12 Micro Cogeneration in Britain

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12.1 Political and Economic Framework

The UK, with its temperate climate, substantial population and number of households connected to a natural gas infrastructure, is ideally suited to the application of existing micro cogeneration technologies. Whilst some other nations are seeking to develop systems with somewhat different characteristics to match their specific needs, the heat to power ratio of Stirling technology aligns well with the electricity and heating demands of typical UK homes and results in relatively long annual operating hours. This, allied to the high price of electricity, both relative to gas and in absolute terms, produces savings more than adequate to recover the initial investment. Furthermore, the additional benefits to the UK as a whole, match well with government aspirations in respect of social, economic and environmental targets.

12.1.1 UK Energy Policy

The UK has been amongst the leading countries committed to combating Climate Change, and committed to achieving a CO_2 reduction of 20 %, more ambitious than the 12.5 % obligation imposed under the Kyoto protocol, although it is likely that only 14 % may be achieved (EEA 2004). Beyond this, following recommendations by the Royal Commission on Environmental Pollution (RCEP 2000), a further commitment to achieve reductions of 60 % by 2050 has been made by the current government. However, the significant early success stories, arising primarily from the abandonment of coal fired generation and the so-called “dash for gas” have largely been swallowed up by organic growth in consumption alongside economic growth and uncontrolled growth in transport emissions.

The publication of the Energy White Paper (2003) proposed extravagant targets for CHP and Renewables, somewhat diluted in the final Energy Act

(2004) which no longer contains specific targets nor obligations for micro cogeneration, although there is an obligation to produce a micro generation strategy by the end of 2005.

Energy Act 2004. The UK Energy White Paper (draft policy document) identified four priority areas:

- security of supply, "to maintain the reliability of energy supplies",
- environment (Carbon abatement), "to put ourselves on a pathway to reduce carbon emissions by 60 % by 2050 with significant progress by 2020",
- fuel poverty, " to ensure that every home is adequately and affordably heated", and
- competition: "to promote competitive markets…sustainable economic growth...improve productivity".

It is clear that there are major conflicts between these goals, particularly the impact of minimizing energy cost on the viability of energy efficiency measures. Although some commentators believe it is possible to reduce energy cost and encourage energy efficiency, it is difficult to see how this can be achieved within a free competitive market. It is for this reason that the UK has developed a number of vehicles to address this issue, such as the Energy Efficiency Commitment (EEC) on energy suppliers. The document also importantly identified the potential contributions of a number of carbon mitigation measures and their relative cost effectiveness. Whilst heavily subsidised technologies such as photovoltaics (PV) had a very high cost (£520-£1250 per tonne CO_2 reduction), energy efficiency and micro cogeneration were identified as the most cost effective measures under current conditions with a negative cost of up to £630 per tonne (PIU 2002).

As micro cogeneration contributes to all four policy goals, the UK government considers micro cogeneration favourably, although there remain sceptics within some of the departments and support measures so far implemented are meagre to say the least. The Act does at least provide an affirmation of support for micro cogeneration and the obligation to produce a micro generation strategy should provide a policy framework for micro cogeneration.

Micro generation strategy. The obligation to develop a micro generation strategy imposed by the Energy Act extends to any generation source below 50 kW_{el} and 45 kW_{th}. It covers CHP, PV, wind and hydro as would be expected, but must additionally consider not only generation of electricity, but also of heat from renewables as well as heat pumps. The strategy must consider the potential contribution to CO_2 and fuel poverty targets, and the potential reduction in demands on the energy networks.

CHP strategy. The recently published CHP strategy (DEFRA 2004) maintains the target of 10 GW_{el} by 2010, set in 1999, when it appeared the earlier target of 5 GW_{el} would be exceeded by 2000. However, unlike renewables, there is no obligation on suppliers to support CHP, and the revised Cambridge Econometrics study (Cambridge Econometrics 2003) shows that even under the most attractive scenario, the 10 GW_{el} target will be missed by a substantial margin. (Interestingly enough, the earlier targets for CHP did not even include micro cogeneration, which is now estimated to provide up to 500 MW_{el} by 2010). Sadly, the UK has so far failed even to reach the earlier 5 GW_{el} target. CHP capacity is stagnant and output is reducing.

