Programme Area: Distributed Energy

Project: Macro DE

Title: Executive Summary - DE2002 / WP2.0: Development of a methodology to calculate energy demand


## Abstract:

The objective of the Distributed Energy (DE) Programme is to increase the uptake of DE through the development of integrated systems in order to reduce through-life costs, improve ease of installation and increase efficiency in the combined generation of heat and electricity. Within this programme framework the objective of the Macro DE FRP will develop and validate a software methodology to enable the design of optimised DE solutions where clusters of demand sites are linked with appropriate DE supply equipment. The project will quantify the opportunity for Macro level DE (up to 50MW) in the UK and the potential to accelerate the development of appropriate technology by 2020 for the purposes of significant implementation by 2030


## Context:

This project quantified the opportunity for Macro level Distributed Energy (DE) across the UK and accelerate the development of appropriate technology by 2020 for the purposes of significant implementation by 2030. The project studied energy demand such as residential accommodation, local services, hospitals, business parks and equipment, and is developing a software methodology to analyse local combinations of sites and technologies. This enabled the design of optimised distributed energy delivery solutions for these areas. The project identified a number of larger scale technology development and demonstration projects for the ETI to consider developing. The findings from this project is now being distilled into our Smart Systems and Heat programme. The ETI acknowledges that the project was undertaken and reports produced by Caterpillar, EDF, and the University of Manchester.

## ETI Executive Summary

**Programme:** Distributed Energy

**Project Name:** Macro DE

**Deliverable:** DE2002 / WP2.0: Development of a methodology to calculate energy demand

## Introduction

The objective of the Distributed Energy (DE) Programme is to increase the up-take of DE through the development of integrated systems in order to reduce through-life costs, improve ease of installation and increase efficiency in the combined generation of heat and electricity. Within this programme framework the objective of the Macro DE FRP will develop and validate a software methodology to enable the design of optimised DE solutions where clusters of demand sites are linked with appropriate DE supply equipment. The project will quantify the opportunity for Macro level DE (up to 50MW) in the UK and the potential to accelerate the development of appropriate technology by 2020 for the purposes of significant implementation by 2030

As such the key outcomes from the project are:

- Evaluation of the potential benefits of system aggregation and optimisation techniques
- Characterisation of energy demand and supply profiles for typical UK site types (typically 100 kWe – 10 MWe)
- Development of software methodology which analyses and integrates combinations of sites to enable optimised DE solutions
- UK benefits case for the development of such an approach
- Identification of the UK deployment and CO2 reduction opportunity for macro DE systems

This report is a key building block for the project. Within the UK there is limited data available to characterise energy demand on a day by day or hour by hour basis, generally referred to as energy demand profiles. Those profiles which are available are generally considered proprietary by those that hold them and consequently they are not freely available. Without energy demand profiles it will not be possible to build a demand aggregation methodology.

This report documents the methodology designed by the consortium to generate demand profiles across geographical subdivisions of the UK, commonly referred to as Middle Layer Super Output Areas (MLSOAs), taking in both residential properties and tertiary industry. MLSOAs are defined by the UK Government; they are part of a geographical hierarchy that covers England and Wales. Each MLSOA has a minimum population of 5000, or around 2000 households. MLSOAs do not align to postcodes or to electoral wards.

## Basis of Designs

The methodology developed is described in detail in the deliverable report, together with the basis of design and assumptions made. At a summary level the methodology is based on a number of benchmarks, indicators and existing energy demand profiles, where:

**Indicators :** Indicators are basic parameters that are directly related to energy demand and represent the basis for energy demand calculations. The residential and non-residential energy indicators are collected from EDF as well as from commercial data vendors.

**Benchmarks :** An energy benchmark is an expected value for energy consumption. For residential and non-residential sectors these benchmarks are either collected from CIBSE or are derived from EDF proprietary data.

