The role of micro CHP in a smart energy world

Supporting widespread uptake to achieve energy policy objectives

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turning energy policy insights into commercial results

Overview

Our energy environment is changing rapidly as Governments globally strive to make cost efficient use of existing resources while enabling the emergence of a low carbon economy. Innovative policy is crucial to enabling the emergence of those technologies that will deliver this.

The UK aspires to be at the forefront of this effort. Policy interventions, such as the forthcoming reform of the Electricity Market, the Heat Strategy and the development of a smarter grid, are designed to replace current infrastructure so as to improve security of energy supply, meet binding carbon targets and generate wider benefits for our economy.

Micro CHP (mCHP), a cost-effective and flexible low carbon solution that generates heat and electricity on-site, can support this transformation of the UK's energy system and relevant policy objectives. Several complementary mCHP products with diverse specifications are already available, or close to commercialisation, in the UK.

At an important juncture for the success of mCHP, this report by key mCHP stakeholders aspires to set a framework for constructive discussion with a wide range of policy stakeholders on the technology's potential to contribute to energy policy objectives. The report also seeks to serve as a basis for cooperation with industry stakeholders, including leaders in the distributed and smart energy sectors and distribution network operators, to examine synergies such as the undertaking of flagship distributed generation projects.

To this end, the report commences by outlining the strategic benefits of mCHP. The report demonstrates that mCHP is the most cost-effective gas-fuelled domestic heating solution. Widespread mCHP deployment can transfer a significant part of electricity generation at local level creating significant benefits for our energy system and empowering consumers.

The report goes on to set out a commercialisation roadmap for mCHP. It highlights the potential of individual and clustered mCHP as a heating solution in new or existing buildings, where it can integrate with legacy heating systems. It also elaborates on the potential of the technology as a grid support mechanism to cope with capacity constraints and short-term spikes in demand and meet the electrical requirements of other new technologies which require electricity such as electric vehicles and heat pumps.

The report concludes by proposing elements for a support plan to capture the diverse advantages of the technology for the energy system:

Providing an initial boost

Support for flagship distributed generation projects involving mCHP could become a factor for quick cost reductions and scale gains at this early stage. Such projects could be financed by the Green Investment Bank and supported under the Low Carbon Networks Fund.

Enhancing incentive and certainty

A FIT increase to at least 17p/kWh would be important to generate improved consumer incentive, which is on par with other supported domestic low carbon heating technologies and drive cost reduction.

Reflecting the benefits of mCHP to the wider energy system

Flexible mCHP generation fulfills the main objectives of the Capacity Market mechanism, planned under the Electricity Market Reform. It therefore should be eligible for this mechanism, particularly in aggregated and controllable applications.

A review of the export tariff design to more accurately represent the value of exported electricity by mCHP and eventually pave the way for dynamic tariffs would also be a solution to reflect the system benefits of mCHP.

Creating a level playing field for low carbon technologies

A change in the Building Regulations by the end of the decade to require any replacement heating system to achieve a carbon reduction improvement vs. condensing boilers has the potential to establish a vibrant low carbon heating market in the UK. Such change would generate a level playing field for low carbon heating products, including mCHP, eliminating the need for continued support.

A. The Strategic Relevance of mCHP

1. The fit of mCHP with key energy strategy priorities

- **Strong fit with objectives of UK's energy strategy**
- **Potential as an enabler of the low carbon transformation of the wider energy system**

The overarching purpose of the UK's energy strategy is to reduce CO_2 emissions while retaining energy supply reliability and sustaining affordability of electricity and heating for consumers.

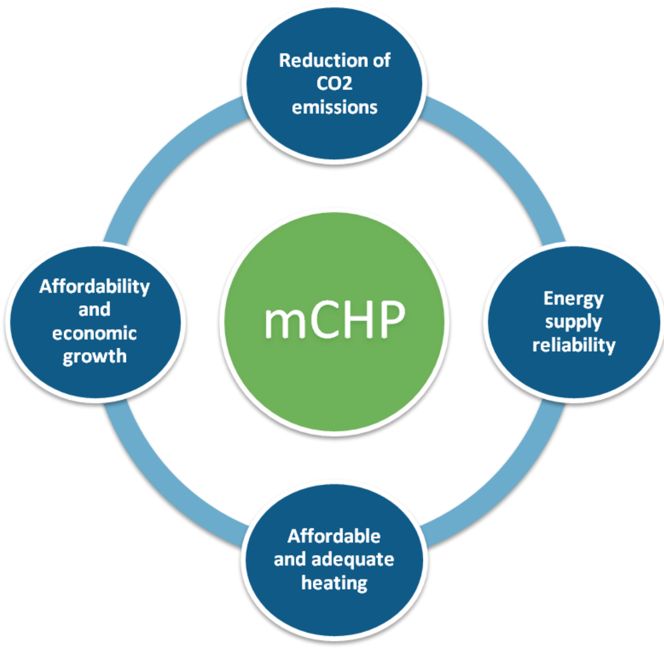
Two key policy mechanisms to achieve this purpose are the Electricity Market Reform (EMR) and the Heat Strategy. The EMR aims to transform Britain's electricity sector to attract investment, estimated at around £110bn by 2020, which will replace current infrastructure so as to improve security of supply, meet binding carbon targets and generate wider benefits for the economy[1].

The objective of the Heat Strategy is to define how the heat system will need to evolve over time to improve heating efficiency and ultimately decarbonise heating [2]. This effort will require a transformation of heat generation and heat use and the emergence of new markets to deliver this change at national and local level.

MCHP is a technology uniquely placed to support the attainment of energy strategy objectives and underpin the success of the Government's flagship policy instruments in the energy sector. As a cost-effective and flexible low carbon solution that generates heat and electricity locally, mCHP can enable the transformation of the wider energy system driven by the EMR and the Heat Strategy (see Figure 1).

Aside from the strong fit of widespread mCHP deployment with core strategic priorities, specific macroeconomic and technological trends further underpin the strategic relevance of the technology.

Figure 1. mCHP is a solution compatible with key energy policy priorities



1 DECC (2012) 'Electricity Market Reform: Policy Overview'
2 DECC (2012) 'The Future of Heating: A strategic Framework for low Carbon Heat in the UK'

2. Cost-effective utilisation of gas at the domestic level

- **Enhanced role for gas fired electricity generation to address renewable intermittency and nuclear inflexibility**
- **Gas dominant in supplying heat for buildings at least until 2030**
- **mCHP, the most cost-effective solution of utilising gas to generate energy at the domestic level**
- **mCHP a hedge against unviability of CCS and long term persistence of gas as dominant fuel for heating**

Gas will continue to play, a leading role in the energy mix beyond 2030. Gas fired units are responsible for 40% of electricity generation and 80% of heat generation[3]. The role of gas in the UK will remain significant, as a means of enabling a reliable and flexible electricity system and providing heat via an extensive and high quality gas infrastructure as well as LPG beyond the gas grid. The important future role of gas in the UK's energy mix is further supported by an improving global gas supply outlook, owing the development of conventional and non-conventional reserves, and considerable remaining indigenous gas reserves[4 5 6].

