Programme Area: Distributed Energy

Project: Micro DE

Title: Executive Summary - DE2003/D3.7: Project Summary Report

Abstract:

Please note this report was produced in 2010/2011 and its contents may be out of date. 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. Energy consumption within buildings represents the largest single category of final energy use in the UK, with UK residential buildings accounting for ~27% of the UK energy production, ~26% of CO2 emissions and 23% of GHG emissions. 82% of the energy consumed within UK domestic buildings is for space heating and hot water production. The “Micro DE” FRP (a scoping and feasibility study) was commissioned to understand the range of opportunities to positively impact on energy consumption / CO2 reduction through technology development and demonstration of building control systems in combination with micro-generation/storage technologies. The project is a feasibility study, with a core element to help shape the benefits case for a much larger project / field trial.

Context:

The project was a scoping and feasibility study to identify opportunities for micro-generation storage and control technology development at an individual dwelling level in the UK. The study investigated the potential for reducing energy consumption and CO2 emissions through Distributed Energy (DE) technologies. This was achieved through the development of a segmented model of the UK housing stock supplemented with detailed, real-time supply and demand energy-usage gathered from field trials of micro distributed generation and storage technology in conjunction with building control systems. The outputs of this project now feed into the Smart Systems and Heat programme.

ETI Executive Summary

Programme: Distributed Energy

Project Name: Micro DE

Deliverable: DE2003 / D3.7 : Project Summary Report

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.

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The "Micro DE" FRP (a scoping and feasibility study) was commissioned to understand the range of opportunities to positively impact on energy consumption / CO_2 reduction through technology development and demonstration of building control systems in combination with micro-generation/storage technologies. The project is a feasibility study, with a core element to help shape the benefits case for a much larger project / field trial.

The project is split into 4 work packages, represented schematically below.

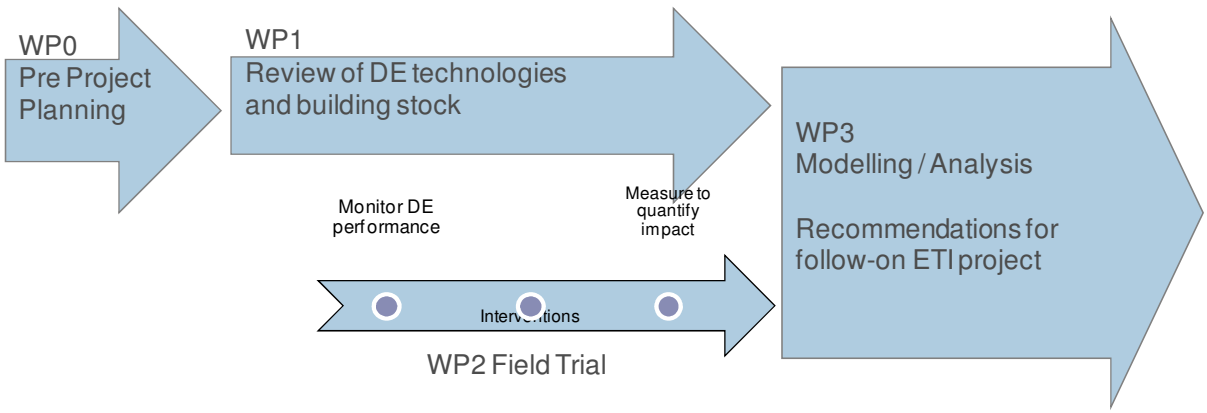

Fig 1: Micro DE Project Structure

The agreed objectives of the project were to deliver the following outputs:

- Evaluation of the potential benefits of current and emerging DE technologies in existing domestic buildings
- Categorisation of
    - The stock of existing domestic UK buildings
    - Building occupants into groups of similar energy use behaviours
    - The main appliance types (energy use patterns, control strategies, etc)
- Evaluation of the platform technologies and standards likely to be used in developing building control systems
- Analysis of the potential benefits of building energy service controls
- Provisional model of existing UK domestic housing stock as the basis for predicting µDE impact out to 2030
- Identification of development and demonstration opportunities [including an outline of how to test these in an appropriate environment]

