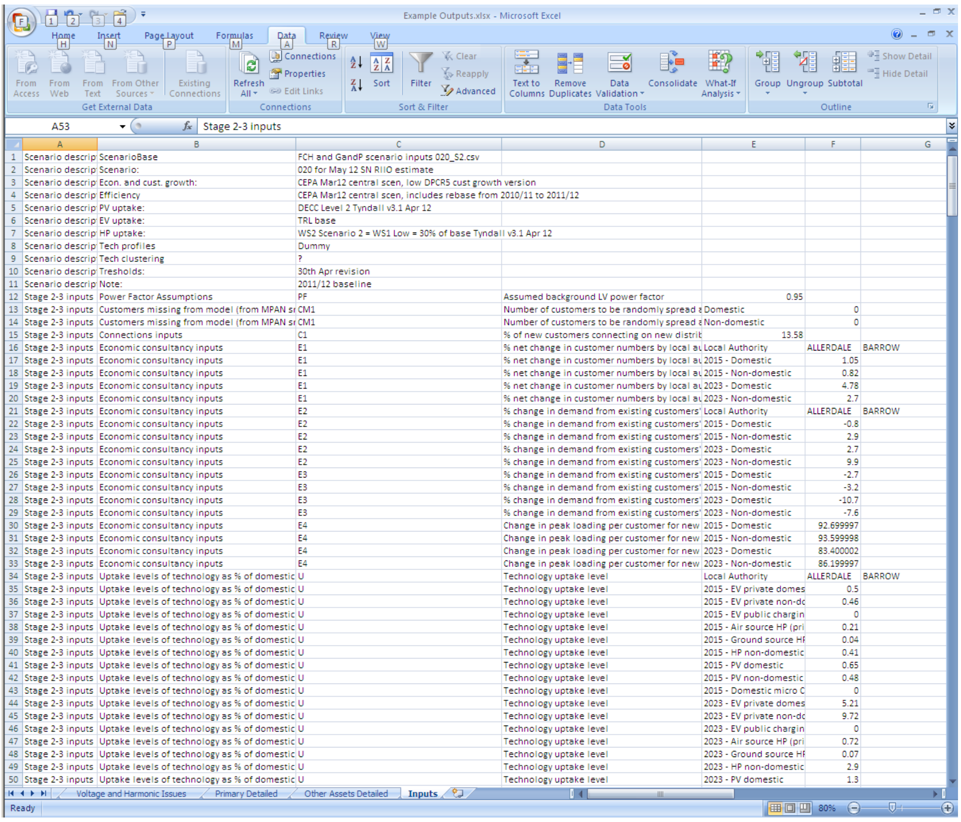
Figure 3.4.5.8-h: Other Assets' Detailed Results (left side)



	Rating Value	Rating Type	Peak Load	Utilisation Factor	CRMS Primary site(s)	00:00	00:30	01:00	01:30	02:00	02:30	03:00	03:30	04:00	04:30
2	800	Continuous	444.57	0.5557	400405 (DODGSON RD)	237	211	202	199	198	222	223	208	201	201
3	431	Continuous	0	0	400405 (DODGSON RD)	0	0	0	0	0	0	0	0	0	0
4	474	Cyclic	22.37	0.0472	400405 (DODGSON RD)	6	5	5	5	5	5	5	5	5	5
5	431	Continuous	101.67	0.2359	400405 (DODGSON RD)	48	40	37	35	35	37	38	35	34	34
6	431	Continuous	327.86	0.7607	400405 (DODGSON RD)	183	166	160	159	158	180	180	167	162	161
7		Missing	444.57		400405 (DODGSON RD)	237	211	202	199	198	222	223	208	201	201
8		Missing	1025.17		400405 (DODGSON RD)	463	421	402	398	396	424	420	397	389	390
9		Missing	627.1		400405 (DODGSON RD)	226	210	200	199	198	202	197	189	188	189
10	4687	Continuous	1025.17	0.2187	400405 (DODGSON RD)	463	421	402	398	396	424	420	397	389	390
11	4058	Continuous	627.1	0.1545	400405 (DODGSON RD)	226	210	200	199	198	202	197	189	188	189
12		Missing	1025.17		400405 (DODGSON RD)	463	421	402	398	396	424	420	397	389	390
13	2515	Continuous	284.31	0.113	400405 (DODGSON RD)	132	123	119	118	118	118	119	113	111	111
14	4687	Continuous	344.94	0.0736	400405 (DODGSON RD)	93	87	81	81	80	84	78	76	77	79
15		Missing	1144.3		400405 (DODGSON RD)	574	534	519	519	519	575	571	534	521	521
16		Missing	150.38		400405 (DODGSON RD)	112	113	117	121	122	150	150	138	132	131
17		Missing	344.94		400405 (DODGSON RD)	93	87	81	81	80	84	78	76	77	79
18	2286	Continuous	284.31	0.1244	400405 (DODGSON RD)	132	123	119	118	118	118	119	113	111	111
19	4001	Continuous	1144.3	0.286	400405 (DODGSON RD)	574	534	519	519	519	575	571	534	521	521
20	800	Continuous	150.38	0.188	400405 (DODGSON RD)	112	113	117	121	122	150	150	138	132	131

Figure 3.4.5.8-i: Other Assets' Detailed Results (right side)

Note that only the first rows of more than 968,000 are shown.