The EMR foresees that gas fired electricity generation will be key in delivering secure and constant supply of energy. New gas-fired power stations will serve as back-up for intermittent renewable generation, such as wind power, and inflexible nuclear generation. The need for new flexible gas capacity will increase as the implementation of an emissions performance standard will effectively prohibit new unabated coal-fired power plants[7 8]. Up to 26GW of new gas plants will be required by 2030 to replace older electricity generation units[9].

As a result of binding decarbonisation targets and an increasing carbon price, the deployment of carbon capture and storage (CCS) will be vital in rendering centralised gas-fired electricity generation viable in the long term, albeit at a substantial efficiency and cost penalty[10 11]. However, the viability of this solution remains in doubt. No European CCS demonstration projects were deemed viable under the EU NER300 funding scheme[12].

3 DECC (2012) 'Digest of United Kingdom Energy Statistics 2012'
4 DECC (2012) 'UK Gas Reserves and Estimated Ultimate Recovery 2012'
5 DECC (2012) 'A call for Evidence on the Role of Gas in the Electricity Market'
6 IEA (2012) 'World Energy Outlook 2012'

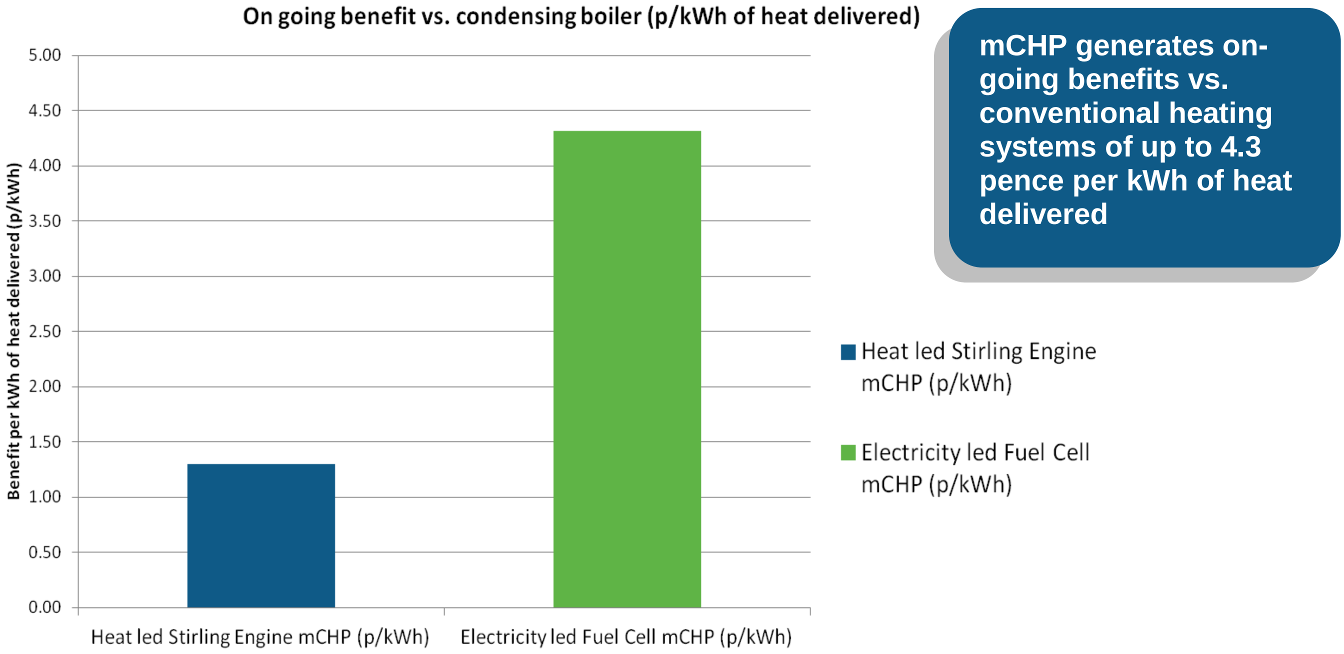
7 HM Government (2009) 'The UK Renewable Energy Strategy'
8 The introduction of an emissions performance standard for new power plants will effectively prohibit new unabated coal-fired power plants, a challenge given that coal accounts for about 35% of generated electricity in the UK
9 DECC (2012) 'Gas Generation Strategy'
10 Carbon Capture and Storage Cost Reduction Task Force (2012) 'The Potential for reducing the Costs of CCS in the UK'
11 DECC (2012) 'CCS Roadmap: Supporting the Deployment of Carbon Capture and Storage in the UK'
12 European Commission (2012) 'Award Decision under the first Call for Proposals under the NER300 Funding Programme'

MCHP is the most cost-effective method of utilising gas to generate energy at the domestic level

It is important to look at alternative options for efficient use of gas resources in electricity generation in order to hedge against any risk of flexible low carbon centralised generation proving to be either technically or economically unattractive. At the same time examining ways of utilising gas cost effectively to deliver heating, given that gas will still be the dominant fuel in supplying heat for buildings, at least until 2030, should also be a priority[13].

MCHP is the most cost-effective solution of utilising gas to generate energy at the domestic level (see Graph 1)[14]. As a highly efficient and controllable solution that generates heat and electricity locally, avoiding system losses associated with central power production, this technology becomes increasingly relevant in a challenging setting. A range of mCHP technologies, several developed in the UK, is currently available at varying stages of market development and with diverse commercial specifications.

Graph 1. mCHP is the most cost-effective method of utilising gas to generate energy at the domestic level



14 Graph 2 assumptions:
Dwelling annual heat requirement: 16,000 kWh
Fuel costs: DECC Energy Quarterly Dec 2012
Stirling Engine mCHP: Capacity: 1kW, Heat efficiency: 70%, Electrical efficiency 15%, 90% efficient auxiliary boiler delivers 20% of required heat
Fuel Cell mCHP: Capacity: 1kW, Load factor: 90%, Hot water efficiency: 25%, Electrical efficiency: 60%, 90% efficient auxiliary boiler delivers remaining heating requirement
Condensing boiler: Heat efficiency 90%

13 DECC (2012) 'UK Renewable Energy Roadmap: Update 2012' (paragraph 2.72)

3. Commercialising a diverse range of mCHP technologies

- **Deployment of all mCHP technologies necessary to exploit full strategic potential**
- **Swift uptake key to cost reduction and commercialisation**
- **Several mCHP products available, or about to enter, UK market**

A variety of mCHP products is commercially available in the UK with diverse, and often complementary, technical and commercial characteristics. MCHP can readily benefit from the substantial industrial and service boiler infrastructure in place in the UK, the largest boiler market in Europe. In order to exploit the full strategic potential of mCHP, widespread deployment of all mCHP technologies is necessary.

MCHP technologies are still at an early stage of market development and therefore manufactured at limited scale with relatively high upfront costs. Compared against a gas boiler market of around 1.5 million units per annum, mCHP products cannot compete with economies of scale in production, distribution and installation at current volumes.

However companies involved in the development of mCHP do have the capacity and experience to upscale rapidly with the right market conditions. Swift uptake is the main route to cost reduction. Scale and several promising developments in design and system simplification means that this technology can anticipate very steep learning-curves[15].

