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04/03/11

I am writing, on behalf of Ceres Power, to respond to DECC's Electricity Market Reform consultation. Ceres Power has already submitted a response to the related 'Carbon Price Floor' consultation by HM Treasury and HM Revenues and Customs.

Ceres Power is developing a residential wall-mounted, micro Combined Heat and Power (micro-CHP) product that runs on natural gas or LPG and is a direct replacement for a domestic boiler. The core technology is a unique 'intermediate temperature solid oxide fuel cell' which was originally developed within Imperial College and is now being commercialised by Ceres Power.

None of the questions in the EMR are directly relevant to Ceres Power, but the changes caused by the reform of the electricity markets could be very important to us. For this reason I will not respond to specific questions in the consultation. Instead, I will outline the beneficial role that micro-CHP products like those produced by Ceres Power could play in future electricity markets and urge you to consider whether the reforms proposed might unintentionally prevent microgeneration (including micro-CHP) from delivering these benefits.

Background to micro-CHP

What is micro-CHP?

Micro-CHP involves the generation of heat and electricity at the same time, with a maximum electrical output suitable for a home or small business (e.g. around 1kW) and packaged in a product designed to replace a normal boiler.

For a micro-CHP product to replace a normal boiler it must meet all of the heating needs of a home. In order to achieve this at a reasonable size and cost, and to help optimise the operation of the product, the electricity generating part of the micro-CHP product is usually combined with a condensing boiler, within the same package.

Efficiency of micro-CHP

By generating power at the point of use many losses are avoided and efficiency is improved resulting in lower fossil fuel consumption, lower CO_2 emissions and lower energy bills. The main losses avoided by micro-CHP are the heat typically rejected via cooling towers in centralised fossil fuelled power stations, and the losses in the transmission and distribution network. Together, these losses can amount to around two-thirds of the energy value in the fuel.

Differences between micro-CHP technologies

A number of different generating technologies can be used to make a micro-CHP product. These include Organic Rankin Cycles (ORC), Stirling Engines (SE), Proton Exchange Membrane Fuel Cells (PEM-FC), Intermediate Temperature Solid Oxide Fuel Cells (IT-SOFC) and High Temperature Solid Oxide Fuel Cells (HT-SOFC).

The two key features for understanding how the different technologies will operate are the 'heat to power ratio' and the 'agility'. The heat to power ratio describes how much heat is delivered for every unit of electricity delivered. Micro-CHP with a high heat to power ratio will tend to generate primarily in winter when there is sufficient heat load to justify operation. Agile micro-CHP is able to turn on an off rapidly, and move from maximum to minimum power rapidly, in responses to dynamic changes in demand.

The Ceres Power micro-CHP product is based on IT-SOFC which offers an ideal combination of heat to power ratio and agility for UK homes and for integration into the UK energy system.

The micro-CHP 'consumer proposition'

The initial proposition to a consumer buying a micro-CHP product is that it looks like a boiler, it installs like a boiler, it is easy to use like a boiler and it delivers all of your space heating and hot water like a boiler, but it significantly reduces your overall energy bill. This annual energy bill saving justifies a price premium over a boiler.

However this current consumer proposition does not include the benefits delivered to the wider electricity system. These less obvious benefits are more relevant to this consultation and are discussed further on in this document.

The potential of micro-CHP in the UK

Broadly speaking, most natural gas or LPG domestic boilers in the UK could be replaced by a micro-CHP unit. So the potential installed base of micro-CHP is very large, roughly the same as the installed base of boilers, i.e. around 21 million[1]. A typical lifetime for a boiler is 10-15 years so most of this installed base could be replaced with micro-CHP by 2020. Assuming each of these is replaced with a 1kW micro-CHP product this translates into a potential for 21GW of generating capacity. Using Ceres technology, this capacity could be dispatched and dynamically varied as an integrated part of the UK energy system.

In practical terms, there are factors that could reduce uptake below this level. Since the technology is very new, product prices are likely to be higher initially and micro-CHP will need government support in the early years to stimulate the volume related cost reductions which are expected to make unsubsidised micro-CHP affordable for the mass market. To some extent the level of uptake of micro-CHP is determined by the level of government support it receives in the early years and the level of support given to other microgeneration technologies (e.g. heat pumps).

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[1] Assessment of the size and composition of the UK gas appliance population – Gastec at CRE for DTI, 2005

However the significant unsubsidised energy bill savings from micro-CHP and the potential for a rapid reduction in product costs over the next decade mean that micro-CHP is likely to be the first microgeneration technology to reach the 'tipping point' where a few years (e.g. 5 years) of unsubsidised energy bill savings can pay for the premium over the product it replaces (i.e. a boiler). This potential for a short payback time combined with the low 'hassle factors' of the installation mean that with some support the installed base of micro-CHP could be significant by 2020. For example, modelling of the growth potential of microgeneration for BERR in 2008[2] showed that with modest government support the installed stock of fuel cell micro-CHP alone could reach almost 7m units by 2020.

The immediate benefits of naturally balancing supply and demand with micro-CHP

Balancing in time

In the UK, there is typically a large overlap between when heat and electricity are consumed in the home. As a simple characterisation, we can say that more heat is consumed in winter than in summer, more heat is consumed during the day than at night and the peak times for heat demand are in the morning and the evening. This profile of domestic heat consumption is well matched by the profiles of domestic (and national) electricity consumption.