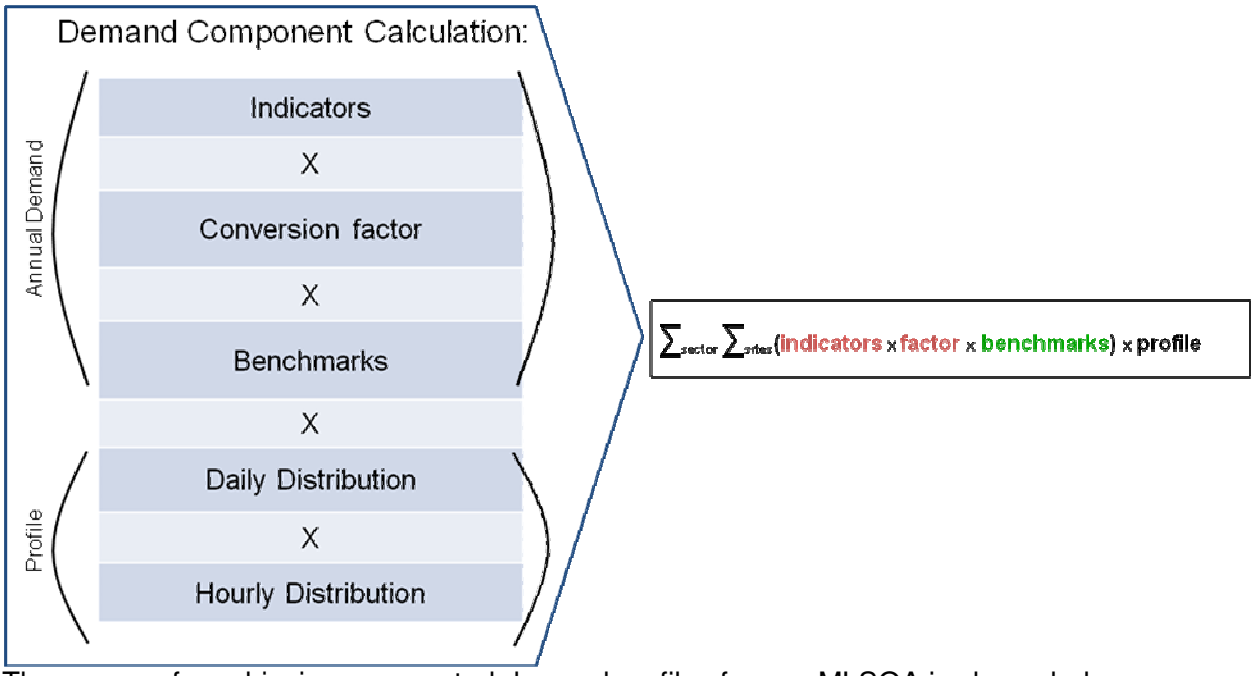
**Profiles :** A demand profile in this instance is a plot of energy demand on an hour by hour basis over a 24 hour period.

Details of the extent of the coverage from the Indicators, Benchmarks and Profiles used within the methodology are shown below.

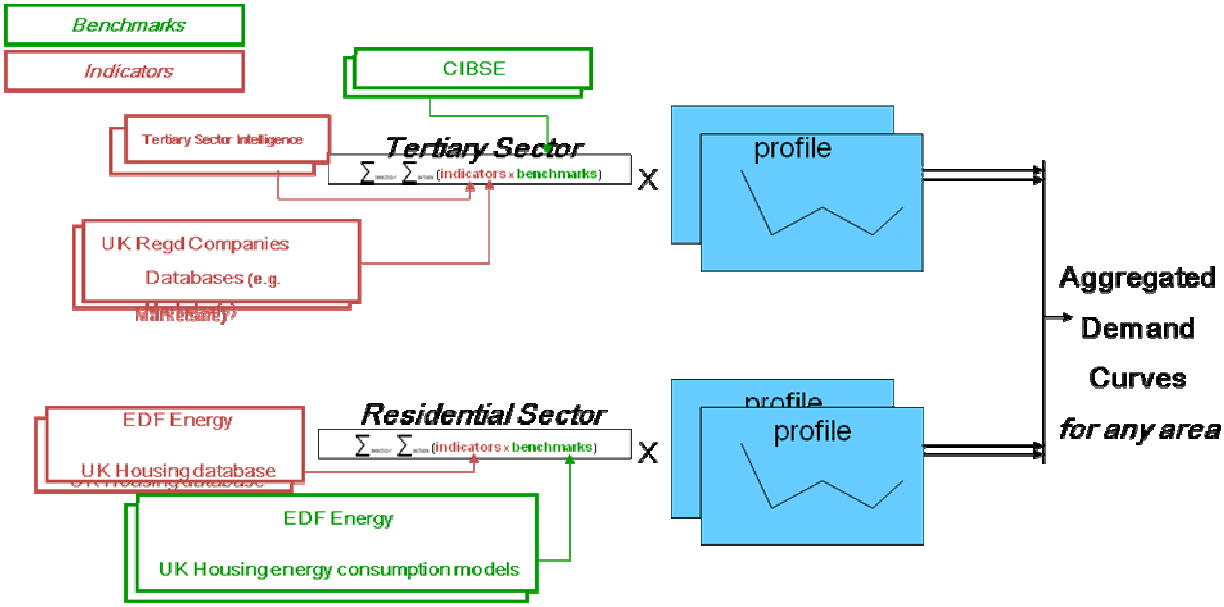
<table>
<tr><th></th><th></th><th colspan="2">Residential</th><th colspan="2">Tertiary</th></tr>
<tr><th></th><th></th><th>Thermal</th><th>Electrical</th><th>Thermal</th><th>Electrical</th></tr>
<tr><td rowspan="3">Indicators</td><td>Data Set</td><td>35 house types</td><td>2 elec contracts</td><td colspan="2">#employees<br>900 SICs</td></tr>
<tr><td>Level</td><td>MLSOA</td><td>MLSOA</td><td colspan="2">Post Code</td></tr>
<tr><td>Source</td><td>EDF Energy</td><td>DECC</td><td colspan="2">Creditsafe</td></tr>
<tr><td rowspan="2">Benchmarks</td><td>Data Set</td><td>>40 house types</td><td rowspan="2">annual demand estimated directly</td><td colspan="2">29</td></tr>
<tr><td>Level</td><td>Region</td><td colspan="2">Region</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| | *Source* | *EDF Energy* | from indicators | *TM46 (CIBSE)* | |
| **Profiles (hourly)** | Data Set | 4 house types x 7 temp ranges | 2 elec contracts | 11 x 7 temp ranges | 8 |
| | Level | Region | Region | Region | Country |
| | *Source* | *BDEW + UK Weather data* | *EDF Energy* | *BDEW + UK Weather data* | *BDEW* |