The mCHP products that are available, or developed, in the UK market fall under three broad technology categories:

- **Stirling Engine mCHP** is a highly efficient heat led solution that has achieved progress in the domestic market and currently accounts for the significant majority of mCHP sales in the UK[16]. It presents a proven and dependable low carbon replacement for condensing boilers in the on-gas and off-gas grid sectors. The success of Stirling Engine mCHP can pave the way for the wider commercialisation of a wider range of mCHP solutions, currently at an earlier stage of commercial development.
- **Organic Rankine Cycle mCHP** is another heat led mCHP technology that serves as an efficient replacement to condensing boilers. This technology is very close to entering the commercialisation phase both in the on-grid and off-grid markets[17].

15 Staffel, I., Green, R. (2012) 'The cost of domestic fuel cell micro-CHP systems, Discussion paper 2012/8'
16 See: http://www.baxi.co.uk/products/baxiecogen.htm
17 See: http://www.genlec.com/homeowner/index.html

Due to its lower up-front cost, this solution has the potential to generate relatively short payback periods and enable rapid market gains. Low upfront cost can enable commercialisation as part of fuel supply arrangements or via leasing schemes thus reducing upfront costs and generating significant on-going benefits for consumers.

Bluegen mCHP unit:
Image courtesy of Ceramic Fuel Cells

- **Fuel Cell mCHP** is a solution that has high electrical efficiency and therefore its output is much less determined by heat demand[18]. As a result, this solution can provide a high level of power generation flexibility and create opportunities for enhanced demand response and combination with other distributed generators (e.g. heat pumps, vehicle to grid). Fuel Cell mCHP has strong potential in all types of properties, including modern and well insulated homes. One product is already commercially available in the UK market, while at least two UK based companies are developing fuel cell mCHP products with a view to entering the market shortly[19].
- **Internal combustion engine (ICE) mCHP** is also expected to enter the UK market soon. ICE is a proven and established CHP technology. ICE mCHP products are currently developed by a diversity of major industry players and it is anticipated that they will become commercially available in the UK shortly.

18 See: http://www.cfcl.com.au/bluegen/
19 See: http://www.ie-chp.com/

B. MCHP as the next Generation Heating System

4. Meeting our heating needs efficiently

- **mCHP is an efficient development of the condensing boiler**
- **Strong commercial potential both in on-grid and off-grid segments**
- **Uniquely placed to operate in a modular fashion in a shared environment**
- **Potential of coupling mCHP with heat pumps at domestic or system level**

MCHP presents a development of a widely available existing technology, the high efficiency condensing boiler. All mCHP technologies work in tandem with the heating needs of new or existing buildings, where they can integrate with legacy heating systems (e.g. radiators, pumps etc.) and serve as a simple means of readily upgrading the existing stock of residential boilers.

MCHP is an efficient commercially available solution for gas utilisation for heating purposes at the domestic level. MCHP can also deliver heating efficiency gains in the off gas grid sector via the commercialisation of LPG fuelled mCHP products. The technology makes particularly strong sense in the off grid segment as a result of typically higher heat load factors in this market that increase attractiveness.

Aside from an ideal like-for-like heating replacement in individual properties, mCHP is well placed to operate in a modular fashion in a shared environment, benefiting from economies of scale. MCHP is an ideal solution for social housing or for a block of flats and community heating schemes. The modular deployment of mCHP may become the predominant commercialisation means as the technology matures and decarbonisation targets become more stringent.

The coupling of mCHP with heat pumps, either at individual property level or at scale, is also a solution examined by industry. As both electricity and gas decarbonise, it is desirable that each will be utilised as efficiently as possible (see Figure 2 for mCHP commercialisation alternatives).

Systems comprising electric heat pumps and mCHP can become an effective means of utilising renewable electricity when available and using gas, or high value renewable gas, as a means of back-up or to feed electricity to heat pumps[20].

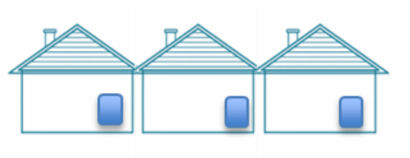
[20] Such a combination would constitute a very efficient method of utilising natural gas. The accompaniment of such a combined system with a common storage tank, to store hot water for tap water and for heating purposes, would render this an attractive solution and offer buffering on expected electricity price changes and fluctuations.

The accompaniment of such a combined system with a common storage tank, to store heat for domestic hot water and space heating purposes, would offer enhanced buffering on expected electricity price changes and fluctuations.

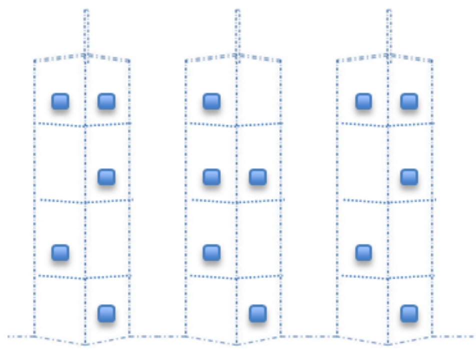
At system level, mCHP can support the proliferation of electric heat pumps given the strong correlation between heat pump electricity demand and heat led mCHP electricity supply (see also Graph 4).

Figure 2. Utilising gas cost effectively to meet heating needs

mCHP can serve as a simple means of readily upgrading the existing stock of residential gas boilers and can integrate with legacy high-temperature heating systems (e.g. radiators, pumps)



mCHP is uniquely placed to operate in a modular fashion in a shared environment, benefiting from economies of scale



Coupling of mCHP with heat pumps, either at individual property level or at scale is an exciting commercialisation prospect

MCHP is a flexible heating solution with diversified commercialisation potential.

5. A heating solution beyond fossil fuels

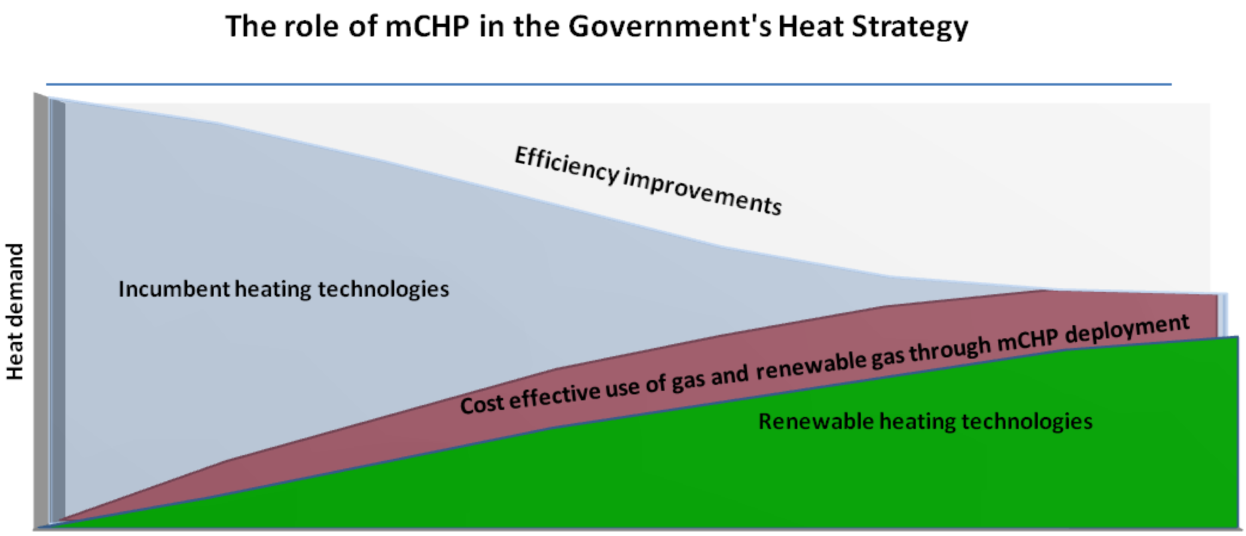
- **mCHP is highly flexible in terms of fuel type utilisation**
- **Renewable gas-fuelled mCHP can readily capitalise on enhanced renewable gas availability**
- **Innovations enable integration of renewable electricity with zero-carbon gas**

