Programme Area: Distributed Energy

Project: Macro DE

Title: Design Practice Characterisation Report

Abstract:

This deliverable is number 2 of 3 in Work Package 1. This report reviews the current landscape surrounding Distributed Energy in the UK and concludes that whilst there are many barriers to its application in the UK, there are also significant potential benefits and opportunities. This research indicates that further work is merited to identify the right solutions to enable DE to become a meaningful contributor to the UK's overall low carbon energy solution.

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 Macro DE Project

Deliverable 1.2

Design Practice Characterisation Report

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25/04/2011

This [Design Practice Characterisation Report] is a summary of the analysis and recommendation of [Work Package 1: Distributed Energy Design Practice Characterisation, Deliverable 1.2] prepared and submitted by the Consortium and is intended to inform the ETI. The consortium is not liable for the subsequent use of this report or the actions arising from that use.

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Executive Summary

This report is part of the Macro Distributed Energy flexible research project (FRP) funded by the Energy Technologies Institute (ETI).

The scope of the Macro Distributed Energy (DE) project is on “community scale” DE technology opportunities from 100kWe to 10MWe (50MWe on an aggregated scale excluding Wind, Marine and Solar PV). The focus is to identify areas of meaningful technology acceleration and development by 2020 for the purposes of significant implementation by 2030.

The project has been commissioned to enable the ETI ~~to make~~to make informed decisions at the end of the project regarding future opportunities for technology development in respect of the aggregation and optimisation of energy demand and DE supply solutions in the (nominal) range 100 kWe to 50 MWe

The project will deliver the following outcomes:

- A clear understanding of existing industry practices and tools.
- Identification of the deployment and CO_2 reduction opportunity for Medium to Large Scale (100kWe-50MWe) DE Systems that would be facilitated by the development and use of a system design tool which aggregates Sites into Zones to increase system efficiencies.
- Clear UK benefits case analysis for the development and implementation of zonal DE system aggregation and optimisation approaches, and for the development of a system design software tool to support the implementation and optimisation of these approaches.
- Identification of other DE efficiency improvement and CO_2 reduction opportunities arising from the above analysis.

As part of the project, work package 1 has focussed on developing a clear understanding of existing industry practices and tools.

This report is a key part of Work Package 1. It focuses on the current processes and practices across the whole DE value chain, which involves the ranges of processes involved from concept to completion. The value chain was expanded to detail the typical organisations that are involved in DE from policy, concept and project development through operators and end users. A detailed questionnaire was developed and used in the stakeholder interviews. These interviews provide market views and observations of the successes and failures of existing DE schemes while depicting the barriers (technical, commercial, and policy) as well as the processes by which DE is implemented. For specific stakeholders, a more detailed assessment of actual performance of a DE system relative to the aims was summarised.

As part of this work package, the following activities were commissioned....

- [1] Delta EE report on landscape of DE technology solutions and value-chain case studies
- [2] WADE [World Alliance of Decentralised Energy] delivered a stakeholder survey across 350 companies
- [3] Caterpillar, on behalf of the project consortia, held detailed stakeholder interview and questionnaire session with 50 contacts across the public sector, academia, SME and large scale industry both within Europe and the US
- [4] Caterpillar, on behalf of the project consortia, held a stakeholder workshop to synthesise the feedback and views across the differing groups in the value chain [It should be noted that whilst the stakeholder engagement process was considered robust, a number of groups were notable by their absence, including appropriate contacts from the finance community]

This report reviews the current landscape surrounding DE in the UK and concludes that whilst there are many barriers to its application in the UK, there are also significant potential benefits and opportunities. This research indicates that further work is merited to identify the right solutions to enable DE to become a meaningful contributor to the UK's overall low carbon energy solution.

The key high-level conclusions from [1] were the following:

- There is a lack of financial incentives to support district heating and gas-fired CHP even though in many countries some financial or regulatory support has been needed for the full potential of these technologies to be realised

- The current and planned incentive schemes mainly relate to support for renewable energy generation at either an individual household level or at national level in response to the commitments to achieving EU renewable energy targets

- There is a view within Government that district heating is a high capital cost option that would lock consumers into a single heat supply system

- There is a growing consensus that heating will increasingly be provided by electricity resulting in reduced carbon emissions as the grid is decarbonised.

The key high-level conclusions from [2], [3] and [4] are described below:

The DE market is characterised by a wide range of technology choices, complex value chains, conflicting policy and bespoke solutions that are dependent on individual customer needs.

DE can be an enabler to reduce our carbon emissions today while ensuring we build an energy infrastructure for the future.

- Combined Heat and Power (CHP) is an example of a successful DE project as it aligns distributed resources, distributed demand and an established DE technology with a clear customer value proposition. CHP has been demonstrated to deliver cost effective CO_2 reduction in many countries.

Based on the consensus of over 50 of the top UK stakeholders and over 350 surveys completed worldwide, DE has a significant role to play in enabling the UK energy market to deliver affordable energy with a significant reduction in CO_2 emissions and increased energy security.

The results of the stakeholder group consultation process revealed a consensus on the following 6 key points:

1. DE is an established technology in the UK and throughout Europe.

2. The value chain for DE is currently too long, too complicated and with a risk reward ratio that is not compelling for potential investors.

3. There is potential to reduce operating costs and reduce carbon emissions in the near term while constructing infrastructure for future development out beyond 2020.

4. DE is inherently flexible as it can both accommodate local level energy targets and complement the grid in times of peak demand.

5. For DE to play a material role in the UK, strong partnerships will be required amongst public and private organisations including relevant funding institutions. It will also be essential to build a desire to deliver superior value and benefit to the customer and the local community.

6. Macro Scale DE requires community [rather than individual's] action to maximise market penetration at an early stage. This requires a high degree of political commitment and potentially legislative action. Therefore it is not just a matter of technology and costs.

Furthermore, there are a number of key recommendations that the ETI and other UK based stakeholders should consider in regards to Macro DE in terms of barriers to deployment:

Key Barriers [and Enablers] for Macro DE Deployment in the Future

MACRO DE PROJECTThe stakeholders that engaged with [2], [3], and [4] highlighted the following areas as key if deployment of Macro DE is to be more widespread in the future.

1. **Policy:** Current policy is too often focused on promoting renewable instead of broader objectives around reducing CO_2 emissions and improving energy efficiency. As a result the CO_2 benefits of gas-fired CHP are not properly recognised compared to other technologies.
2. **Investment:** There are clear advantages around the establishment of a "green investment" bank, whose aims are to unlock UK investment in low carbon industry and technology. This will enable investors to understand the long-term nature of district heating infrastructure
3. **Allocation of risk:** the allocation of risks between private and public sectors and the significant difference in economic lifetimes of heat generation sources (typically 15 years) and heat networks (30 years or more).
4. **Capital Cost:** The high capital cost of the heat networks remains a barrier to a greater adoption of DE into the UK and there is evidence that our costs are higher than those seen on the continent. A new financial model needs to be identified recognising the; long-term nature of the infrastructure such that the life cycle costs become materially more attractive.
5. **Business Models:** A need to develop a new and smarter set of business models that are applicable across the UK, especially with respect to system level solutions.
6. **Technology:** Fuel flexibility and equipment modularisation could improve the robustness and cost of DE solutions.
7. **Grid Flexibility**: Investigate how potential DE solutions will enable the future flexibility of the UK grid, (with respect to heat and electricity) cost effectively, while simultaneously decarbonising the future energy system.
8. **Heat Demand:** Mapping the UK heat demand to identify the potential role of aggregated DE in meeting the future heat needs.
9. **Value Chain:** Required investigation to simplify the existing and complex value chains to provide a better investment opportunity.
10. **Grid Connectivity:** The cost and time to connect to the grid have to be radically reduced. Regulatory consistency has to become standard practice.
11. **Behaviour and Education:** Programmes need to be developed that address the required behavioural changes and overall awareness of DE and its benefits across government, business and the general public.
12. **A Deeper Understanding of Customer Requirements** and needs. Customers of DE vary considerably: their respective position and requirements have not been researched in detail. A greater understanding of their requirements would allow for more aligned solutions.

Introduction

1.1 Project Overview

The primary objective of the Macro Decentralised Energy (DE) flexible research project (Macro DE Project) is to assess the opportunity for optimising low-carbon distributed energy solutions that will be economically viable by 2020 and beyond for aggregated energy demand profiles in the UK. The project will evaluate the costs and benefits of such an approach focusing on potential cost savings, increased energy efficiency and security, and reduced CO_2 emissions.

The Macro DE Project will provide the following outcomes:

- A clear understanding of existing industry practices and tools.
- Identification of the deployment and CO_2 reduction opportunity for Medium to Large Scale (100kWe-50MWe) DE Systems that would be facilitated by the development and use of a system design tool which aggregates Sites into Zones to increase system efficiencies.
- Clear UK benefits case analysis for the development and implementation of zonal DE system aggregation and optimisation approaches, and for the development of a system design software tool to support the implementation and optimisation of these approaches.
- Identification of other DE efficiency improvement and CO_2 reduction opportunities arising from the above analysis.