The Final Summary Report is intended to act as a top level record of the activities carried out within the project and to summarise the key findings from the project. It is one of 7 reports created in the final project work package, these reports can broadly be split into 3 categories

1. Create insight and learning
2. Provide reference material or instructions for follow-on work
3. Are techno-economic studies that are dependent on validation of the UK Stock model predicting µDE impact to 2030.

Basis of Designs

The D3.7 provides a summary of the activities carried out within the project, as indicated in figure 1 the project was broken down into 4 work packages, these form the basis of design:

WP0 : Pre-Project Planning

Objective of the work package was to gather and catalogue data on household energy loads and DE usage based on existing and previous field trials. This data would then be used to drive modelling and field trial design.

WP1 : Review of DE Technologies and Building Stock

Building on the work of WP0, Work Package 1 of this project ‘Landscape Review and Planning’ has assembled existing information and field trial research on µDE, energy storage technologies, control systems, and appliance types. It has also reviewed the existing building stock and user behaviour, and how both of these aspects might usefully be segmented, together with future scenarios, particularly in relation to the development of a UK housing

stock model (see Work Package 3). It also included planning for the Work Package 2 field trial.

WP2 : Field Trial of DE and Control Technologies

A two phase field trial of µDE and control technologies carried out in 18 properties across the UK. The field trial was originally planned to cover 20 properties however 2 dropped out for personal reasons. The trial was structured into 2 phases,

1) Installation of monitoring equipment into properties which already had µDE systems installed by the owners / occupiers. A number of the properties were social housing, a number were owner occupiers. The data acquired was reviewed to assess its performance in situ before interventions were made to properties to assess the impact that improvements would make.
2) Continued monitoring following planned performance enhancing interventions.

The technologies monitored within the field trial were, in alphabetical order:

- Air source heat pumps
- Biomass boilers
- Ground source heat pumps
- Photovoltaics
- Solar thermal

Across the 18 properties there were 30 different µDE technologies installed.

At the planned conclusion of the project is was agreed to continue the monitoring of the properties post intervention for an extended period to gather further data. This will allow the impact of interventions made to improve the performance of µDE systems to be fully assessed over a summer (relevant for solar thermal and solar PV technologies) and over an additional heating season (relevant for heat pumps and biomass systems). In addition this extended period of data acquisition will provide further insight and knowledge to take forward into further work in the area of Micro DE or Smart Systems. This review is to be carried out on a quarterly basis. The value of continued monitoring will also be reviewed quarterly.

WP3 : Modelling, evaluation, analysis and estimation of potential energy and CO2 reductions from technology development; recommendations for ETI project(s).

This work package draws together the outputs from the previous two work packages to form a conclusion. This includes a coherent view of the technology opportunities, an analysis of the confidence levels that are possible from the evidence collected and an outline of what would be required to move to the next stage.

Each of these work packages is divided into a number of individual deliverables.

Results and Key Findings

The key findings from the project are:

- DE equipment, as installed, does not reach the full potential of its laboratory promise. Current technology on its own can be classified as Technology Readiness Level 9 but once integrated into the home, along with control systems and storage requires extensive testing and can only be classified as TRL 5. Typically, heat pumps with a potential Coefficient of Performance (COP) of 4.5 (manufacturer' specifications) achieve actual COPs of around 2.5.