MCHP is a heating solution that is flexible in terms of fuel type utilisation. Therefore renewables, in the form of renewable gas, should not be overlooked as the eventual fuel of preference for mCHP. Renewable gas fuelled mCHP would allow the technology to become part of the portfolio of renewable heating solutions to attain full decarbonisation of domestic heating by 2050 (see Graph 2).

It has been suggested that renewable gas has the potential to make a significant contribution to renewable and carbon reduction targets by 2020 and in the long term meet a significant part of UK residential gas needs[21]. The potential of renewable gas has been recognised by DECC which expects renewable gas capacity to play a progressively important role in the decarbonisation strategy[22].

Renewable gas prospects will increase with the deployment of novel production technologies. As the electricity grid decarbonises due to the introduction of large scale renewables, so the gas grid could do exactly the same. Intermittent renewable electricity is already used in European markets, via the power-to-gas process, to produce hydrogen or synthetic gas for injection into the gas grid[23].

Graph 2. mCHP as an enabler of the Government's Heat Strategy



21 National Grid (2009) 'The Potential for Renewable Gas in the UK: A Paper by National Grid'
22 DECC (2011) 'Renewable Heat Incentive Impact Assessment (IA)'
23 'The potential for Renewable Gas in the UK', Ernst & Young for National Grid, January 2009

Power-to-gas, allows the conversion of excess power that is generated by wind farms into hydrogen, which can in turn be converted into syngas. The produced gas can subsequently be fed, or stored into the regional gas grid where it is then available for producing heat and power. Innovations, like power-to-gas, will progressively enable the integration of increasing renewable electricity capacity with zero-carbon gas availability to be used for heating[24].

The development of renewable gas is also possible in the off gas grid sector. Biopropane, a gas physically and chemically equivalent to fossil fuel propane that can be purified to meet LPG standards, can be used directly in conventional LPG equipment, including mCHP, in off gas grid homes and businesses[25]. The potential of biopropane used in combination with mCHP is considerable.

Baxi Ecogen Unit: Image Courtesy of Baxi Group

24 See 'E.ON starts Construction of Power-to-Gas Pilot Plant in Germany', http://www.eon.com/en/media/news/press-releases/2012/8/21/eon-startsconstruction-of-power-to-gas-pilot-plant-in-germany.html

25 DECC (2012) 'Renewable Heat Incentive, Call for Evidence: Biopropane'

C. Generating benefits for the wider energy system

6. Beyond mCHP as a heat led innovation

- **mCHP can transfer electricity generation to the local level**
- **mCHP can empower consumers by giving them control of their electricity bills**
- **Local electricity generation to alleviate losses from transportation to consumer**
- **mCHP is the most controllable distributed electricity generator**
- **Natural complementarity with heat pumps and PV**

In tandem with its role as an efficient heating solution, mCHP has the potential to facilitate the substantial improvements to our energy system foreseen under the EMR. Widespread mCHP uptake could complement significant investment in centralised generation under the EMR, or indeed transfer a considerable proportion of electricity generation from big centralised power stations to the domestic or local level.

Circa 7% of all generated electricity is lost as it is transported to consumers as a result of transmission and distribution losses[26]. MCHP penetration would allow the generation of electricity efficiently by alleviating losses of electricity resulting from its transportation to the customer. It would also engage consumers in their energy use and empower them to reduce electricity bills and become active participants in the energy market[27]. At scale, mCHP could address renewable electricity generation intermittency flexibly and cost effectively.

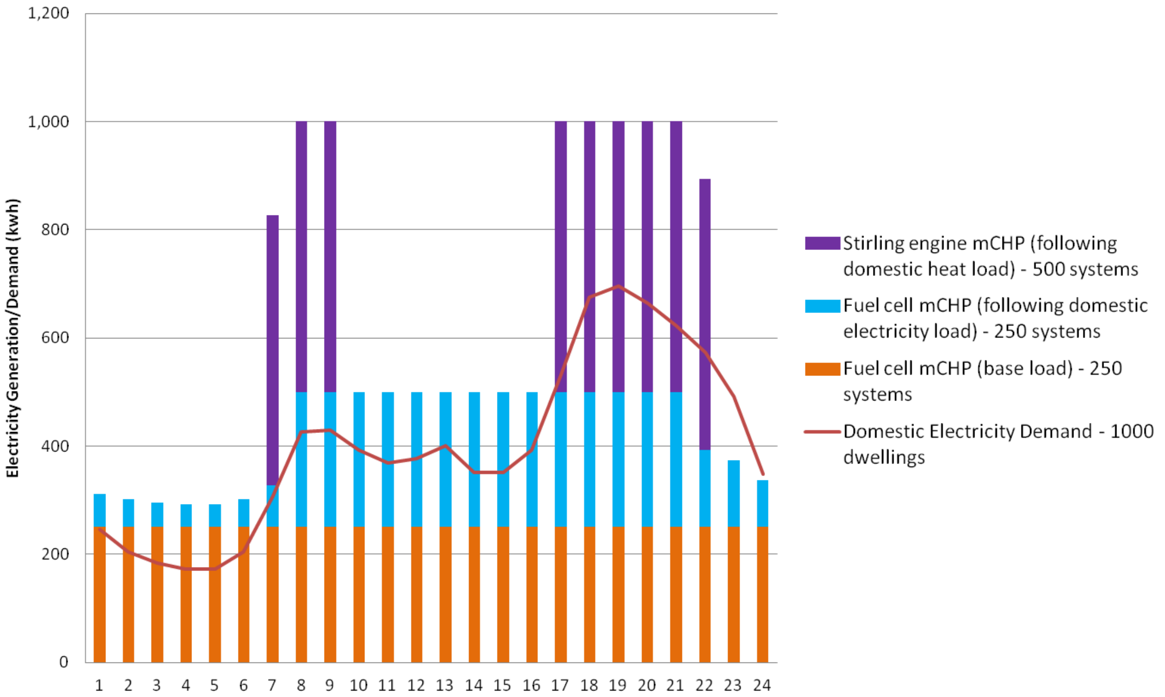
In an environment that favours a more important role for local energy generation, mCHP is the most controllable distributed energy technology. The power output of mCHP can allow enhanced viability in local power generation as a result of its flexibility and natural fit with key renewable solutions and domestic electricity demand (see Graphs 3 and 4)[28][29].