The project comprises 5 work packages to identity the opportunity for distributed energy in the UK. A schematic of the project is shown in Figure 1. Work Package 1 (WP1) is to evaluate the current market to form a baseline for comparison and to develop the UK benefits case. WP2 is to define the heat and power profile for over 8500 geographic areas (middle layer super output areas) within the UK with validated commercial and industrial site energy demand profiles, waste heat recovery, and DECC gas and electricity data to represent the UK by 10-20 characteristic energy zones. WP3 is to characterise DE supply equipment into a library of technology performance characteristics to integrate into WP4. WP4 is to develop and validate a tool methodology for identifying optimal DE solutions based on economic and environmental factors, for each characteristic zone. WP5 is to provide a complete summary of the UK and ETI benefits case.

This project will examine the potential benefits of demand aggregation and optimisation of DE solutions for the development of DE within the UK, while enabling the integration of renewable energy sources and equipment.

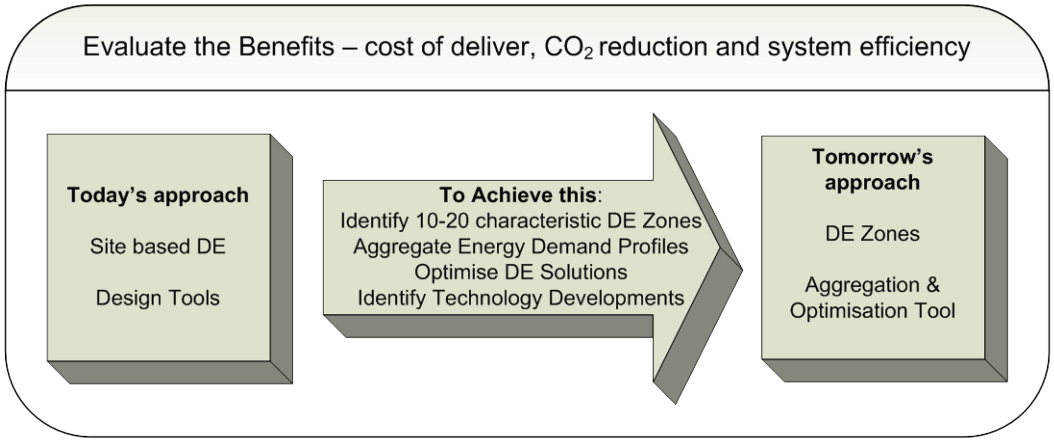


Figure 1 - Schematic representation of proposed project

1.2 Purpose of Report

This report is a key part of WP1. It focuses on the current processes and practices across the whole DE value chain, which involves the ranges of processes involved from concept to completion. The value chain will be expanded to detail the typical organisations that are involved in DE from policy, concept and project development through operators and end users. A detailed questionnaire has been developed and used in the stakeholder interviews. These interviews provide market views and observations of the successes and failures of existing DE schemes while depicting the barriers (technical, commercial, and policy) as well as the processes by which DE is implemented. For specific stakeholders, a more detailed assessment of actual performance of a DE system relative to the aims will be summarised.

1.3 Our Approach

The ETI has the unique capability to simplify the landscape for DE through working with global industries and the UK government simultaneously. This landscape will only be simplified if an opportunity exists to meet the criteria of reducing CO_2, increasing energy affordability while increasing technology development, increasing the security of energy supply and helping create a pool of skill in the low carbon industry.

Task 1: Delta Energy and Environment

Delta Energy and Environment (Delta) is a consultancy firm with extensive experience in DE over five continents. Delta was tasked with carrying out a review of the DE landscape in the UK and across Europe. Their work addresses the relationships between key stakeholders and the processes they typically use for delivering DE projects. Delta summarised this in a report, (see Appendix A) along with a schematic overview of existing approaches and best practice processes for developing DE.

Task 2: World Alliance of Decentralised Energy (WADE)

The consortium compiled a web-based survey to allow for international assessment of DE opportunities. WADE, along with other project partners, used their networks to ensure a broad range of expertise input via the survey. The aspects covered included international best practices for the deployment of DE, potential integration of DE within the UK and the barriers to deployment.

Task 3: Caterpillar

The consortium designed, developed and compiled a detailed questionnaire. This enabled the consortium to cover all possible aspects such as DE installation, operation and design. The questionnaire was used to engage with key stakeholder groups. via face-to-face or phone interviews. The groups covered were:

- Regulators (including national, local and regional)
- Lobbying groups
- Government
- Packagers
- Original Equipment Manufacturers
- Consultants (both market and technical)
- Utility companies
- Financing bodies
- End users

Task 4: Caterpillar

The consortium organised a workshop, to bring together relevant people in the DE sector. This workshop was used to present the details and high-level findings from the web-survey and stakeholder interviews. The working groups then were used to identify the underlying fundamental problems for the barriers to DE in the UK. This high-level assessment can be used by the ETI to identify points of interest that require further work and assessment. The main highlights for the workshop are summarised within Appendix E.

2 Design Practice Characterisation and Value Chain

The following table describes the design practice characteristics, which must be considered when taking on a DE opportunity. The table describes the process from the concept of the DE idea and what value can be gained right through to the installation and operation contracts that will be involved for the project life. The table covers the DE market at a high level, the reason for this is to allow condensing the information. Due to DE having many technology options, it would be an extensive task to cover all aspects and technology choices. There are many considerations to be made along the way and this adds to the complexity of DE when compared with the standard (centralised power) in the UK, which benefits from economies of scale.

Table 1. DE Design Practice Characterisation.

DE Task Requirements	Description	Decisions	Time required
Opportunity Identification	• Goal identification for the end user, energy cost reduction, energy price certainty, improved security, and CO2 reduction or other. • Normally the developer goes looking for these opportunities and approaches the customer.	The customer needs to be convinced the idea will add value to his/her business in order to proceed. The **first decision gate** takes place here. The feasibility will cost £20k to gain an accuracy of +/-20%.[?]	1 Month
Feasibility Need for demand data. One-year gas and electricity consumption.	• This initial feasibility will lead to the development of the project and help decide if it is worth going ahead. It will include: • Initial design • Types of technology available • Some high level costing. • High light which business model would best suit	After the initial feasibility comes the next **decision gate.** This is when the customer decides whether or not the project is a go or no go.	3 Months
Financial	• Financing of projects can be directly from the developers' own balance sheets, from customer balance sheets, loans through traditional financial institutions and banks, or through leasing arrangements.	This can then be approved by the bank or financed by the customer or DE supplier. This could lead to another **decision gate** if the finance proves to be too expensive. This decision can lead to a re-design, pay for detailed study or **say no**.	1 Month
Detailed Design	• The detailed design includes: • Final cost • Detailed Technology choice and assessment. • Construction • Foundations	This detailed design is normally tendered out for 3 or 4 cost estimates. After the detailed design is completed and the quote comes back	3-6 Months