By definition micro-CHP products generate electricity and heat at the same time. Micro-CHP products respond firstly to local demand in the home, so there is a natural alignment between when power is needed and when power is provided by micro-CHP. As a result most of the power generated by micro-CHP will be consumed within the same home, and any excess power will tend to be exported and consumed within a closely neighbouring home.

The use of domestic hot water storage allows the generation and the consumption of some heat to be 'time-shifted' by a few hours. Also different micro-CHP technologies will have different shapes to their generation profiles, and the most agile technologies (such as that developed by Ceres Power) will have the best alignment of supply and demand. However neither of these factors fundamentally change the principal that micro-CHP naturally balances the supply and demand of power.

The consequence of this is that micro-CHP is a natural demand side management and peak load reduction measure, even before the introduction of a 'smart grid'.

Balancing in space

One of the major challenges and sources of inefficiency in our electricity system is that power is consumed and generated in different places. Generating power at the point of use with micro-CHP reduces the amount of power than needs to flow through the transmission and distribution systems. Micro-CHP will be particularly effective at relieving the pressure on congested distribution networks. Many believe that capacity constraints in the distribution networks will be one of the most difficult and urgent bottlenecks hampering the electrification of heat and transport over the coming decades. A handful of micro-CHP products, in the same street, reducing the peak load of that part of

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[2] The Growth Potential for Microgeneration in England, Scotland and Wales – Element Energy for BERR 2008. The scenario described assumed a Feed In Tariff of 5p/kWh, paid on all electricity generated and capitalised at a government discount rate of 3.5%

the network, could make a real difference to the 'headroom' of capacity hotspots. It is our belief that in many circumstances installing a few micro-CHP devices will be a quicker, simpler and more cost effective solution than upgrading the infrastructure, allowing DNOs to defer and optimise their investments and hence improving cost effectiveness to consumers.

But how to incentivise and capture the value?

Most of the value that micro-CHP delivers to the wider electricity system by matching supply and demand in time and in space is not currently captured. The benefits are real and will not be lost from the perspective of the UK economy as a whole, but under the current regulatory structure they will tend to be socialised. If the value cannot be captured by the user of the micro-CHP product, the manufacturer of the micro-CHP product, or a business partner (e.g. the energy supply company) then there is little incentive to maximise this benefit.

Consider the specific example of micro-CHP reducing strain on the distribution network. The DNO will be able to defer upgrading parts of their network, which will reduce their costs, which will reduce the Distribution Use of System charges of all suppliers using that network, which will result in lower bills for all consumers in that network. The DNO has responsibility for efficiently delivering sufficient capacity, and hence should have an incentive to encourage and focus the installation of micro-CHP.

But under the current regulatory structure the business model of DNOs is based on receiving a regulated return on long term infrastructure assets; they currently have little incentive to consider the benefits of peak demand reduction via dispatchable microgeneration located within homes. The support for demand side management and distributed generation in Ofgem's latest Distribution Price Control Review (DPCR5) is an improvement but it will not be sufficient to unlock the true value of dispatchable microgeneration in a distribution network.

The future benefits of dispatchable micro-CHP in a 'Smart Grid'

As a 'Smart Grid' develops and micro-CHP products become able to communicate with the wider electricity system, the potential benefits from dispatchable micro-CHP increase.

Micro-CHP products will become aware of the needs of the local or national power system in addition to those of the home and the more flexible micro-CHP technologies (such as that developed by Ceres Power) will then be able to respond to those needs.

Incentives will have to be developed to engage the consumer in demand side participation. Perhaps the first example of this will be simple, fixed 'time of use' tariffs, incentivising consumers to use less power at times of high national demand. Over time these signals will become dynamic and demand side participation will develop to the point where consumers can deliver some of the 'balancing services' needed by the System Operator by altering the pattern of their demand. In the commercial and industrial sectors where loads are larger and transaction costs are lower this sort of demand side participation in balancing services has already begun[3]. Dispatchable micro-CHP will be a very useful tool to allow homes and smaller businesses to deliver similar services.

In the future micro-CHP could offer benefits to the power system in a number of ways and it is not currently clear which would be the most likely mechanism. Micro-CHP could sell power directly to energy markets, to energy suppliers and other traders, or to system operators at a transmission or

[3] For example the provision of 'Short Term Operating Reserve' (STOR) to National Grid by EnerNOC. For more information see www.enernoc.com.

distribution level. Alternatively micro-CHP could sell its output as demand reduction 'negawatts' to energy suppliers trying to balance a 'short' position or to the same groups it could sell power to. Micro-CHP could sell capacity rather than power and be on standby to provide 'power quality' in the event of voltage or frequency variations. Finally micro-CHP could be interruptible generation, offering to postpone or cancel its operation when there is too much wind and too little demand. Residential 1kW micro-CHP products would have to respond together at the scale of at least a few MW for the services offered to be useful, but this could be achieved with just a few thousand products, an installed base that could be realistically achieved in a couple of years. Synchronised operation of this 'virtual power plant' could be delivered via aggregators such as energy supply companies, DNOs, the TSO or third party aggregators. In the longer term the synchronised response could be delivered directly using price signals sent to all homes via smart meters; no individual unit would be certain to respond but over time a high statistical confidence could develop around the average response, just as is currently done for large central 'balancing mechanism units'.

All of these mechanisms for micro-CHP involvement in the future electricity system are feasible. What is important at this stage is that none of the mechanisms are unintentionally closed off before they have had a chance to develop.
Ceres Power would be very willing to explore any of these themes further with DECC and we look forward to participating in the reform of the electricity market.

Yours sincerely,

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