With the deployment of smart meters and the smart grid coupled with improvements in energy storage, mCHP flexibility would generate innovative possibilities to incorporate the demand side more actively in power system operation with considerable benefits.

26 The World Bank Data for period 2008-2012. Retrieved on 15/01/2013

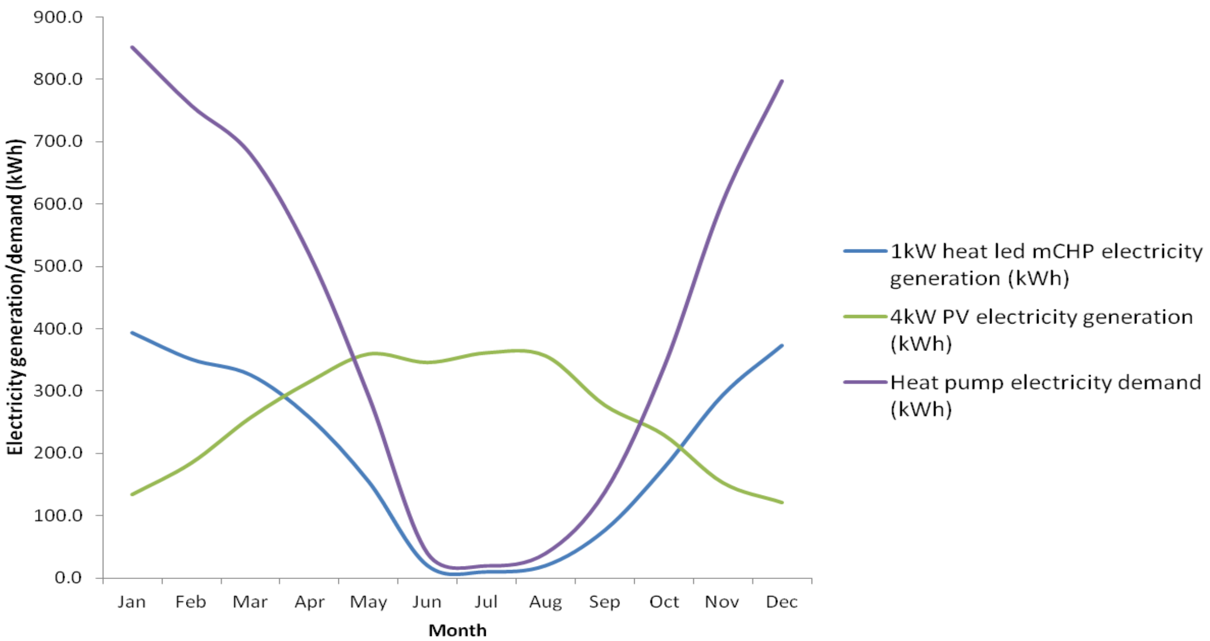
27 DECC (2011) 'Planning our Electric Future: a White Paper for secure, affordable and low-carbon Electricity' (p.31)
28 Graph 5 assumptions:
Stirling Engine mCHP: Capacity: 1kW
Fuel Cell mCHP: Capacity: 1.5kW
Domestic electricity demand: Elexon 'Load Profiles and their use in Electricity Settlement', Figure 1, Average Domestic
29 Graph 6 assumptions:
Dwelling annual heat requirement: 16,000kWh
Stirling Engine mCHP: Capacity: 1kW, Heat efficiency: 70%, Electrical efficiency 15%, 90% efficient boiler auxiliary boiler delivers 20% of required heat
HP: SPF: 3.2
PV: Capacity: 4kW

Graph 3. Complementarity of a system of diverse mCHP technologies with average daily electricity load



Different mCHP technologies are complementary. If deployed at scale they can address the electricity demands of a local community on a typical winter day and export electricity particularly during periods of peak electricity demand.

Graph 4. mCHP complementarity with annual PV generation and heat pump electricity demand



Electricity generation from mCHP fits naturally with annual generation and demand patterns of key distributed renewable technologies

mCHP engages consumers in their energy use and allows them to reduce electricity bills while becoming active participants in the energy market

7. The opportunity of widespread deployment

- **Widespread mCHP deployment naturally fits with winter time peak demand**
- **Virtual power plant would allow flexible mCHP generation to address wind intermittency**
- **Virtual power plant projects already implemented in European markets**

MCHP generates electricity that can address a significant part of domestic needs and reduce rising electricity bills. Electricity produced by mCHP can also be exported to the grid generating significant benefits for consumers, energy suppliers and distributors.

Heat led mCHP tends to generate more power at times of peak demand (e.g. evenings and winters) and so naturally reduces the need to operate, or maintain, fossil-fuelled peaking plants. This creates substantial financial net benefits for the wider energy system from avoided capacity, energy and emissions costs. This benefit has been estimated at 6.2p/kWh electricity generated, assuming widespread mCHP deployment[30] [31].

MCHP is also a highly controllable electricity generation solution. Advanced control of modulated mCHP units, especially mCHP with higher electrical efficiencies, can enhance the potential and corresponding benefit of this technology as a balancing mechanism for wind intermittency. The clustering of distributed mCHP units, to constitute a virtual power plant, controlled and operated by a central entity, would allow power generation to be modulated up or down to meet peak loads.