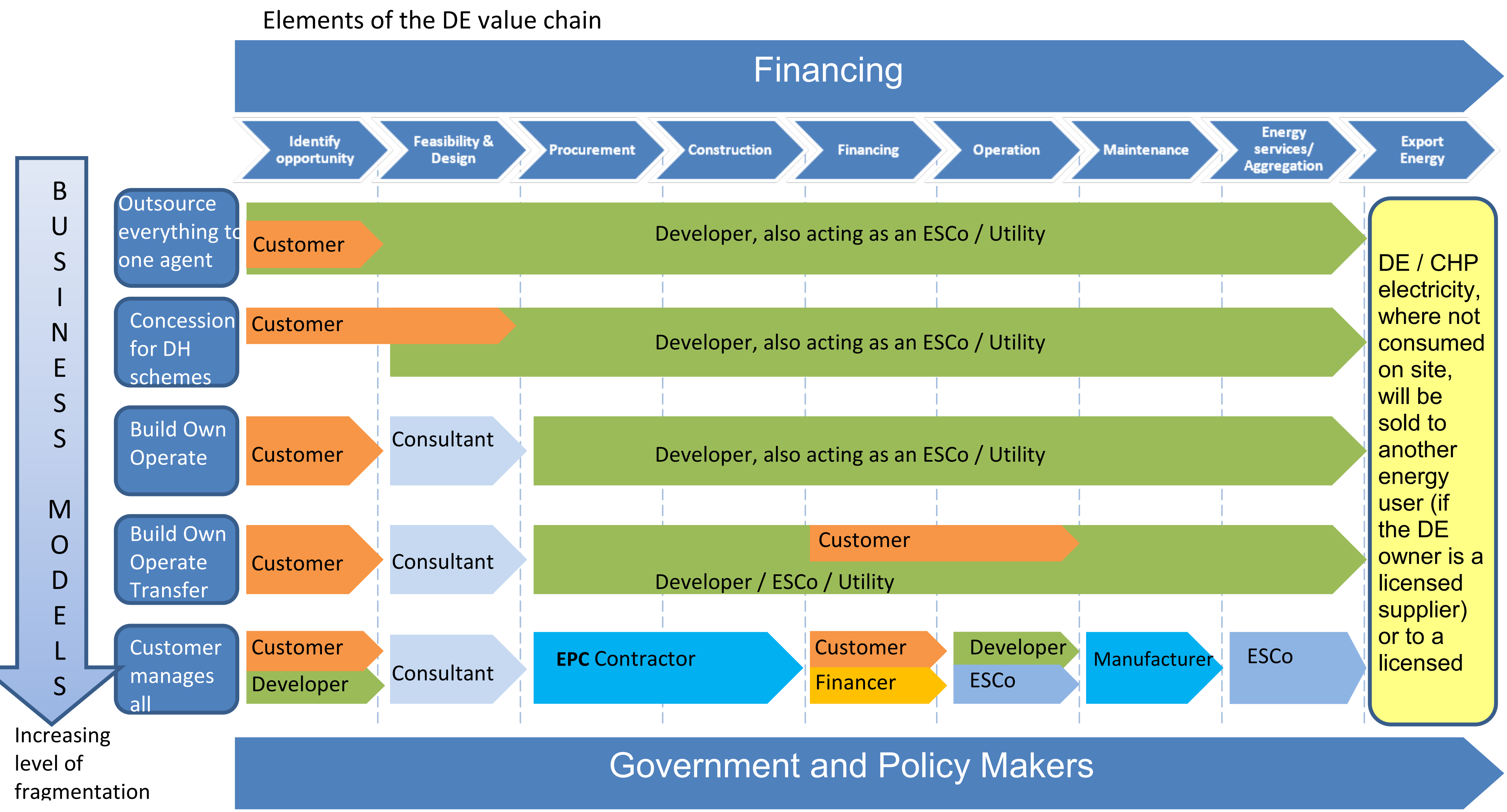
	• Installation • Commissioning and • Grid connection • District heating network • Building connections	normally the customer will require an adjustment and a 'Build to Budget' approach. During this period a planning application will be submitted	
Procurement	• This will include the procurement of all assets and materials necessary for the project. For example: o Genset, generator, boiler etc. o Controls o Instruct DNO to connect to the grid o Heat exchangers o Exhaust o Piping and insulation o Foundations o District heating network o Building connections	This is when the next real **decision gate(s)** is required. When the items are being procured from a developer, the price for the assets will normally depend what type of contract is available for the operation and maintenance. The developer may give a 20% discount on the genset if he receives a 5-10 year rolling contract for the servicing of the system. Some of the equipment can depend on availability.	6-12 Months
Construction	• This covers the installation of the technology and storage building(s), including: o Concrete foundations (if required) o The installation of the equipment and all relevant controls and piping. o Storage facilities for fuel etc. • District heating network • Building connections o	Normally the planning conditions will be taken into account in the detailed design and therefore the only real decisions in this area will be around unforeseen circumstances. Such as endangered species found on the site once building starts.	1-5 Years
Operation and maintenance	Operation • Manages the day to day running of the system. • This may include the contract for securing the gas supply, and contracts with the customer for taking the energy produced / guaranteeing supply. • The operator can also be tasked with managing payments from customers. Maintenance • Payment is monthly / annually, based on kWh output or hours	No real decisions to be made in this area as the contracts are normally agreed at the procurement stage. This is an important consideration for the business models identified during the detailed design. Decisions on setting of the heat price to encourage growth may	On going

	run per year, agreed in the initial contract. • Guarantees the performance and availability of the system. • Payment is monthly / annually, based on kWh output per year, agreed in the initial contract.	be needed where firm indexing is not included. Decisions will be needed on future expansion	
Energy service provider	• Manages the relationship with the customer and manages the collection of payments for energy.	Main decision here will be around the contract, how long it is for, the costs associated and the benefit to each stakeholder.	On going

There are many players along the currently accepted DE value chain all trying to maximise profits and gain the best value for their organisation or company. For this reason, some players try to act in as many different areas of the chain as they can. The benefit of this is their company or organisation may have the resources to gain more value with little or less effort than employing many individuals involved across the value chain therefore maximising potential gains. Many have been mentioned in the stakeholder section and Figure 3 below is a schematic of where each player fits along each step.

FIGURE 2 TYPICAL VALUE CHAINS, AND VALUE CHAIN PARTICIPANTS, FOR DEPLOYING DE

Customers can opt to outsource the complete development and operation of a system to one developer at one end of the spectrum, or at the other end, can work closely with developers along the entire length of the chain. This schematic shows the key steps in the value chain for deploying DE (top of the figure) and for each of the business models (left hand side of the figure) illustrates where the key stakeholders are positioned along the chain.



3 Outline of the Current Processes and Industry Practices – Appendix A

3.1 Stakeholders and Key Drivers

For the purpose of this report a stakeholder is defined as "anyone who has impact or influence along the value chain and those who can deliver or capture value from the process". Developing DE projects offers differing levels of value to a range of different stakeholders. By understanding in greater depth the key drivers and commercial rationale that lead these different stakeholders to develop DE projects, we can then understand the areas where the most impact can be made or more resources deployed.

The drivers for deploying DE projects can vary widely, and can stem from the various sources of value for each stakeholder.

The first question to ask regarding any stakeholder is why would they want to select DE and what benefit or value it adds. The responses to this question included:

- Value can be driven by economics Value can be obtained from other sources (e.g. green marketing, improving security of supply, regulatory or planning compliance) that are difficult to factor in to the cost – revenue comparison, but certainly help to drive some projects. They are not normally sufficient in themselves to stimulate significant levels of new project development.
- Security of supply for those who require power 100% of the time such as
    1. Food processing sector
    2. Hospitals and emergency services
    3. Data storage facilities
- Planning compliance is an increasing driver: for a building developer, the value in using CHP over other DE technologies is that it may be a more cost-effective means of meeting specific planning requirements.
- A developer's priority is firstly a positive return on their investment and then carbon reduction benefits are a secondary gain.
- Potential community benefits such as creating local jobs and skills that can add value, stability and prosperity to the area rank behind achieving the required IRR and CO_2 reduction.

TABLE 2. DE PROJECT STAKEHOLDERS. (*COMPANIES UNDERLINED HAVE BEEN INTERVIEWED AND SHOULD BE TAKEN OUT BEFORE BEING SENT TO PUBLIC)

DE Player	Description	Examples
Equipment supplier	• Supplies the complete packaged system • Supplies different items of plant such as engines, turbines, piping, heat recovery boilers and back-up generators.	**Prime movers:** Aircogen, Centrax, Solar Turbines (Turbomach), MAN, Siemens Energy, Cummins, LowC, Caterpillar, Wärtsilä, MWM, Broadcrown, Finning UK

Design Consultant	• Assesses the feasibility of a site for DE and can size and design a system to meet the specific needs of the customer. • Can also be employed to assess the opportunity for different DE technologies at a site. • Typically charges on the basis of a day rate fee, which can sometimes be indexed to potential size of the energy savings the customer will receive. • The fee may also increase 'along the chain' as the project moves from identifying the opportunity to finalising the system design. • Sometimes a system packager can complete the design consultation also as part of the package.	**Design consultants:** Parsons Brinckerhoff, AECOM, Ove Arup, Ramboll, LowC, Thames Energy**,** Green Energy Partners, URBED, Scott Wilson, BRE (Building Research Establishment), AEA, Finning UK
Financial and legal services	• Financing of projects can be directly from the developers' own balance sheets, from customer balance sheets, loans through traditional financial institutions and banks, or through leasing arrangements. • Legal firms provide niche expertise in relation to the many contractual aspects of project development, eg fuel supply contracts.	**Financial**: Co-operative Bank, GE Capital, Triodos, **Legal services:** Brodies, Hill Dickinson, Nabarro.
DE Developer	• Can offer packaged systems, and can deliver bespoke turnkey solutions via outsourcing construction and maintenance. Various financing contract packages can also be available. • Typically operation and maintenance contracts are also offered alongside the system.	**Developer:** Dalkia, Cofely, Cogenco, ENER-G, Vital Energi, Clarke Energy, ContourGlobal, Font Energy, Fleetsolve, Elyo, Finning UK ESCOs, LowC
Operator	• Manages the day to day running of the system. • This may include the contract for securing the gas supply, and contracts with the customer for taking the energy produced / guaranteeing supply. • The operator can also be tasked with managing payments from customers. • Payment is monthly / annually, based on kWh output per year, agreed in the initial contract.	Can be the customer, **A CHP developer:** Dalkia, Cofely, Cogenco, ENER.G, Vital Energi, Clarke Energy, ContourGlobal, Font Energy, Fleetsolve**,** Elyo**,** Finning UK. **A utility:** (eg RWE npower, E.ON UK), EDF energy an ESCO or packager A local authority or arms length management organisation
Utility	• Can cover a number of roles such as developer, operator or energy	**Utility:** E.ON UK, SSE, RWE npower,

	service provider.	Scottish Power
Maintenance	• Guarantees the performance and availability of the system. • Payment is monthly / annually, based on kWh output per year, agreed in the initial contract.	**Maintenance:** Typically the equipment suppliers will carry this out. Developers offer this service but can outsource to the manufacturers.
Energy service provider	• Manages the relationship with the customer and manages the collection of payments for energy.	Aberdeen Heat and Power, Utilicom, Thameswey Energy
Aggregator	• Manages and aggregates a number of distributed generators • This maximises the value of generation and potentially offering ancillary services.	Flexitricity, Smartest Energy
Customer / consumer / user	• Define these roles – noting difference between 'customer' which may be a housing association or other collective, and 'user' i.e. individual site, business or home • Definitions needed for clarity in following discussion	Tesco, Ikea, Local Authorities, Industry, Boots, Hotels, Hospitals and Universities

Names of companies to be removed when sent out to the general public

Other companies and organisations interviewed include:

- Cal Energy Consulting
- Challock Energy
- Delta E&E
- CHPA
- Orchard Partners
- WADE
- Carbon Trust
- LDA
- NIRAS and MoonyKelly
- GLA
- Alyesford News
- Renewables East
- ICF International
- Burns and McDonnell
- Recycled Energy Development
- Hiltner Combustion
- Ameren Energuy
- Habi-Tek
- DE Solutions

Some companies usually offer a combination of these services. For example a CHP developer can offer to design, procure, finance, and operate the system, and arrange installation and maintenance – providing a complete turnkey solution of a standardised solution for the customer.