It might therefore appear that the negative market environment for CHP generally would be even more severe for micro cogeneration, which faces additional manufacturing and service costs. However, the main obstacles to larger CHP, namely the "spark-spread" between gas and electricity, and the uncertainty of electricity export prices under NETA[1] do not apply to micro cogeneration. Due to the high heat to power ratio of micro cogeneration (typically around 1:8), the additional gas burn required to produce electricity compared with a conventional gas boiler is negligible; even compared with a condensing boiler, it is relatively small. As a result micro cogeneration is virtually cost free in terms of primary fuel input. It is also the case that the spark-spread in the wholesale market has not impacted the domestic ratio where gas is still only around 20 % of electricity prices. In addition, the majority of the value of micro cogeneration to the end user comes from the avoided cost of import, not the value of export; this value is substantially higher in the domestic sector (and is less susceptible to price volatility) than for commercial CHP operators.

The relatively poor market conditions for CHP and the desire to see a contribution in the domestic sector, have led the government to provide a £50million subsidy to Community Energy, although nothing for micro cogeneration.

[1] The New Electricity Trading Arrangements (NETA), were intended to overcome perceived abuse of the wholesale market (Pool) by generators. The resulting arrangement exposes buyers and sellers to the risks of "imbalance" on the margin, so that there is value in having certainty in trading volumes. The characteristics of CHP, which is led by heat load, means that CHP export (being uncertain) exposes the buyer to risk, and therefore has a very low value.

12.1.2 Implementation of Policy

The UK suffers from a complex range of government and regulatory bodies, support schemes and accreditation bodies. There is no unitary Energy Ministry. DTI (Department of Trade and Industry) is responsible for various technical and commercial elements of the energy industry, DEFRA (Department of Environment, Food and Rural Affairs) is responsible for environment and sustainable development (including the CHPQA support scheme), ODPM (Office of the Deputy Prime Minister) is responsible for Building Regulations and housing and OFGEM (Office of Gas and Electricity Markets) is the regulatory body charged with promoting competition and environmental objectives in the liberalised UK energy industry. Within this context the level of progress so far achieved is somewhat surprising.

12.1.3 Support Measures

There are two significant support measures for micro cogeneration which may be implemented in the near future. However, both are subject to the outcome of field trials currently being undertaken under the auspices of the Carbon Trust (a QUANGO charged with encouraging carbon mitigating technologies and measures in commercial buildings).[2] Although early results are encouraging, in that they support the anticipated carbon savings achieved in earlier independent trials, it is unlikely that the results will be adequate to trigger the support measures prior to late 2005 for EEC and April 2006 for VAT.

The measures are:

- *Reduction of VAT rate* from 17.5 % (standard rate) to 5 %, the same rate as used for domestic energy and which has also been recently approved for a number of other energy efficiency measures. This is considered simply as redressing an anomaly in the market, that energy and energy saving should be subject to the same VAT rate and as such, can hardly be considered a subsidy. In addition, a recent study showed that this measure would impose a loss of VAT representing less than £50/tonne Carbon, about one quarter the cost of the Renewables Obligation (Ilex 2002).
- *EEC (Energy Efficiency Commitment) approval and enhancement*. EEC is an obligation on energy suppliers to implement energy efficiency

[2] EST (Energy Saving Trust) is the equivalent body with responsibility for the residential sector.

schemes on behalf of their customers. The obligation is measured in TWh annually and the method and cost of achieving the target is up to the supplier (subject to approval of the measures against a standard database). Thus suppliers are constantly seeking more cost effective means of achieving their goals and, as the cheaper options are taken up (roof insulation is now complete for the majority of applicable homes for example), they are forced to seek alternatives. Micro cogeneration is a relatively cost effective measure and, equally importantly, has a high value per installation, thus reducing the management overhead. In order to stimulate the micro cogeneration market, DEFRA has agreed to enhance the accredited value of micro cogeneration (and a number of novel technologies) by a factor of 1.5. In other words, if micro cogeneration actually saves 20,000 kWh (lifetime net present value, NPV) it will be deemed to save 30,000 kWh. This EEC enhancement has been most effective in accelerating the introduction of the most efficient domestic appliances, such that it is now virtually impossible to buy a poorly performing refrigerator in the UK. This support measure is applied only for a short period, until the market matures and the true value of micro cogeneration can be realised through normal commercial channels.