  In the Micro DE field trial with its limited sample of Air Source heat pumps (4 off), COPs ranging from 1.9 to 2.8 were achieved with an average of 2.4. The higher value came from a unit that was used for space heating only and not used to generate domestic hot water. The Ground Source heat pumps (4 off) achieved an average 1.6 COP with only one unit achieving a COP greater than 2. These findings are in general agreement with those from other much larger trials, such as those conducted by the Energy Savings Trust (on heat pumps) and the Carbon Trust (on micro CHP). Based on analysis performed within the project these shortfalls against expected performance are believed to be due to poor systems engineering as opposed to poor inherent performance of the heat pumps themselves.

  Based on analysis earlier in the project of the CO_2 benefits of heat pumps, the consortium estimates that with 75% of heat pumps underperforming by at least 25%, carbon reduction targets are losing out on 1,300 tonnes per annum now. Assuming a decarbonisation of the grid by 34% by 2030 then if this situation continues through to 2030 this would mean an under achievement of 0.8 million tonnes per annum – assuming that the underperformance did not prohibit take up.

- Buildings Energy Management Systems (BEMS) are required to maximise the efficiency of both existing heating systems (e.g. gas boilers) together with complex, multiple technology µDE technologies installed within the home. In addition to optimising the efficiency of operation of heating systems, BEMS are required over and above conventional controls to:

  - Optimise energy storage and use within the home, both by reducing overall demand as well as smoothing out peak demand (e.g. filling heat stores such as hot water cylinders in the home whilst energy is plentiful or cheaper and drawing heat when it is scarce or more expensive).
  - Facilitate a home response to future smart grid demands.

  Findings from trials conducted by the Energy Savings Trust found that even when relatively simple condensing boilers are installed, up to 30% of the expected efficiency improvements are not achieved due to issues with control and installation. A small scale trial by PassivSystems of 25 occupied homes has shown that savings from the installation of Buildings Energy Management Systems could result in up to 25% reduction of energy consumption at an individual dwelling level. The ongoing monitoring of the 18 ETI field trial properties will provide further data to quantify these potential savings further.

Testing this finding on a larger, significant scale would be a key element of future work within the Smart Systems project.

- The reasons for underperformance of µDE equipment centred in two areas:
    - The technologies themselves are sensitive to incorrect design and installation.
    - The technologies are sensitive to the manner in which they are operated. Traditional domestic heating and hot water technologies are well-understood by homeowners and it has been wrongly assumed that the same applies to µDE technologies. In practice they are much more complex. Few people understand how best to control a heat pump; µDE technologies are not installed in isolation – conventional technologies are usually already present and other µDE technologies may be installed at different times by different installers.
- Energy storage is essential to maximise use of generated energy within the home and reduce use of supplemental supplies (of heat or electricity) or export (of electricity). Within the UK the amount of hot water storage has reduced significantly over the last 30 years due to space constraints and the introduction of combination boilers. What storage exists is currently not well integrated with µDE systems.

Further work

The Micro-DE FRP was originally planned as a pre-cursor to a larger demonstration project focused around µDE, control and storage technologies. Such a project would draw heavily on the experience gained through the execution of the FRP. During the execution of the FRP the strategy of the ETI has developed in this area, to this end it is not planned to have a stand-alone Micro-DE demonstration project, rather this work will be 'bundled' with demonstration projects from other ETI projects in the Distributed Energy, Buildings, Transport and Energy Storage and Distribution programmes. This will potentially form a city scale demonstration project encompassed by the Smart Systems project.

From a µDE perspective, the following aspects need to be considered for inclusion in the Smart Systems project. These have been reviewed and agreed with the Distributed Energy SAG.

- Pre- Installation and Design
    - Integrated assessment of legacy systems including storage, heat exchangers, and control.
    - Monitoring / Diagnostic tools for optimum design of future systems.
- Installed Systems
    - Buildings Energy Management Systems for heat [and electricity], e.g. heat management with zoning.
    - Integrated Micro Distributed Energy Technology Development [e.g. Heat pumps, solar thermal, with storage].
    - Systems optimisation and control tools.
    - Data management, monitoring, and integration with Smart Grid.
    - Condition and feedback monitoring.