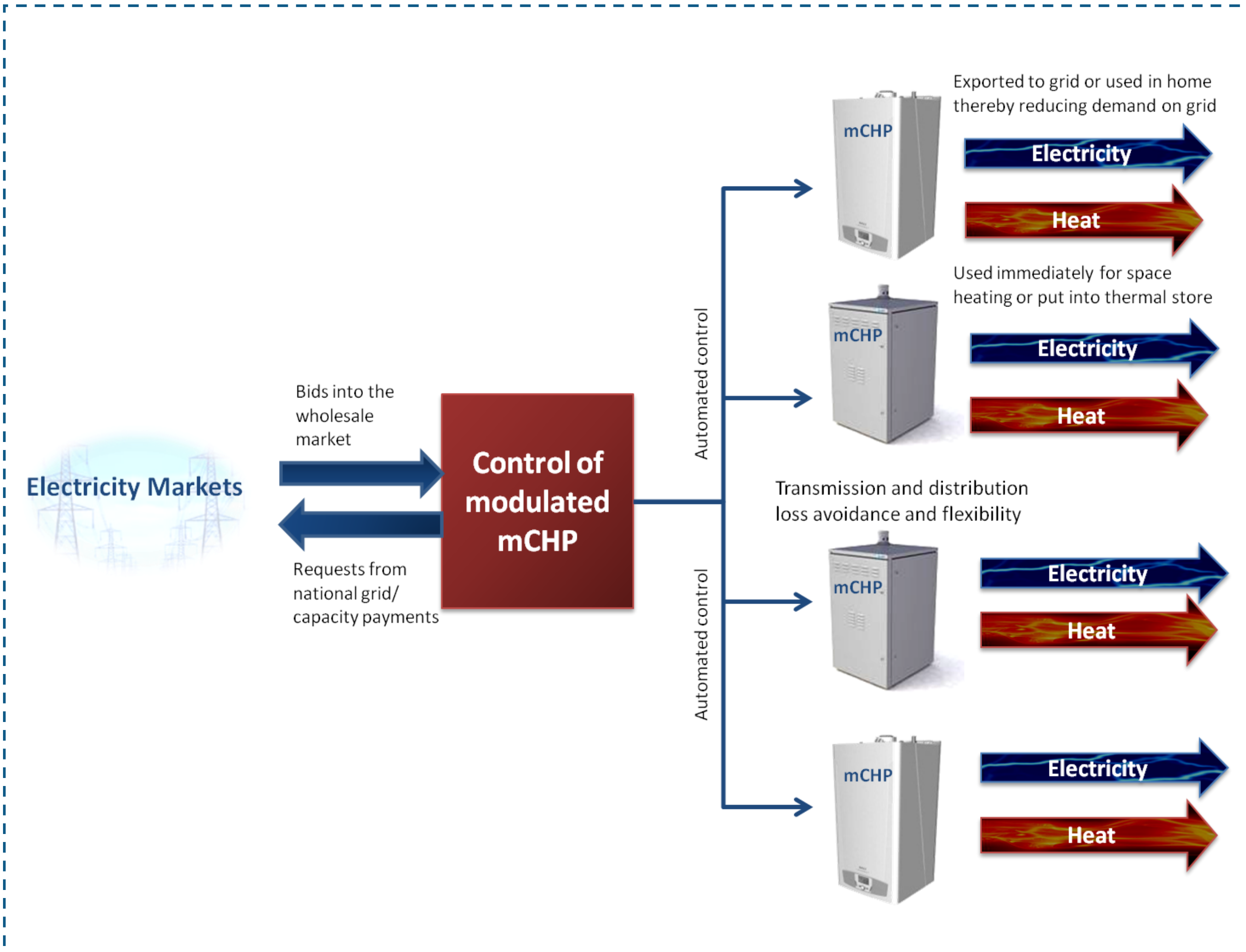
Flexible generation would balance intermittent power from wind or solar, with higher efficiency and more flexibility than large centralised power stations (e.g. CCGT plants). By producing energy where it is needed, mCHP would also ease the burden on electricity distribution networks and prevent distribution losses associated with conventional centralised generation methods (see Figure 3).

The concept of the virtual power plant is systematically examined in a number of European markets as a means of a more efficient application in the domain of distributed generation. A series of pilot projects have already been implemented and commercial virtual power plants, such as the ones in Germany in the state of North Rhine-Westphalia and in the Netherlands, have now commenced operation or are expected to become operational during 2013[32] [33]. In Germany Lichtblick, an energy supplier, is already implementing this novel commercialisation model for mCHP with a view to creating a virtual power station of mCHP units.

[30] JDS (2011) 'Micro-CHP as an integral Component of the UK's Energy Strategy'
31 SIAM (2004) 'System Integration of additional Micro-Generation (SIAM)

32 Fuel Cells Bulletin (2012) 'German Virtual Power Plant Project using 25 BlueGen mCHP Units', Volume 2012, Issue 10, October 2012
[33] CHPA (2012) 'Bluegen microCHP to be used in Virtual Power Plant'

Figure 3. mCHP virtual power plant - Aggregating the electrical output of mCHP



8. The prospect of demand response at local level

- **Capacity and flexibility of response to real time prices via smart metering**
- **Enabler of 'local' markets where consumers trade energy via dynamic pricing**
- **The role of the smart grid and development of energy storage key**

Beyond applications of clustered mCHP aimed at delivering peak load electricity, mCHP control presents the capability for flexible demand response by responding to real time electricity prices. Real time pricing information will be enabled via the widespread deployment of smart meters and the implementation of the smart grid[34].

MCHP, as a controllable distributed generator that provides heat and power simultaneously, is well placed to be the central part of a localised demand response energy system. Fuel cell mCHP in particular, due to its higher electrical efficiencies, is less constrained by heat demand and offers an especially high level of flexibility in its power production[35].

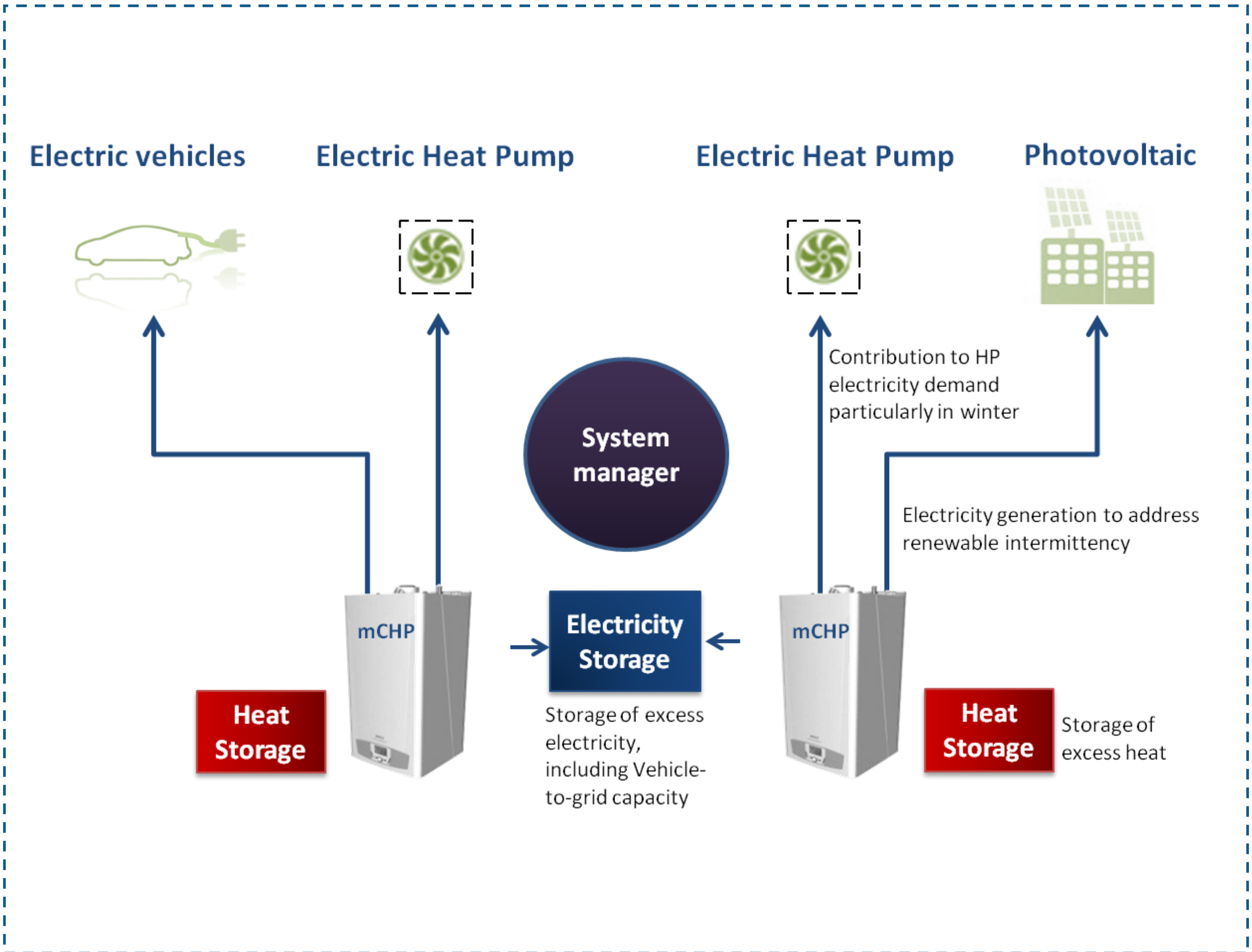
In the longer term, a promising demand response application for mCHP, would be at the local level via the gradual emergence of highly automated, 'local' *peer to peer smart markets* in which small generators trade energy amongst each other[36]. These local markets would consist of end-users that are both producers and consumers of electric power while remaining part of the national network.