3.2 Flowchart of the entire Stakeholder Interaction

Developing a DE project is a complex activity, involving a number of different players. Each player endeavours to capture revenue by adding value along the value chain.
The complexity can depend on how involved the customer decides to be when getting a system installed on their site, and also to the 'standardised' nature of the project. For example:

- The customer could outsource the entire project to a single ESCO or CHP developer, minimising the points of contact, risk and parties involved in the process, or

- The customer could manage the entire process; contracting with designers, engineers, manufacturers and utilities, to implement a system bespoke to their specific needs making the project much more complex. This could add as much as 20% in value if the right resources and capabilities are available to manage, maintain and operate the project.

- The customer could use utilise variations on the above alternatives to achieve their objectives.

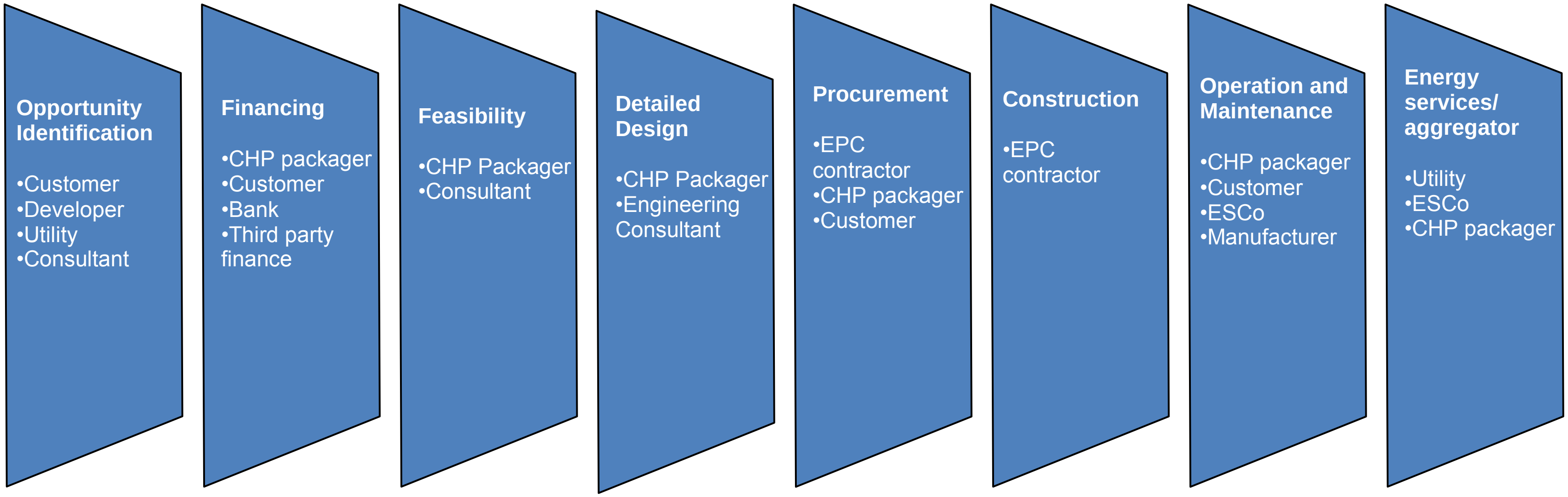
A schematic of the process follows below (Figure 3). The gaps between each stage in the figure are of significant importance. They represent that at any time during the project that it is possible it could fail.

- Many steps of the process could be completed And costs incurred, but the developer could not source the necessary finance.
- The risks surrounding financial packages have pursueded some players to focus on different areas within the overall process-thus limiting their own exposure in event of the overall project failure.
- A thorough project study is important to ensure all material aspects have been considered before any installation is undertaken.

There are many descion gates which have to be made along the project life:
Opportunity Identification-define the goal of the customer and ensure they are aligned.
Financing- Major decsion for the project as the cost for financining can put an end to the project or lead to a redesign. The investment needs to make sense.
Feasibility Study- the decision maker needs to accept the outcome of the feasiblity to proceed.
Detailed Design- Needs to align with the customer goal and the planning and costing need to be locked down.
Procurement- Next major decsion, who supplies the equipment and provides the service contracts. What is the time line for commisioning? Contracts to be arranged
Construction- No real decisions, only unforseen circumstances, such as endangered species on site or unexpected services below ground
Operation and mantenaince- Contract is normally agreed at the procurment stage.
Energy Services-No major issues, most companies will be happy to provide the service of buying fuel and selling power, and the contract should be tied up before this stage.

FIGURE 3. TYPICAL BREAKDOWN AND PLAYERS OF A DE VALUE CHAIN

The variety of activities involved in making a DE project successful offers many revenue streams for different players. Some players operate at a few points along the value chain only.



Examples of the different players mentioned in the above figure can be found in **Table 1**.

4 Business Models for Successful DE Projects- (Appendix A Section 3)

- The success of a DE project is driven by the application of process discipline and competent project management, all aspects of the DE project from design construction and operation need to be considered and optimised if an economically viable solution is to be achieved.

Additionally the business structures and contracts required for DE projects are complex. These are based on the finance, design, installation, operation/maintenance and fuel supply for contract periods of between 5 and 15 years. This generic business model seeks to provide long term secure revenue streams with blue chip clients.

However there are many different business models involved in DE. Depending on the circumstances of the customer and operator, these models will be adapted to gain the maximum value possible. Inherent in all models are:

- Definition of assumed risk profile, the resources and their capabilities available to the company.
- The assets already in place (evaluated with respect to e.g. IRR, Cost of Capital), plus the assets required and the availability of capital over the life of the project.
- The whole life cycle operating costs and contractual price for the maintenance requirements.
- A full financial review of the customer and the supplier.
- The fuel costs and volatility associated with the energy market
- The possible long term energy savings with respect to the 'spark spread' (Difference between the gas price index and the electricity price index)
- Environmental image and profile of key partners.
- The tax and benefits received for such systems, e.g. CCL (Climate Change Levy) or ROC (Renewable Obligation Certificate) and capital allowances.
- The projects emissions signature and CO_2 profile.

The main business models for deploying DE are common at both the individual building level and industrial level. The real differences are for district heating (DH) schemes, where the economics are often not attractive to private investors, and therefore require either local authorities to intervene or a much greater level of incentives, or a mixture of these.

The main business models being deployed in DE are mentioned below and are covered in more detail in Appendix A Section 3. **[These models may apply to the entire project or to a part of the project, e.g. capital outlay only or operating costs only.]**

1. **Capital Purchase -** Under this model the customer purchases a complete turnkey package and has this asset on their balance sheet with the option to run the DE system or contract out the operations and maintenance to the developer.
    - This model is for customers who are cash rich or can borrow capital easily at low interest.
    - Due to the investment and all the risk belonging to the customer, the customer receives the maximum benefits.
    - **A detailed case study, of the Radisson Hotel at Stansted airport shows how the capital purchase model is used. The case study can be found in Appendix A on page 77.**

2. **Discounted Energy Purchase (DEP) -** This model is similar to the capital purchase model except the CHP developer takes the burden and risk of the investment away from the customer. The customer carries the risk for purchasing fuel, which leaves them susceptible to fuel price fluctuations but also control on fuel costs if long term contracts are agreed.

    - This is very favourable for some customers who do not have the available capital and thus reduces their risk.
    - Due to the reduced risk, the benefit is less for the customer. Typically, because they purchase the fuel, the contract would be written so that the customer receives the heat for free and pays for the electricity.
    - A recent application of this model included ENER.G installing two 225kWe in Sheraton hotel at Heathrow. The contract is for 12 years and provides an average saving of £20,000 per year.
    - An example of this model (for Edinburgh University) can be found on page 67 of Appendix A.