Two key examples of value recovery channels not yet in place, are the trading of exported power from the unit and the attribution of environmental benefits to micro cogeneration. At present the exported power from a typical unit has a market value of around 3p/ kWh, an annual value of £30 and an NPV of around £200. However, it is not possible to trade such small amounts of energy in the wholesale market, so until micro cogeneration customers attain a critical mass and trading systems are modified to trade this power, some form of support is required to recognise the real contribution they are making to the UK power system.

The principle environmental benefit of micro cogeneration is the displaced CO_2 emission from central generating plant. A typical home generating 3000 kWh of electricity from micro cogeneration will displace CO_2 with a lifetime NPV of around €300, based on a value of €30 per tonne and CO_2 displacement in line with the Ilex study, €200 based on average generation mix displacement. Again, there is no mechanism for the householder to acquire this benefit which currently accrues to society as a whole.

12.1.4 Independent Bodies and Lobbying Activity

A great deal of the progress achieved in removing market barriers can be attributed to the efforts of industry alliances and environmental lobby groups. In particular the Micropower council, established to represent the interests of all micro generators (not just micro cogeneration) has successfully lobbied for the introduction of various support measures and legislation and has provided practical support to technical standards committees. Further support is provided by the Green Alliance, SBGI (Society of British Gas Industries) and CHPA (Combined Heat & Power Association).

12.1.5 Current Issues

As it is introduced into the UK market, micro cogeneration has raised a number of issues regarding the anticipated benefits to the community and possible adverse impacts on existing players in the energy industry. In particular, the anticipated carbon mitigation and fuel poverty benefits are coming under scrutiny; indirect impacts on generation mix and distribution networks are also being closely studied.

A number of studies in these areas have recently been completed with results of specific relevance to the UK. The results are surprising, in that the benefits identified generally exceed the earlier claims made by manufacturers. Three studies in particular show that micro cogeneration makes a substantial contribution to fuel poverty, carbon mitigation and diversity of supply targets.

A recent Policy Studies Institute paper shows that micro cogeneration contributes almost as much to fuel poverty as all other measures put together including micro cogeneration (Dresner and Ekins 2004). This paradox is explained by the fact that, if thermal improvements are made to a home, the reduction in thermal load means that the micro cogeneration unit will operate for less hours each year to fulfill the reduced thermal demand. This in turn leads to a reduction in electricity production and as the capital cost is the same regardless of the thermal demand of the home, the payback becomes rather long. In this case, it is unlikely that micro cogeneration would be installed in such homes. In other words the cheap insulation measure has "cherry-picked" the easy savings and made it uneconomic to exploit the full potential for that home. Hence: "Micro cogeneration can do almost as much for fuel poverty as making all possible energy efficiency improvements, including micro cogeneration."

A special report by Ilex, commissioned by Powergen, shows CO_2 displacement for the next 10 years at a level higher than both average generation mix and marginal generation emissions (Ilex 2004). Current government policy is based on 0.44 kg/ kWh which is the average mix, a somewhat arbitrary and in this case, inappropriate measure. Micro cogeneration is shown to displace marginal plant and the study, which matches actual generation profiles for installed WhisperGen units against marginal plant, shows a displacement of 0.54 rising to 0.67 kg/ kWh by 2010. This counter-intuitive result is the consequence of the increasing cost of coal-fired generation which, although it reduces the total amount of coal generation in the overall mix, shifts all coal generation into the margin.

Further indirect benefits accrue to micro cogeneration as it has a profile which supports intermittent wind resources and, by nature of its diversity, reduces the need for back-up capacity. The Environmental Change Institute study based on 20 years of wind and consumption data, concludes that only 400 MW_{el} back-up capacity would be required if micro cogeneration were to support 10 GW_{el} of wind generation (ECI 2004).

The SIAM (System Integration of Additional Microgeneration) study was expected to identify adverse impacts of large-scale implementation of micro cogeneration on Distribution Networks, potentially requiring significant investment in network upgrades (SIAM 2005). In fact, the study showed that in only a few extreme cases would micro cogeneration incur additional short term costs, that in the majority of cases it would have beneficial impacts and the overall benefit to the UK distribution network was substantial; savings in deferred network upgrades and improved operational efficiency were estimated at up to £1.2 billion by 2020 assuming a high penetration level of micro generation.