In such a distributed system, mCHP would be the obvious choice for balancing purposes given the intermittency of renewable microgenerators. Controllable microgenerators, principally mCHP, would respond to system demands and price signals based on sophisticated algorithms or via heat loads designed into the system[37]. The possible combination of mCHP with heat and electricity storage facilities, including vehicle-to-grid capacity, would significantly enhance its balancing capability.

The future role of mCHP within localised energy systems should be examined further as part of the effort to design small scale energy systems with enhanced autonomy capability (see Figure 4).

[34] DECC (2012) 'Smart Meters Programme: Smart Meters Programme Plan'
35 Houwing, M. et al. (2011) 'Demand Response with Micro-CHP Systems'
36 See for instance Steinheimer, M. (2012) 'Energy Communities in Smart Markets for Optimisation of Peer-to-peer interconnected Smart Homes'
37 Kuech, J. et al (2003) 'Micrograds and Demand Response'

Figure 4. mCHP as a balancing mechanism in localised energy systems



D. Towards effective support mechanisms

9. Effective support as a prerequisite for mCHP deployment

- **Timely economies of scale and learning to reduce costs key to success**
- **Cost reductions expected to be steep with scale**
- **Solid support important to attain scale and achieve cost reductions**

MCHP is a commercially available solution, currently manufactured in low volumes, which leads to a relatively high starting price. Achieving timely economies of scale and learning to reduce costs is a challenge. Support is critical to kick start this industry.

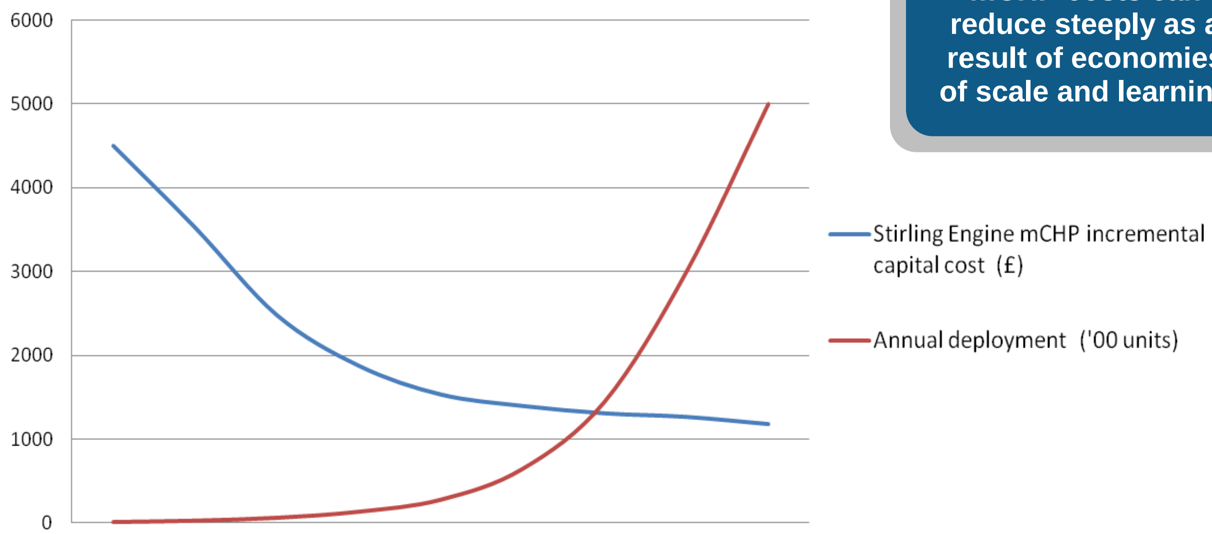
Solid support has already delivered greater deployment in markets like Japan - with around 20,000 domestic mCHP sales in 2012 - Germany and South Korea. MCHP prices in Japan were estimated to drop by 25% by the end of 2012 compared to 2010 levels[38 39].

Although the UK cannot readily benefit from cost reductions abroad due to considerably diverse market and therefore product specifications, a similar cost reduction trend is anticipated in the UK during the early stages of domestic mCHP deployment (see Graph 5)[40].

With the right support, the industry is committed to bringing this innovation to the mass market in order to create high value UK manufacturing jobs and deliver the numerous benefits of mCHP to consumers, communities and our energy system.

With solid support mCHP costs can reduce steeply as a result of economies of scale and learning

Graph 5. Scale as a driver for mCHP cost reductions



38 FuelCellToday (2013) 'Analyst View: Latest Developments on Ene-Farm Scheme'
39 See also Staffel, I. et al (2012) 'The Cost of Domestic Fuel Cell micro-CHP Systems'
40 Experience curve based on industry average projections (2013)

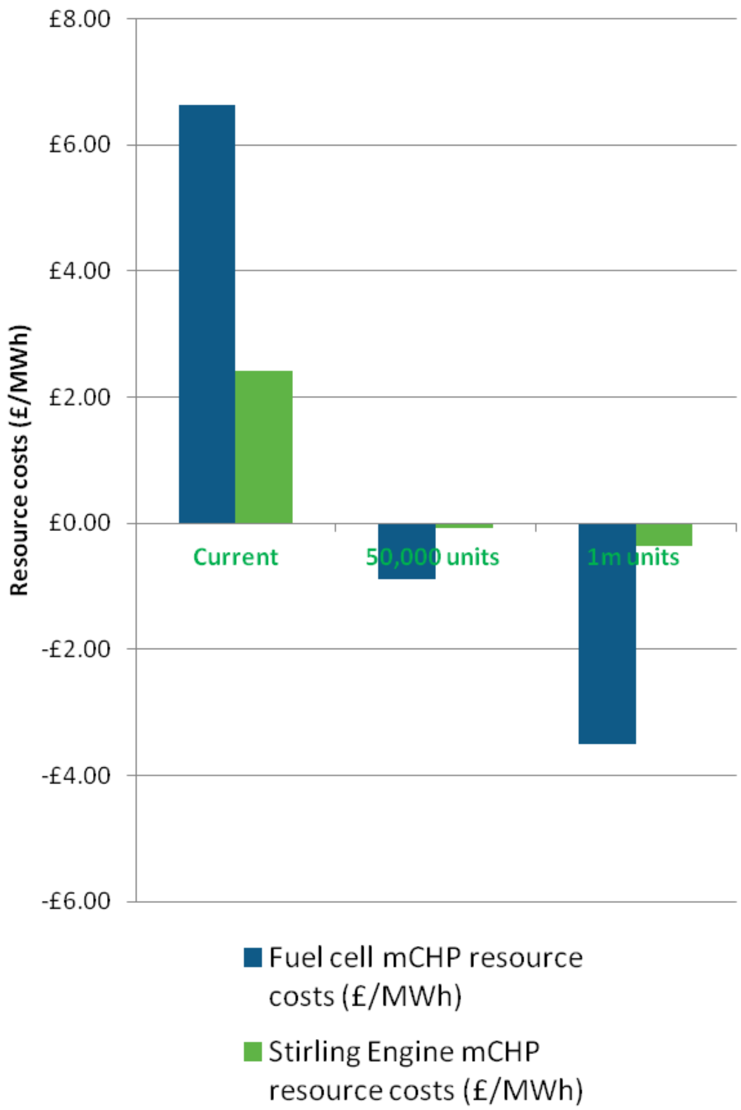
Solid support for mCHP would kick start this market and allow the capitalisation of the numerous benefits of the technology