3. **Energy Services Performance Contracting-**Under this model, the developer builds and owns the plant purchases the gas and the customer purchases both electricity and heat from the developer at set tariffs for one customer. This is usually in the form of a single upfront payment, and then unit rates for heat and electricity. Some of the gas price risk is shared with the customer by indexing the heat and electricity rates to gas prices.
    - Again this model is very favourable for some customers who do not have the available capital and thus reduces the risk.
    - Although the customer does not take any risk with the gas prices, they must pay for heat and almost certainly pay more than the discounted energy purchase model.
    - **A detailed case study of this model can be found in Appendix A on page 85. It shows average savings of around £200,000 per year for a company with a large fermentation process.**

4. **ESCo Model -** This model is usually applied when the CHP system, or DH network, is serving multiple users rather than a single building. Dealing with a

variety of customers such as a mixture of residential and commercial customers requires a relatively granular billing system to be implemented as compared with just one end user.

- This model normally provides a guarantee of reduced energy costs for the end user.
- This model is attractive for new developments, which need to meet building performance targets.
- The downside is the ESCO must make the collection of payments and therefore the risk of default payments from customers or residents.

5. **CHP leasing programmes -** In this model, once the design of CHP system has been specified (either by the customer or the developer), the investment in the CHP system is made by the developer, a bank or a dedicated leasing company.
    - This model is attractive for customers who do not have the cash flow available for purchase and may need convincing.
    - The contracts are normally flexible.
    - Due to some projects saving more than expected, the customer may wish to purchase the whole system instead of leasing it for longer.
    - **A detailed case study of this model can be found in Appendix A page 80.**

6. **Peak Shaving -** The availability of market pricing for energy provides a new opportunity to use on-site power generation for cost savings. Customers buying power at the hour-by-hour or "spot" rate pay a lower price, most of the time, than regularly adjusted flat rates. For a few hours each month, when electric demand is highest, the spot price for electricity rises well above the flat rates. At these times it becomes more economical to generate power on site than to buy the higher-priced power from the "spot" market.

    - This model is for a customer who has the potential to generate on site during peak demand time.
    - This model allows the customer to maintain a low cost structure for their energy costs by switching the asset on when energy costs are high and fuel costs are low.
    - The customer must have the resources available to run this system.
    - This can be run by the customer himself or herself or by a central control room that manages many.

- **It is worth noting all the business models mentioned above can be provided in three different ways: heat only, electricity only and combined heat and power. This will depend on individual customers to assess which system adds most value to them.**

7. **Back up Generation-**Table 2 below shows the opportunity for systems which have extra generating capacity to back up the national grid in times when large energy generators are not fully available. It is expected the equivalent of a coal power station will fail once a month and for this reason the grid invests heavily in back up generation to ensure customers have power according to local requirements.

    1. This model applies for those companies and industries, which have their own back-up generation and can provide spare capacity to the grid in time of demand or failure.

Table 2 Types of National Grid Back Up (Source: Claverton Energy Research group, last visited 2010-08-25**)**

Service Name	Min Service Size	Max Notice Period before service delivered	Time limits around service delivery	Typical Payment
Short Term Operating Reserve (STOR)	3 MW (Smaller sites can be aggregated into a 3MW load)	240 min	Must be able to sustain delivery for minimum of 120min if required	£40,000 (per MW capacity per year)
Fast Reserve	50 MW	2 min	Must be able to sustain delivery for minimum of 15min if required	£50,000 (per MW capacity per year)
Frequency Response	3 MW	<2 sec	Able to sustain up to 30min if required	£56,000 (per MW capacity per year)

For these business models the crucial issue is the analysis of the risks of the project and deciding who is best placed to take on that risk. The various business models that have been developed may allocate risk in different ways but ultimately a transfer of risk is normally reflected in higher cost for that aspect of the project.

5 List of Software Tools Used in the DE Market

As part of creating a baseline to the current project, we identified and analysed existing software tools for DE systems. The software tools listed below will be examined in detail in Deliverable 1.3 report. The review in D1.3 will include the target DE market segment, the tool's function in the design of DE systems, its capabilities, effectiveness and market take-up**. In addition, its relevance in the UK market context will be considered. This report can be found in Appendix B. Termis and Energy Pro were the two tools selected for trials according to their functionalities and sub-routines.**

TERMIS

- Termis is the leading district energy network management software. It is designed to improve network performance while reducing energy loss, operating costs, customer complaints and capital investments. **This is seen as one of the most beneficial software to help with the development of the tool in WP4.**

ENERGY Pro

- Energy Pro is used for combined techno-economic analysis and optimisation of both cogeneration and tri-generation projects and energy projects with a combined supply of electricity and thermal energy (steam, hot water or cooling) from multiple different energy-producing units. **Due to the sub routines of the tri-generation this software package could help develop the opportunity for demand side aggregation.**

RETScreen

- RETScreen (Version 4) facilitates initial feasibility analysis of a wide range of clean energy technologies. These include renewable energy, cogeneration and district energy, a full array of financially viable clean power, heating and cooling technologies, and energy efficiency measures.

HOMER

- HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed generation applications.

BCHP Screening Tool

- This tool is used for assessing the economic potential of combined cooling, heating, and power systems for commercial buildings. This tool uses the DOE-2 simulation engine

GT PRO

- A design program for gas turbine based power and cogeneration systems.

GT MASTER

- Extends design produced by GT PRO to simulation, detail optimisation and considers running the plant at various loads, ambient conditions, hardware degradation, etc.

STEAM PRO

- Automates the process of designing a conventional (Rankine Cycle) steam power plant. It is particularly effective for creating new plant designs and their configurations.

STEAM MASTER

- Extends design produced by STEAM PRO to simulation to evaluate the impact of running the plant at various loads, various ambient conditions, hardware degradation, etc.

THERMFLEX

- Thermflex is a modular program with a graphical interface that allows the user to assemble a model of a DE system from over one hundred different components. The program covers both design and simulation and models all types of power plants.

6 Gaps and Barriers Faced by DE

As per Section 1.3 (pg 6) the consortium compiled a web-based survey to allow for international assessment of DE opportunities.

As per Section 1.3 (pg 6) the consortium then designed, developed and compiled a detailed questionnaire and thereafter organised a workshop in London.

This section 6 summarises the responses of a wide range of stakeholders to a web-based survey, and the workshop. The views presented are the opinions of the **expert individuals** interviewed, and do not represent the views of the project consortium or of the ETI. The points made in this section are from direct comments received during the stakeholder interaction process and **no attempt has been made to elaborate on these comments.**

6.1 WADE International Assessment

The results of this survey have been used to form a baseline understanding of expert opinion to help develop the benefits case for DE later in WP5, with a summary of any major barriers and potential opportunities for greater deployment. Over 300 responses collected and collated are presented below. As the survey covered 15 questions only a summary of the main findings is given below.

1. 59 % of the people interviewed had more than five years experience in the DE market, 21 % with 10-20 years and 17 % with more than 20 years experience to date.

2. 45 % of the people who completed the survey were from North America, the next largest region was Europe at 39%, meaning over 80% were from developed nations.

   If the North America data is stripped out of the survey, it does not make a significant difference. Probably the main reason for this is that the US energy market is very similar to our own energy market, in that it is a relatively free market.

3. 66 % agree it would reduce the overall cost of energy and 22 % are not sure.
   a. “Once again the situation will drive the correct answer. Siting DE sites at optimum locations with costs supported by Gov't grants, minimizing distribution costs and losses will yield energy cost reductions. Without gov't regs e.g. wind/PV doubt with availability challenges and high costs these DG solutions are not cost effective”.

b. “By using less fuel through more efficient combustion and heat recovery in internal and combustion engines”.
c. “DE supplied power is more efficient, thus less costly power.

4. It was indicated the main benefits of DE would be
   a. Increased energy efficiency (which means financial efficiency)
   b. Increased national security of supply
   c. Better local control over energy supply
   d. Reduction in transmission and distribution losses
   e. Could lead to an increase in renewable technologies

5. When asked the biggest obstacles regarding DE?
   a. Lack of long-term government strategy (47 %)
   b. Cost of infrastructure (42.4)
   c. Current policy (38.6 %)
   d. Government backed finance or incentives to de-risk the market (31 %)

6. When asked what should be done to improve DE?
   a. Long term government strategy needs implemented (62%)
   b. Operating incentives such as feed-in-tariffs (46 %)
   c. Simplified policy (39 %)
   d. Capital incentives such as tax breaks (36 %)
   e. Regulation concerning grid connectivity (34%)

Q. Distributed energy will help the world reduce overall emissions of CO2 and GHGs. Do you agree?

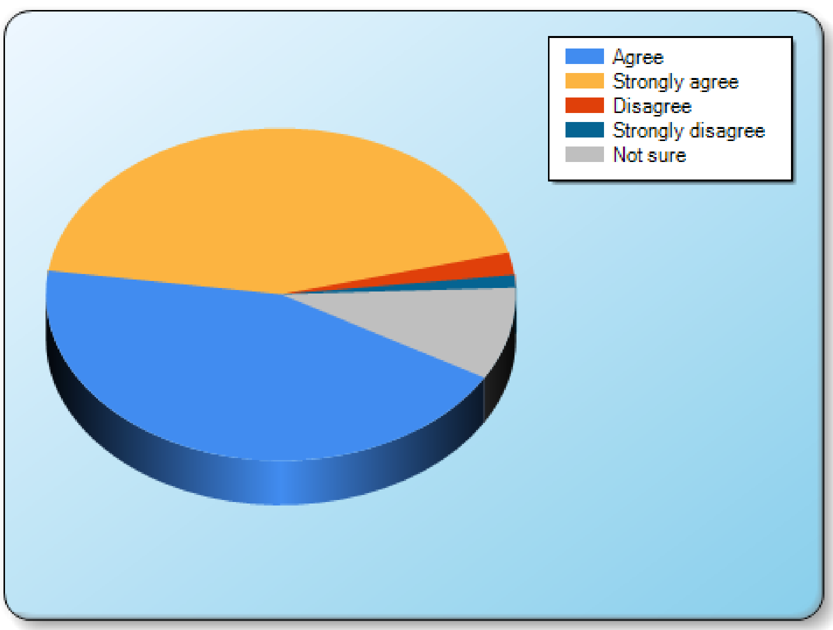


Figure 4 Benefit of DE regarding CO_2

87.7 % agree DE would reduce GHG and 8.9 % are not sure.