12.1.6 Legislation and Regulation

The two principal areas of regulation related to micro cogeneration concern the application within the building’s energy system, to which the Building Regulations apply, and the connection to the electricity and gas networks.

Recent amendments to the Building Regulations (Part L, April 2002) for the first time apply retrospectively to domestic energy systems. It is now mandatory, when replacing the boiler within a central heating system, not only to replace the boiler with a boiler of specified efficiency, but also to upgrade the entire system to current new-build standards. This efficiency will be raised to 86 % with effect from April 2005 and has a somewhat confusing result for micro cogeneration. For a micro cogeneration unit with a thermal efficiency of 80 % and an electrical efficiency of 12 %, the overall efficiency is 92 %, well above the threshold. However, the current regulations do not recognise electrical output; indeed quoted boiler efficiencies do not even have to include parasitic (pump and fan) losses in their efficiency ratings. It is therefore difficult to compare micro cogeneration with boilers and work is currently under way to provide a standardised assessment procedure for micro cogeneration units.

The area of electrical connection to the public electricity network has been much simplified by the agreement of Engineering Standard G83/1 (2003), which sets standards for type approved products which can be installed by a competent installer without prior agreement of the DNO (Distribution Network Operator). Work continues to amend regulations for wiring within the home to take account of "double-fed" circuits, and a revision to the IEE Wiring Regulations is expected to be published in 2006 (17^{th} Edition) including advice on connection to radial/ring mains, disconnect times and shock and overload protection. For the time being, micro cogeneration units are being installed using a dedicated circuit to the consumer unit, with its own protection (a motor rated fuse).

There is currently no legislation regarding NO_x emissions from gas appliances, although the current high NO_x emissions from some micro cogeneration (Stirling engines in particular) are likely to be significantly reduced as products evolve to meet increasingly stringent standards.

12.1.7 Energy Prices

Although energy prices are still (31 %) lower than pre-privatisation in real terms (DTI), they are no longer regulated. Instead, since early 2002, OFGEM decided that competition would continue to exert downward pressure on prices as effectively as regulation had done until that point. For an initial period, domestic energy prices had been regulated according to a formula based on the Retail Price Index (RPI-X %), and customers became accustomed to annual price reductions. Between the initiation of full competition in 1999 and 2003, prices had fallen in real terms by over 10 %. This situation has now changed dramatically as suppliers have responded to significant wholesale price rises with increases from major suppliers in 2004 of over 18 %.

A typical customer with an electricity consumption of 3300 kWh and gas 18,000 kWh, would expect to pay between £236-£275 for electricity, and £526-£650 in total depending on supplier and method of payment.

12.2 Market Context

The fundamental requirement for economic viability of micro cogeneration is that the marginal investment cost (compared to a conventional boiler) can be recovered from energy savings (primarily generation of electricity) within a reasonable period. This depends on the cost of primary fuel and imported electricity, and the value of export, as well as the amount of each of these. A higher electrical output produces better fuel bill savings, provided it is not achieved at the expense of additional primary fuel input. The ideal market is therefore one where there is a network of low cost primary fuel, relatively high electricity costs, a housing stock which requires space and water heating and a heating season long enough to result in extended running hours. In each of these respects the UK is ideally suited to the characteristics of Stirling engine micro cogeneration.

Under current standards (base case boiler efficiency >78 %) and energy prices as above, the viability of micro cogeneration is limited to homes with a heat loss of at least 12,000 kWh per year in order to give a payback less than 7 years (often considered to be the threshold for consumer investment). For a typical family home (18,000 kWh annual heat loss), the WhisperGen unit would generate 3,000 kWh of electricity of which around 2000 kWh would be used within the home (avoiding import cost of ~7.5p/ kWh) and the remaining 1,000 kWh exported to the network at a value of 3p/ kWh. The total benefit would be £180 and, with a marginal investment cost of £600, a payback of 3-4 years would be achieved.[3]

12.2.1 Housing Stock and Energy Use

Of the 23 million households in the UK, 89 % (20 million) have central heating of some type. The majority of these were constructed prior to 1970 and consequently have relatively high heat loss of 0.05 kWh/m2/degree day (compared with Sweden (0.038), Netherlands (0.041), Germany (0.07). Average household floor area is 85m2 (Sweden (90), DE (78)). Progressive improvements in Building Regulations since 1970, and the increasing number of smaller households is resulting in homes with

[3] The base case scenario is for a conventional boiler with 78 % thermal efficiency, the current standard. In April 2005 most boilers will need to achieve 86 % so that the micro cogeneration unit will achieve relatively lower savings, about £150 taking account of £25 additional gas cost. However, it is also likely that the higher efficiency boilers will cost more so that the marginal investment also falls and payback is relatively unchanged.

significantly lower space heating demands, but with ever increasing domestic hot water usage.