	A	B	C	D	E	F	G
1	Scenario descrip	ScenarioBase	FCH and GandP scenario inputs 020_S2.csv				
2	Scenario descrip	Scenario:	020 for May 12 SN RIIO estimate				
3	Scenario descrip	Econ. and cust. growth:	CEPA Mar12 central scen, low DPCR5 cust growth version				
4	Scenario descrip	Efficiency	CEPA Mar12 central scen, includes rebase from 2010/11 to 2011/12				
5	Scenario descrip	PV uptake:	DECC Level 2 Tyndall v3.1 Apr 12				
6	Scenario descrip	EV uptake:	TRL base				
7	Scenario descrip	HP uptake:	WS2 Scenario 2 = WS1 Low = 30% of base Tyndall v3.1 Apr 12				
8	Scenario descrip	Tech profiles	Dummy				
9	Scenario descrip	Tech clustering	?				
10	Scenario descrip	Tresholds:	30th Apr revision				
11	Scenario descrip	Note:	2011/12 baseline				
12	Stage 2-3 inputs	Power Factor Assumptions	PF	Assumed background LV power factor	0.95		
13	Stage 2-3 inputs	Customers missing from model (from MPAN si	CM1	Number of customers to be randomly spread a	Domestic	0	
14	Stage 2-3 inputs	Customers missing from model (from MPAN si	CM1	Number of customers to be randomly spread a	Non-domestic	0	
15	Stage 2-3 inputs	Connections inputs	C1	% of new customers connecting on new distrib	13.58		
16	Stage 2-3 inputs	Economic consultancy inputs	E1	% net change in customer numbers by local au	Local Authority	ALLERDALE	BARROW
17	Stage 2-3 inputs	Economic consultancy inputs	E1	% net change in customer numbers by local au	2015 - Domestic	1.05	
18	Stage 2-3 inputs	Economic consultancy inputs	E1	% net change in customer numbers by local au	2015 - Non-domestic	0.82	
19	Stage 2-3 inputs	Economic consultancy inputs	E1	% net change in customer numbers by local au	2023 - Domestic	4.78	
20	Stage 2-3 inputs	Economic consultancy inputs	E1	% net change in customer numbers by local au	2023 - Non-domestic	2.7	
21	Stage 2-3 inputs	Economic consultancy inputs	E2	% change in demand from existing customers'	Local Authority	ALLERDALE	BARROW
22	Stage 2-3 inputs	Economic consultancy inputs	E2	% change in demand from existing customers'	2015 - Domestic	-0.8	
23	Stage 2-3 inputs	Economic consultancy inputs	E2	% change in demand from existing customers'	2015 - Non-domestic	2.9	
24	Stage 2-3 inputs	Economic consultancy inputs	E2	% change in demand from existing customers'	2023 - Domestic	2.7	
25	Stage 2-3 inputs	Economic consultancy inputs	E2	% change in demand from existing customers'	2023 - Non-domestic	9.9	
26	Stage 2-3 inputs	Economic consultancy inputs	E3	% change in demand from existing customers'	2015 - Domestic	-2.7	
27	Stage 2-3 inputs	Economic consultancy inputs	E3	% change in demand from existing customers'	2015 - Non-domestic	-3.2	
28	Stage 2-3 inputs	Economic consultancy inputs	E3	% change in demand from existing customers'	2023 - Domestic	-10.7	
29	Stage 2-3 inputs	Economic consultancy inputs	E3	% change in demand from existing customers'	2023 - Non-domestic	-7.6	
30	Stage 2-3 inputs	Economic consultancy inputs	E4	Change in peak loading per customer for new	2015 - Domestic	92.699997	
31	Stage 2-3 inputs	Economic consultancy inputs	E4	Change in peak loading per customer for new	2015 - Non-domestic	93.599998	
32	Stage 2-3 inputs	Economic consultancy inputs	E4	Change in peak loading per customer for new	2023 - Domestic	83.400002	
33	Stage 2-3 inputs	Economic consultancy inputs	E4	Change in peak loading per customer for new	2023 - Non-domestic	86.199997	
34	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	Local Authority	ALLERDALE	BARROW
35	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - EV private domes	0.5	
36	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - EV private non-dc	0.46	
37	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - EV public chargin	0	
38	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - Air source HP (pri	0.21	
39	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - Ground source HF	0.04	
40	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - HP non-domestic	0.41	
41	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - PV domestic	0.65	
42	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - PV non-domestic	0.48	
43	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2015 - Domestic micro C	0	
44	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - EV private domes	5.21	
45	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - EV private non-dc	9.72	
46	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - EV public chargin	0	
47	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - Air source HP (pri	0.72	
48	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - Ground source HF	0.07	
49	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - HP non-domestic	2.9	
50	Stage 2-3 inputs	Uptake levels of technology as % of domestic	U	Technology uptake level	2023 - PV domestic	1.3	

Figure 3.4.5.8-j: Inputs Output

Note that only a subset of the output is shown.

Appendix 2: Relationship between LA and FCH

The following diagram represents a simplified view of the relationship between LA and FCH. The LA core is shown in red. This is not a complete description.