Some reasons why:

1. "DE is wide subject area, and includes high, low, and zero carbon supply technologies. All round savings from efficiency, and especially offsetting heat generation through heat networks, when fired by biomass/waste etc."

2. "Quite simply going from 30% to 80% efficiency makes an enormous amount of sense."

3. "Distributed power will enable local control over energy fuels. Biomass, wind, solar and biodiesel are all more practical when they are used in concert with appropriate small, distributed technologies. This will reduce carbon because of the nature of the fuel and reduction in high voltage transmission over long distance."

4. "It will but at the same time we need to improvements in grid infrastructure to make sure that these are connected to the grid. Also energy efficiency improvements are required. We also need to look into smart and super grids to improve energy distribution from renewables."

5. "DE implies widest opportunities for greatest diversity of techniques for generation closest to point of consumption thus providing possibility for maximum reductions."

Q. Rate how effective distributed energy would be when used for the following. Please rank each option where 1 is not beneficial and 5 very beneficial

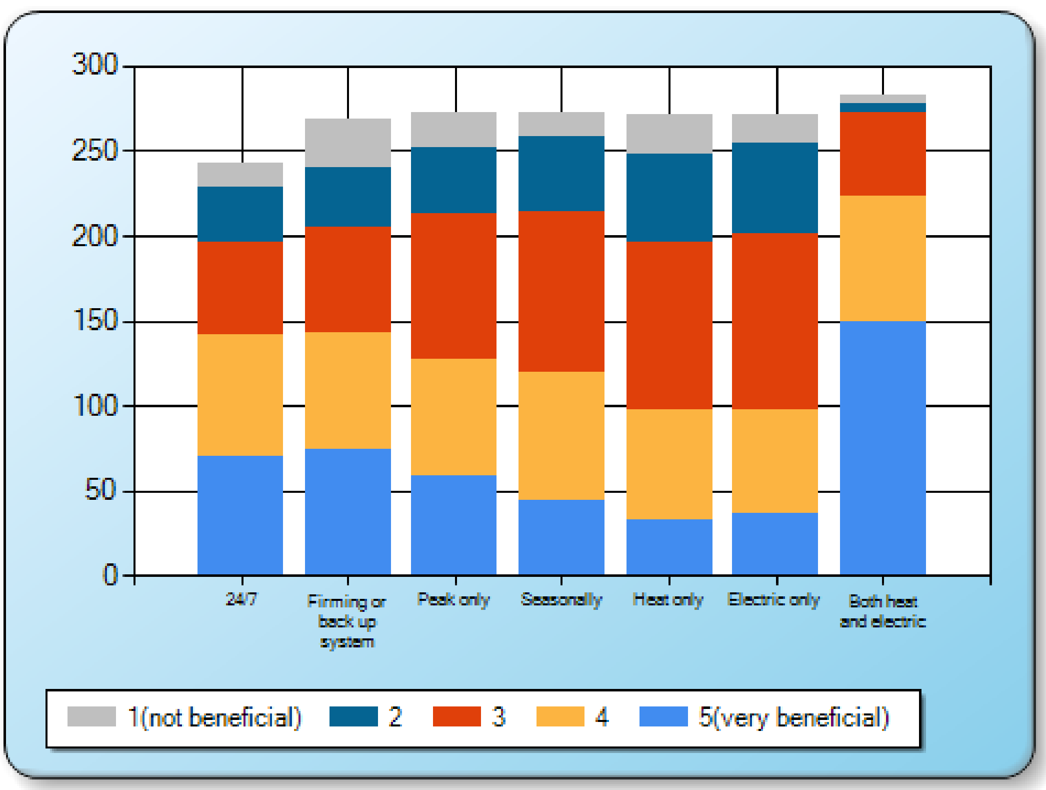


Figure 5 Beneficial Uses of DE

From the response presented above, it is clear that the greatest benefit is expected when **both heat and electric to come from DE** in the form of combined heat and power (CHP), regardless of the primary energy source (e.g. bio-fuels, energy from waste, reciprocating diesel engines). These responses indicate that people in society are changing their views regarding fuel consumption and energy use. These results indicate people would like to see the best and most efficient use of their primary fuel.

Q. From the list below rank the importance of each group in terms of influence to help drive distributed energy into the market place? (Please rate where 1 is low influence and 5 is high influence).

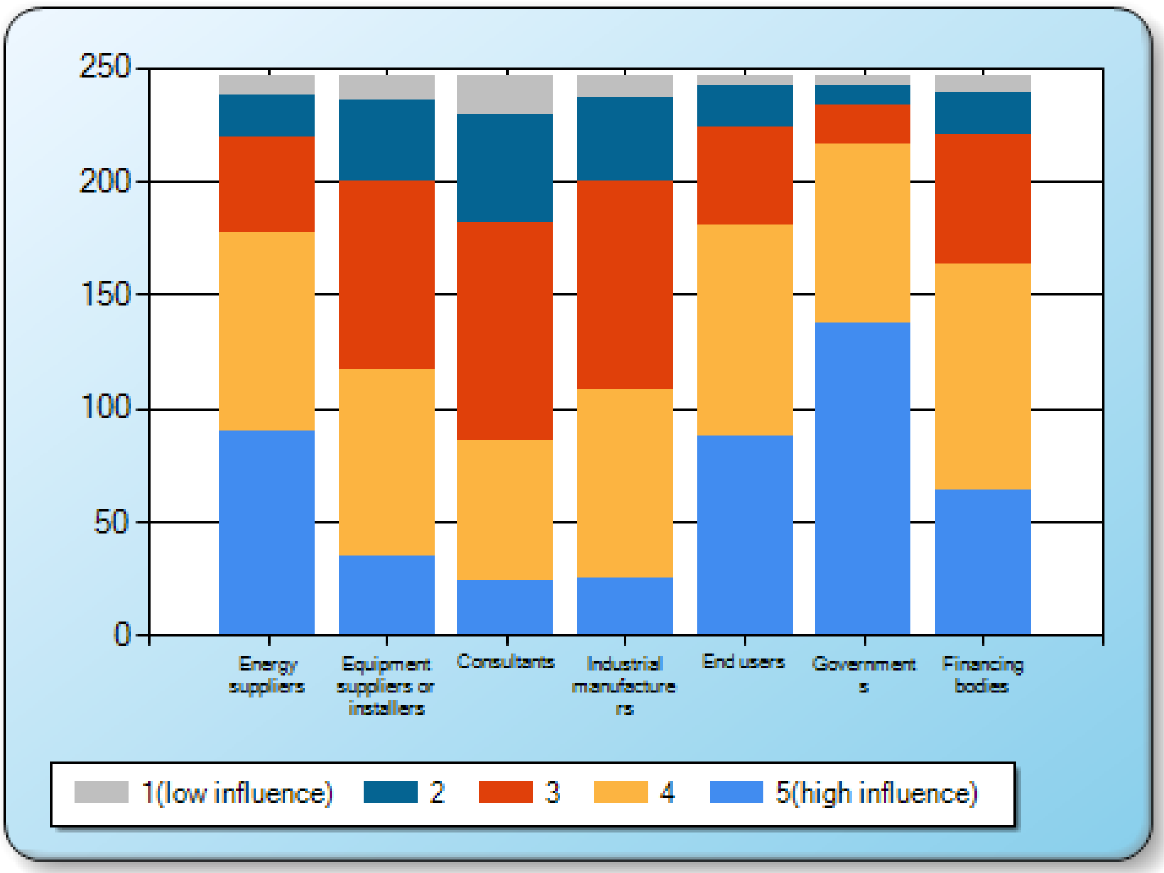


Figure 6 Influential groups to help implement DE

The chart above gives a clear indication of who should be involved to implement DE projects

- The first part is that the **end user/customer must positively want DE**. This is the most simple but fundamental issue regarding DE. If the customer does not want their energy supplied by DE then it will never work. Customer acceptance could be achieved by educating customers about the benefits of DE, in the same way they have been for renewable energy, e.g. wind, wave and solar. It must be remembered though that the customer will only want DE if it brings a financial benefit to them, such as a cheaper fuel bill, although even this will not guarantee take-up.