In contrast to other European countries such as Germany, the UK preference is for owner occupation (68 %), although the tendency to move home on average every 7-8 years does not encourage long term investment in energy efficiency measures, so that short paybacks are essential for successful products. Fortunately, micro cogeneration falls into this category with typical paybacks of 3-4 years. However, for the social sector, investments tend to be made on a longer term basis by the (normally public sector) landlords, both on an economic basis and to fulfill statutory obligations.

A typical UK family home with a gas central heating system requires around 18,000 kWh of space heating annually, together with 5000 kWh of water heating and 3,500 kWh of electricity consumption. The resulting heat to power ratio for the typical home thus aligns well with the characteristics of Stirling engine technology and the relatively low electrical efficiencies are in fact a benefit rather than a disadvantage as was earlier believed. This is significantly different from the U.S. for example, where electrical loads are substantially higher and the case for higher electrical output is justifiable.

12.2.2 Climate

The other major feature of the UK that makes it suitable for micro cogeneration is its climate. As a result of its cool maritime climate, all of the UK has a significant heating season spread over several months. For the majority of the (poorly insulated) housing stock this imposes a demand for space heating of between 2,000 – 4,000 running hours. Although this might appear low compared with the requirements for industrial and commercial installations with anticipated hours of anything from 6,000 – 8,760, the higher unit value of electricity at the domestic level is able to compensate for this.

Interestingly enough, the very severe climates of Scandinavia are not attractive to micro cogeneration. Although the most populous regions have degree-days around 50 % higher than the UK, the heating season is more concentrated and would require the installation of a significant supplementary boiler to meet the extreme peaks. (As with heat pumps, it is neither practical nor economic to size the engine itself to meet peaks). This requirement would adversely affect the economics, even if there were a widespread gas network in Scandinavia.

12.2.3 Heating Systems

Around 18 million homes have gas central heating installed, an additional 1 million have fuel oil or LPG (Liquefied Petroleum Gas) central heating systems and a similar number have coal-fired systems. Electric (non-hydronic) systems, usually incorporating storage heaters, account for around 2.5 million homes.

Hydronic central heating, fired by natural gas is the cheapest in operation for the majority of family homes and electrical systems are generally limited to smaller houses and flats. Indeed, gas heating is almost a status symbol and is assumed to be “best” even to the extent that many will choose LPG off-network in preference to fuel oil in the mistaken belief that, because it is gas, it must be cheaper!

District Heating (DH) is relatively uncommon, with only 1 % market share. This is to some extent a reflection of the high level of owner-occupation and the desire to have independent control, allied to a traditional focus in the UK on low first cost. It is also difficult to see how the conflicting demands of DH (which logically requires all homes in an area to be connected for economic viability) and a competitive market (which demands that all customers may choose their energy supplier and their energy system) can be resolved.

Various studies have identified up to 5 million homes within areas with sufficiently high heat densities to justify district heating (BRE 2003). The areas identified tend to be central urban sites with high rise apartments, unsuitable for micro cogeneration both from a heat loss perspective and due to the physical size and construction of the properties. Micro cogeneration and DH can therefore be considered complementary rather than competing technologies, although, where practical, micro cogeneration is preferable on economic and environmental grounds (Harrison 2002).

12.2.4 Boiler Market

The UK boiler market of 1.5 million sales annually, is weighted heavily towards replacement of existing boilers (1.2 million) with around 100,000 for new systems in existing buildings and 200,000 for installation in new homes.

Of these, an increasing number are wall-mounted, with combi-boilers also becoming increasingly popular, due primarily to space considerations. It might therefore appear that floor-mounted micro cogeneration units would face a challenging market. However, there are still estimated to be

7-8 million old, cast iron floor-mounted boilers in place with very low operating efficiencies. With a replacement rate of 7 %, there is thus a potential annual market of up to 500,000 floor-mounted micro cogeneration units in the UK. Within this sector, the smaller output micro cogeneration units will be ideally suited to homes with annual heat loss above 12,000 kWh and the larger units suited to those above 23,000 kWh (Fig. 12.1).