The indicators, benchmarks and profiles are then combined to give an overall energy demand profile for a given MLSOA, a schematic of the calculation process is given below:




The process for achieving aggregated demand profiles for any MLSOA is shown below.




## Results summary

The outputs of the demand forecasting methodology have been compared with 2 set of 'real' measured data, namely:

1) Annual energy demand has been calculated across the district of Harrogate, compared with DECC annual consumption data and plotted as error scatter graphs.

2) Hourly thermal load has been calculated for an existing district heating system and compared with the measured load to give an indication of the likely hourly and daily prediction error.

## Key findings

Key findings of the study are:

- The results from the comparison of generated energy demand for Harrogate with DECC annual data showed random errors in residential thermal demand calculations of approximately 10% (annual electric demand will use DECC's data directly). The tertiary demand calculations contained a larger uncertainty of approximately 30%.

- The hourly thermal load calculated for the existing district heating scheme showed an error of 13% at a daily level and 22% at the hourly level. The tertiary predictions had larger errors but the building sample was too small to draw firm conclusions from.

The methodology provides a data-rich, bottom-up, calculation of energy demand on an MLSOA basis suitable for the UK. The calculation uses hourly models of aggregated electric and thermal demand derived from energy utility methods for predicting loads on gas and electric grids – the commercial stake of this approach ensures that it is fundamentally sound. Demand predictions have been compared with DECC annual energy consumption data for the Harrogate region and with the real measured thermal load on a UK district heating network.

As such the method is deemed to be successful in calculating the annual residential energy demand. The combined EDF housing data provides an uncertainty of 13% on thermal demand calculations and DECC electric consumption is expected to be accurate to within 5%.

The results for the tertiary sector show larger uncertainties: approximately 30% for thermal and electric demand. The employee data restoration method developed seems to be effective in removing the energy underestimates seen in the initial calculation method. The company site dataset provides comprehensive data coverage of tertiary energy indicators but with low accuracy.

It has been agreed with the consortium that the methodology for the residential thermal demand is sound and that there is sufficient data such that a 10% uncertainty is reflective of the potential propagating error for the UK. While the tertiary sector data methodology is sound, there are two key issues with the data sets that may cause the larger error:

1) The registered company information databases used in the tertiary sector demand calculations contain many records that are missing the number of employee data;

2) Conversions between employee numbers and building floor area can only currently be performed at large tertiary sector groupings.

The contribution of demand uncertainty from the tertiary component could be projected and tracked in the resulting demand calculations.

Subsequent to this report it was agreed to purchase CreditSafe's registered company database due to its better overall accuracy of key indicator data for the tertiary sector.

## Further work

Having developed and validated a method for forecasting energy demand, the next steps within this particular work package are

1) To develop an approach for creating around 20 UK "Characteristic Zone's" to calculate aggregated zonal demand.

2) Develop an approach for assessing large UK waste heat emitters

In addition with a separate work package (WP4) the consortium will develop a design/optimisation methodology to aggregate zonal energy demand data and design/optimise zonal DE centre's using the temporal demand profiles from this deliverable together with a library of DE technology/equipment (WP3). This design/optimisation methodology will be embedded in a pre-prototype software tool.

## References

Extensive references are included within the deliverable.