- Secondly, the energy supplier, such as the grid or district network operator (DNO) must want to or have the means to support this system, and at the same time be able to gain some benefit from supplying the energy in this way.
- Lastly the Government must facilitate this interaction between the end user and energy supplier, possibly through stricter regulations and/or some form of initial incentives. Most fundamental is all these players will gain some value from DE.

6.2 High Level Stakeholder Interviews and Workshop

All the completed interviews (with over 50 top companies) were with experts in the DE industry across the value chain, some with over 30 years experience. One of the most important aspects of DE is that the customer must want DE and gain benefit. This leads us to the question of 'why would they want it?' The main reason would be to improve their company image, bring down energy costs and increase reliability. Added value could come from:

- Lower energy bills for electricity and heating.
- Better service and less responsibility for the user/consumer due to one firm being responsible for maintenance and servicing contracts.
- Community value and confidence in a more reliable system. Most faults with the system will occur in the central energy centre, negating the need for boiler repair /plumbing contractors to come into residents' personal living space.
- Simpler and more compact equipment in an apartment due to a heat exchanger and circulating pump instead of a gas boiler.
- Commercial business will possibly pay less rent due to less space required for the boilers required.
- Industrial facilities would be less susceptible to black outs if there ever was a problem with the grid.

It appears that the Government targets of 80% CO_2 reduction by 2050 and improved energy security matters are secondary to improving end user experience according to many of the interviews. From the stakeholder interviews, the top reasons for using a DE system based on expert opinion were:

*The results add to more than 100% as interviewees were asked for their top three choices. *

- Increased efficiency (61%).
- Cost of energy (53%). (Many of these experts are hands on operators working with the customer)
- Green house gas reduction (48%). (Many of the experts stressing this opinion works in the public sector)
- Increased national security of energy supply (16%).

6.2.1 Policy

Issues

During the interviewing process and the stakeholder workshop many aspects related to policy were identified as problematic.

1. Non-renewable DE (CHP with gas engines/turbines) receives very modest benefits compared to other technologies such as wind. DE is considered to be renewable and non-renewable but because of this policy, the best, most efficient technology may not prevail.
2. Policy is directed at the generation sources and there is nothing to support the cost of infrastructure.
3. If policy were technology blind and only targeted CO_2 reduction linked to the long-term government strategy, it would allow market forces more freedom to facilitate the most cost effective solution while decarbonising the energy system. Many experts at the workshop highlighted this.
4. Concerns were raised about long documents being time consuming for modest benefit, conflicting policies and complexity of policy.

Constraints

Current incentives for fossil fuelled DE that is non-renewable are not strong enough! The issue was raised that only renewable technologies receive substantial benefits. The main issue around this is the EU target of increasing renewable energy to 20% of all energy generated by 2020.

- This does not mean DE incentives are modest but that they are also penalised, unless they are renewable, which is not the best way of meeting the UK target of 34% CO_2 reduction by 2020. These penalties work against meeting emissions targets but may help meet renewable targets.
- A long-term government strategy that is signed off by all political parties is needed. Over 50% of the people who were interviewed indicated that a long-term government strategy for DE would help break down many of the barriers that exist.
- Local authorities and consumers need to be educated on the benefits of DE and district heating, the same way government has educated people on renewable technologies.
- It is perceived that there is a lack of understanding of DE across politicians and officials.

Opportunities

The top three suggestions for policy changes, which would influence the DE market, include:

*The results add to more than 100% as interviewees were asked for their top three choices. *

- Increase operating incentives such as feed-in-tariffs (93%), this has worked very well in countries like Germany for CHP.

- Increase capital incentives (80%).
- Long-term government strategy (50%). This then would provide certainty which is vital for investors. If they know strategies and incentives are in place for a long time then they will invest.

One recommendation from the majority of stakeholder interviews; there should be a carbon tax, which adequately reflects the targets set by the UK. To be effective many countries need to adopt a similar approach otherwise businesses move to less regulated countries. If a Carbon tax were introduced then all aspects of DE would see a benefit. 48% of the stakeholders suggested this would be the best way to catalyse the DE market.

If one recommendation could be made it would be for the government to be technology blind and only targeted CO_2 reduction linked to the long-term government strategy, it would allow market forces more freedom to facilitate the most cost effective solution while decarbonising the energy system.

6.2.2 Grid Connectivity

Issues

The UK grid is complicated and many considerations need to be taken into account before permitting access to the network. A lack of standards has led to the grid connectivity becoming costly, difficult and variable. These opinions come from our research for this project. In some cases industry experts believe they are paying to upgrade old electric grid infrastructure. In another case it drove a DE project to use private wires (Mackie's Ice Cream in Scotland). Major concerns raised by the experts were:

- Cost of connection can vary dramatically from utility to utility (80%).
- Standards for connection, such as time limits and capacity charges (55%).
- The length of time the DNO takes to make the connection (45%).

An example of the process and time issues surrounding grid connections can be found in Appendix 1 of the report from Ofgem '**Condition 4F. Standards for the provision of non-contestable connection services 2007'** [3]. It is also worth noting if the quotes for connection are believed to be excessively high the operator can be recommended to Ofgem for review. This table is due for review and financial penalties for exceeding the time frame would be the best way to ensure the DNO does all it can to connect DE to the system.

Constraints

The Electricity Industry comprises three key stakeholder areas. They are:

- **Generators** – Owners of power generation plant who are responsible for generating the energy we use in our homes and businesses.
- **Distributors** - are the owners and operators of the network of towers and cables that bring electricity from the National Grid to homes and businesses (EDF,

United Utilities, etc.). Many of the stakeholders interviewed suggest the district network operator (DNO) is not financially driven to connect DE.

- **Suppliers** - are the companies who supply and sell electricity to the consumer.

Many years ago when the electricity network in the UK was established it was a regional grid. Many generation sites were located close to the customers they supplied and simple networks transmitted this power to the consumer. As time went on the network became more complex and implimented nation wide. The high voltage transmission system was developed and energy generated in one place in the country could be used to satisfy demand anywhere else. This network has been built up over several decades and mainly consists of centralised power. The reason for this is to allow the network to benefit from economies of scale and provide cheap power for most of the country.

Although all such large power grids have their own special historical and geographical peculiarities, they all tend to use methods of control and stabilisation similar to those used by the UK National Grid, to a greater or lesser extent. This leads to the conclusion we need a smarter grid system to connect all of these intermittent supplies and standards for connection. A smart grid system will be one which can read electricity supply and demand in real time and have response systems to adjust the flow of electrons accordingly so we can have bi-directional flow as opposed to one way flow as exists today.

Opportunities

The grid is an old system largely established in the late 1940s, which needs to be upgraded. The grid infrastructure complexity has limited the opportunity for DE to an extent, but DE could be used to support and enhance the grid infrastructure and development. Increased capacity needs to be available to all energy providers and increased flexibility of the grid is also needed, especially if intermittent renewable technologies are to be incorporated onto the grid. The question remains about how the UK should pay for the upgrade of the grid and how this cost will be passed on to consumers. Ofgem, on the 4th of October 2010 released a vision to charge consumers for the upgrade of the infrastructure for gas and electric. DE may be able to help reduce this cost.

According to a response letter to Ofgem from The Combined Heat and Power Association (CHPA), the District Network Operator (DNO) is penalised to connect DE and therefore Ofgem should conduct a study to show how DE can be used to help balance the grid, especially during peak demand.

6.2.3 District Heating (DH)

DH plays a major role in the energy supply chain in Scandinavia and Europe, mainly because they have laws and policies to promote uptake due to the lack of local gas reserves and an energy crisis that existed in the 1970s. In a DH network, heat is transported through pipes in the form of water. The heat supplied can be generated by any means and is therefore fuel agnostic.

Issues

The cost of infrastructure is a key issue, 76% of experts suggest infrastructure cost is in the top three barriers to implementing DE followed in second place by initial capital cost at 64%, at £1000 to £1200 per m [4] of piping it is not surprising DH seems expensive. The cost of the DH network is significantly affected by density (energy demand and number of users per hectare) and scale (total heat demand).

- The main competitor to DH in the UK is individual gas boilers. These gas boilers use established gas grid infrastructure and the costs for this grid were paid for from the public purse many years ago. Therefore DH looks an expensive alternative.
- The DH system would need to complement the gas grid and use the available gas grid infrastructure to maximise the use of public money already spent, at the same time placing piping infrastructure for the future.

Constraints

Besides the cost of infrastructure, other hurdles to overcome include:

- Public acceptance/perception.
- The disruption that would be caused by laying pipes.
- The perceived lack of control, compared to operating a user-owned boiler, and the image of DH as 'old-fashioned'.

These are all barriers to public acceptance. The benefits of DH in terms of cost, CO_2 emissions and operator responsibility are not well understood and need to be explored further.

Opportunities

There clearly exists an opportunity to put DH infrastructure in place to prepare for the future **while decarbonising the gas infrastructure now through more efficient use**.