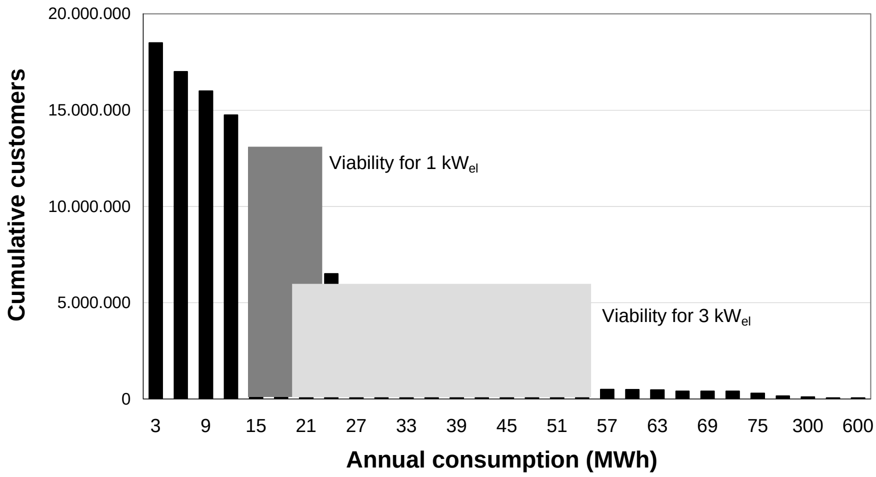

Fig. 12.1. UK domestic gas consumers (dark grey area indicates viability for 1 kW_{el} , grey area for 3 kW_{el})

12.2.5 Technology Developments

As micro cogeneration enters the commercial phase, the products themselves are reaching a level of maturity which primarily requires developments to be of a "design for manufacture" nature rather than addressing fundamental issues of performance and reliability. The products also need to be adapted to the peculiar requirements of each market, and this section outlines technology developments of specific application to the UK market.

At the same time, it is becoming apparent that the implementation of micro cogeneration can be accelerated by the availability of "enabling technologies" such as advanced controls and metering which improve the performance within the home and which allow the true value of micro cogeneration to be realized.

Thermal storage. When micro cogeneration products were first being developed in the UK, it was believed that generation should be closely aligned with demand in order to avoid export and maximise the value of micro cogeneration. Indeed, BG Technology proposed 1m^3 of thermal storage and sophisticated electronics in order to completely avoid export and ensure operation which could be considered grid-isolated. This was to avoid the former complexities of applying for permission to connect to the grid. Although grid connection has now been simplified to the extent where it no longer represents an obstacle, thermal storage still has practical benefits in terms of reduced engine cycling and peak lopping, allowing greater operational flexibility and improving system performance.

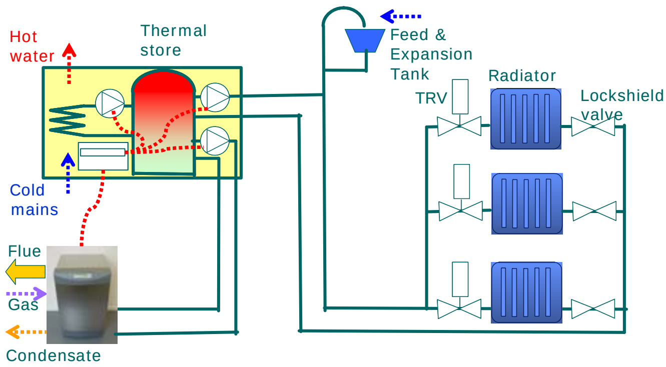

Fig. 12.2. Gledhill thermal store package

The Gledhill thermal store (Fig. 12.2) has been developed to meet these requirements; it is effectively a packaged hot water cylinder in which the stored water is part of the primary circuit. The package incorporates three pumps. The first pump runs whenever the store temperature falls below 55°C and continues to run until the store temperature reaches 75°C, taking heat from the micro cogeneration unit. A second pump is switched by the programmer/thermostat to take water from the tank to the radiators whenever there is a demand for heat. The third pump operates when there is a demand for hot water and passes stored water through a high capacity plate heat exchanger, which instantaneously heats cold mains water. This has the additional benefit in the UK where pressurised hot water systems are not the norm and where the resulting hot water pressure is unsuitable for showers.