10. Defining key aspects of effective long-term support for mCHP

- **Support for flagship distributed generation projects**
- **A FIT increase to at least 17p/kWh to generate viable incentive**
- **Enhanced export tariffs and capacity payments to reflect mCHP system benefit**
- **Change in the Building Regulations to establish low carbon heating level playing field**

Solid support for mCHP would kick start this market and allow the capitalisation of the numerous benefits of the technology. Like most microgeneration technologies, mCHP presents on-going benefits against conventional alternatives such as condensing boilers but high upfront costs as a result of limited scale. An effective policy roadmap to drive mCHP deployment would reduce costs rapidly to competitive levels, eventually leading to negative resource costs for diverse mCHP technologies (see Graph 6)[41 42].

Graph 6. mCHP Resource Cost Reduction trends



As a result of capital cost reductions, all mCHP technologies will generate an overall positive outcome for our economy beyond 50,000 units compared to incumbent technologies.

41 In this case mCHP resource costs include the foregone investment opportunities resulting from the capital and operating costs of a mCHP installation and the resulting fuel savings from an installation compared to a condensing boiler counterfactual;

42 Graph 10 assumptions:
Dwelling annual heat requirement: 16,000kWh
Fuel costs: DECC Energy Quarterly 2012
Stirling Engine mCHP: Capacity: 1kW, Heat efficiency: 70%, Electrical efficiency 15%, 90% efficient boiler auxiliary boiler delivers 20% of required heat, Costs: as per Graph 5
Fuel Cell mCHP: Capacity: 1.5kW, Load factor: 90%, Hot water efficiency: 25%, Electrical efficiency: 60%, 90% efficient auxiliary boiler delivers remaining heating requirement, Costs: Staffel, I. et al. (2012)
Condensing boiler: Heat efficiency 90%, costs: £2,700

Key aspects of a long term regulatory plan to reflect and capture the diverse benefits of mCHP are outlined below.

a. Providing an initial boost

Given the cost involved in developing mCHP and limited market scale at present, a plan to demonstrate the technology at scale would serve as a vote for confidence for this industry. An early thrust would generate a step change in volume, establish mCHP benefits and lay the foundations for market development in the UK[43].

Viable financing for flagship distributed generation projects, such as virtual power plant applications, involving mCHP from a financial institution such as the Green Investment Bank could become a factor for quick cost reductions and scale gains at this early stage. This financing could be accompanied by support from schemes such as the Low Carbon Networks Fund as a means of demonstrating a new operating arrangement that can support security of supply while alleviating the need for local network reinforcement due to anticipated load growth.

Countries like Germany are already implementing novel approaches to encourage major mCHP projects. The German federal state of North Rhine-Westphalia is introducing a support programme of €250 million for mCHP, including supporting virtual power plant applications. The UK should also aspire to remain at the forefront of mCHP innovation.

b. Enhancing incentive and certainty

Unlike condensing boilers, mCHP has not yet reached commercial maturity. MCHP is a new technology, currently manufactured in low volumes, which leads to a relatively high starting price. However, at the customer level it must compete with condensing boilers, a mature technology which benefits from significant economies of scale and value engineered manufacturing processes.

To incentivise consumers to take up mCHP at this stage, fiscal support to generate an adequate return versus incumbent technologies is necessary. The support for mCHP under the FIT scheme was recently increased to 12.5p/kWh. However this is still lower than the support of 17p/kWh deemed essential to deliver a rate of return for consumers closer to 7.5%, which is considered necessary for the uptake of low-carbon heating technologies to be supported under the domestic RHI[44].

A FIT increase to at least 17p/kWh therefore is necessary at present to allow mCHP to compete on par with other low carbon heating solutions. Beyond the current FIT review point of 30,000 mCHP installations, a subsidy diversification may need to be examined in order to reflect

43 See for reference the objectives of ene.field. a project to deploy and monitor 1,000 new residential mCHP installations in EU member states

44 The industry has argued since 2010 that a FIT of 15p/kWh would be necessary to generate a RoR close to 7.5%. This would be 17p/kWh in 2013 prices taking into consideration annual RPI rates.

the different commercialisation stage and specifications of diverse mCHP solutions.

c. Reflecting the benefits of mCHP to the wider energy system

By generating power at the point of use and typically at times of peak demand, mCHP reduces the strain on transmission and distribution systems, deferring the need for infrastructure upgrades. This generates cost reductions and economic gains in different parts of the electricity supply chain.

Some of these savings are captured by the consumer through the avoided purchase of electricity, but much of the value cannot be captured under current market arrangements and is socialised. The current export tariff, set at 4.5p/kWh, does not adequately reflect this and still remains lower than the market value of wholesale electricity. A review of the export tariff design to more accurately represent the value of exported electricity is important. This could pave the way for the emergence of 'time of generation' or even dynamic export tariffs via the deployment of smart meters.

Under the EMR, the Government currently plans the implementation of a Capacity Market designed to provide certainty to investors to put adequate reliable capacity in place and protect consumers against the risk of supply shortages. As part of this arrangement, providers of capacity will receive a predictable revenue stream for providing reliable capacity. Flexible mCHP generation fulfils the main objectives of the Capacity Market and should be eligible for participation in this mechanism, particularly in aggregated and controllable applications (e.g. Virtual Power Plant). The potential contribution of flexible distributed generation as part of the capacity mechanism needs to be more adequately captured as relevant policy deliberations move forward.

d. Creating a level playing field for low carbon technologies

Solid support can put mCHP, and other low carbon technologies, on a sustainable path of growth and decisively reduce up-front costs. As a result of scale, it may be challenging to sustain fiscal support for low carbon heating technologies beyond 2020. Alternative policy means need to be explored to drive essential uptake during the next decade

The introduction of an efficiency performance standard for boilers in 2005 under the Building Regulations effectively mandated condensing boilers and made the UK the biggest market for these products in Europe. This positive regulatory intervention led to a steep increase in investment and installation rates for condensing boilers and a corresponding significant reduction in up-front costs for consumers.

A change in the Building Regulations by the end of the decade to require any replacement heating system to achieve a carbon reduction improvement vs. an A-rated condensing boiler has the potential to establish a vibrant low carbon heating market in the UK. Such change would generate a level playing field for low carbon heating products, including mCHP, triggering a mass shift from conventional products and eliminating the need for sustained support.

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