- DH could initially be commissioned using existing technologies, such as gas engines and large gas boilers. These technologies can be changed to renewable or different technologies in the near future when they are available and ready.
- Given that heat density is very important in the determining the cost-effectiveness of DE in a given area, a map of heat demand density across the UK could facilitate deployment of DH.
- These technologies should be considered with major upgrades to the gas grid infrastructure. "The sooner the potential of DH is realised the better off the future energy system will look as a whole regarding emissions and cost".

6.2.4 Capital Cost

Issues

- Attitude of potential investors/ bankers that the technology is unproven and risky.
- Site location costs could be significant due to being in high dense areas.
- Rate of return available is not attractive enough for investors. Available incentives are not sufficient.
- Planning authorities and application process uncertainty.
- Capital cost has come up as one of the main issues concerning DE; 76% of experts as one of the top three barriers to implementing DE.
- Inability to compare new technologies with old because of existing investment in infrastructure.

Constraints

The existing gas and electric networks represent both an opportunity and a constraint, as the cost of installing new heat networks cannot compete with the existing gas network. The gas and electricity grids are upgraded all the time and these costs for assets management are factored into all our energy bills. This is the main reason why DE is perceived as being expensive, due to everyone regularly paying for the gas and electric infrastructure upgrade without realising.

How can we set up a review model that factors in the benefits for existing assets/infrastructure while phasing in the new technologies to complement the system?

Opportunities

- In DH networks the generation and piping typically have different asset lifetimes. Business models and investment criteria should recognise the longer life of the piping infrastructure.
- Modularisation (pre-fabrication) would allow investors to relocate generation equipment for re-use as appropriate so as to overcome the fact that today each system design is highly bespoke. Opportunities exist to standardise generation equipment, which could reduce capital costs, increase ownership flexibility and/or maximise asset value to the benefit of the whole of the UK.
- The support of long-term financiers is needed to accrue the benefits over a longer period of time that make the risks worth taking and hence de-risk the overall project.
- A review of the benefits of adding DH during grid upgrades to understand if it would dramatically reduce piping costs and extra delays by laying pipes
- If DE were rolled out on a larger scale it would inevitably bring down costs due to economies of scale.

6.2.5 Operating Costs

Issues

- One of the main aspects for the operating cost is that the "Spark Spread" (cost between gas price index and electricity price index) cannot be predicted. Unpredictable spark spread is seen as an unacceptable risk by financiers.
- The cost of the feedstock, whether it is biomass, gas or types of renewable, is uncertain and volatile, which leads to uncertain revenues and associated risks.
- Poor design and installation is the next biggest problem in this area. Over-sizing was a common problem in the past, causing projects to proceed but loose money in the process. Ensuring a sizeable and stable customer base remains a challenge.
- Lack of regulation of the heat industry compounds this challenge. There is a need to differentiate between the 'Heat' and 'Power' sectors and their regulated structure. 47% of CO_2 produced in the UK comes from heat use[ ].

Constraints

There are several constraints around operating costs:

- Stakeholders perceive the price paid for electricity exported to the national grid to be low relative to electricity import prices. Increased revenue from power export can improve business cases for DE significantly.
- Each project is bespoke and therefore has different operation and maintenance costs associated.
- There is no way of predicting operation costs accurately, which leads to uncertainty in the revenue generated and associated risks, which in turn can lead to higher financing loans.
- Heat does not have a value that adequately reflects its benefits. This leads to technologies producing more electricity that may not lead to the most efficient use. This hinders the development of CHP as one of the major benefits is generating heat while producing power.

Opportunities

Thermal energy storage using hot water provides an opportunity to optimise the operating schedule for heat generation for highest efficiency and revenue. This however requires extra operating footprint for the storage facility.

DE could help provide greater security for industry and public sector buildings that need to ensure they have their own back up capacity in case of emergency black out if the CHP is configured for island mode and if there is demand management for the site so that the CHP output is able to meet the site demand.

6.2.6 Commercial Development

Issues

Some of the main issues around the industrial sector are that leading industries are risk adverse. They want to continue in known technologies that pay their shareholders at the end of the year. Large corporate industries want technologies with return on investment (ROI) and rate of return of 15% and nothing less.

Next is the residential consumer, there are areas of DE for the consumer which shows a lack of understanding

- Focus on Capex and not the whole life of the project- just like double glazed windows the benefit will take some time to reap the full benefit. The initial capital cost seems very. This benefit depends how long the resident stays in the house or how long they perceive themselves staying in the house. If they move home will they ever recoup the investment?

- Operation and maintenance, many potential users (residential and commercial) assume it will be more difficult and more time consuming to run DE such as CHP or DH. Experience indicates that it takes less time to sort the problem than conventional gas. This again is an educational process, which the public need to understand.

Constraints

- Financiers are perceived to lack understanding of DE. There is a lack of structure in place to encourage investment in these areas. This was all too apparent when trying to find banks with knowledge of the area for the interview process. All due to the uncertainty of the revenue generated by DE schemes banks are reluctant to participate. There really needs to be some understandings or some kind of de-risking for these projects. The government will be the one to facilitate this gap and encourage investors in to the market.
- Due to this lack of security of revenue, there are not many projects that can find funding. The only project(s) that can find the funding at the moment are those, which are community schemes, which receive grants. Investors want long term (25 year) contracts for heat and electricity and only the public sector such as local authorities can make these investments/decisions as it currently stands.
- Other projects then become a niche market, ones with high-energy demands and heat loads, such as hotels.
- There also seems to be a lack of understanding at the local authority level as an option for energy strategy to meet targets

Opportunities

There is no real price around heat in the UK. There is a price for gas and electricity but not heat. It would be easier to understand the benefits of DH/CHP if there were a regulated price for heat.

- There is the possibility to bring in a regulated heat market.
- How do customers assess the value the system can bring?
- This is an opportunity to investigate what the customer wants.
- It might be good for residential customers to tie the loan to the property, but again the issue comes up of will the next buyer appreciate the value which is added to the house.
- The commercial customer needs to understand the benefit gained over the life of the lease for the building.

6.2.7 Technical

Several technical issues need further review:

- Future electric networks and systems need to be developed - the grid needs to become more flexible if it is to cope with the amount of projected intermittent renewables and DE. There are a few options here:
    - The grid can design control IT systems which act as a smart grid type system.
    - Secondly, spend a lot of money reinforcing the grid to increase capacity.

  The first step would be preferable, as it would upgrade the controls and response of a grid to different situations and be of further benefit for future networks. The second seems the most costly as increasing capacity can be expensive. DE could then be used in a back up capacity to help asset this new smart grid. It would balance the overall system using renewable and cost effective options.
- Systems, which can run on different fuels (fuel flexibility), would be an advantage to help balancing the energy system at different times of the year. These could include energy from waste, gasification or biomass.
- Energy (heat and electric) storage could be the key to help the grid balance intermittent energy supplies and help incorporate DE more smoothly into the energy system. Energy could be produced when it is the cheapest to, and then be dispatched at times when it is most needed (during peak demand). A plant could then be run at full design output and maximum efficiency, with the stored energy being distributed at times of higher demand to gain the maximum economic benefit.
- Cost of infrastructure piping: this is one of the main concerns over implementation of DH. The current costs associated are in the region of £1000-£1200 per m depending on location, pipe diameter and underground congestion. This is very expensive and a cheaper method or even a more productive method of installing the pipes is needed. The last part of piping infrastructure from the

road to the house is the most expensive, and a clever/more economical idea for this would be of great benefit to the cost of projects.

- The need for modularised (pre-fabricated) DE generation equipment that can be used in many instances around the country and not just bespoke niche solutions.

Opportunities

The value of introducing these systems could help overcome some barriers related to the deployment of DE, assuming a solution could be found. These areas, such as energy storage, bio-energy and energy from waste are already receiving significant resources from the ETI to help accelerate their development, but other areas could require financial assistance and help from elsewhere.

7 Conclusions

From the research carried out for this report it is possible to draw the following conclusions with respect to DE;

- DE is an established technology in the UK and throughout Europe.

- The value chain for DE is currently too long, too complicated and with a risk reward ratio that is not compelling for potential investors.

- There is potential to save money and reduce carbon emissions in the near term while constructing infrastructure for future development out beyond 2020.

- DE is inherently flexible as it can both accommodate local level energy targets and compliment the grid in times of peak demand.

- For DE to play a material role in the UK, strong partnerships will be required amongst public and private organisations including relevant funding institutions. It will also be essential to build a desire to deliver superior value and benefit to the customer and the local community.

- Macro-scale DE requires community [rather than individual's] action to maximise market penetration at an early stage. This requires a high degree of political commitment and potentially legislative action. Therefore it is not just a matter of technology and cost.

Also if DE were implemented correctly it could help meet some of the targets set out in the Government's 2009 White Paper 'The UK Low Carbon Transition Plan' such as;

- Deliver CO_2 emissions cuts of 18% of 2008 levels by 2020.

- Help produce around 40% of our electricity through low carbon resources.

8 References

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For more information on this project please visit the following web page

http://www.energytechnologies.co.uk/Home/Technology-Programmes/Distributed-Energy.aspx

or contact