So far trials have demonstrated clearly that it is possible to de-couple the production of heat and power on a diurnal basis, eliminating the engine cycling problems (which could adversely impact engine life and maintenance) as well as allowing the engine to run only at its optimum efficiency level and minimising the parasitic losses during stopping and starting; this is particularly relevant during the marginal heating season (spring/autumn) when only a small thermal output is required, but for extended periods of the day.

In the example illustrated (Fig. 12.3), the blue line represents operation with a conventional heating system and shows 16 cycles on the day in question, several of which never achieve full electrical output before being terminated. The red line shows 4 cycles for the same operating conditions and a significantly higher electrical production.

What has not yet been attempted in practice, although certainly feasible in theory with the correct controls and communications, is to operate the unit with its primary target of electricity production to match periods of peak value, either to the householder by matching own loads, or to the energy supplier by matching peak wholesale market prices.

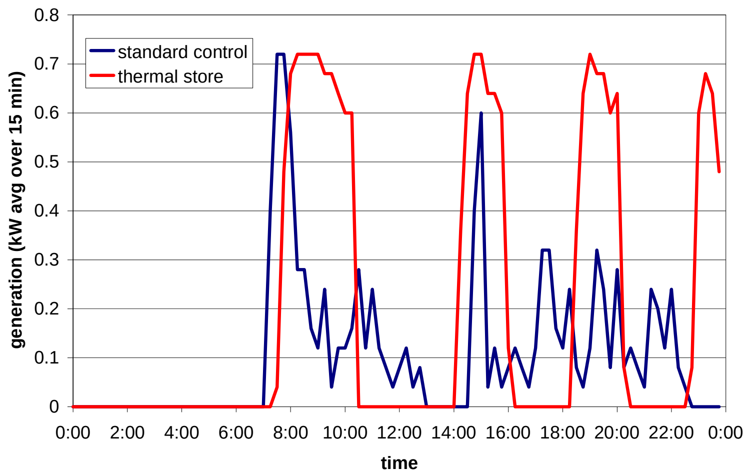

Fig. 12.3. Comparison of cycling performance between conventional system and thermal store

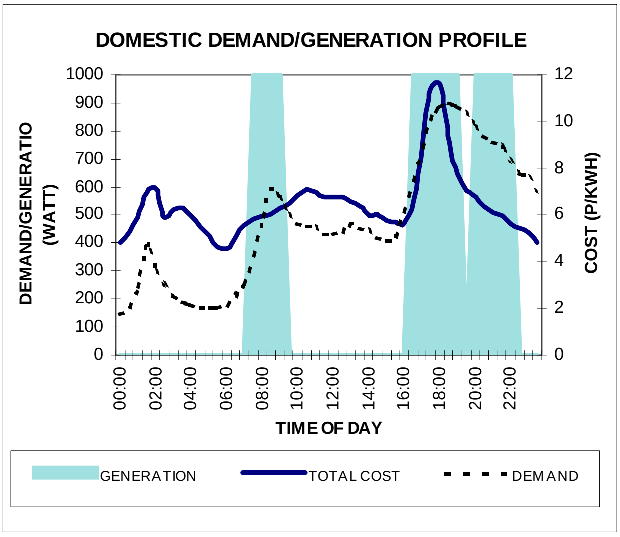

Fig. 12.4. Variation of electricity cost throughout a typical winter's day shows the value of micro cogeneration. Generation coincides substantially with peak supply cost, as does domestic demand. Demand weighted value of micro cogeneration is around 3.4 p/ kWh over the year compared with an average pool price less than 2.8 p/ kWh

Metering & control. From a very early stage, the regulator (OFGEM) imposed a requirement for separate metering of imported and exported electricity. This was deemed essential in order to understand energy flows within the distribution network and as a means of attributing the true value of generation to its correct source. Initially, metering on a half-hourly (HH) basis was envisaged (as with the commercial market), but the excessive administrative costs (around £800 annually per site) meant that it would not have been viable.

A solution for micro generators was agreed and now generators up to 30 kW_{el} may register exports on a non-half-hourly (NHH) basis (P81 standard), normally simply showing kWh totals on a cumulative basis as for standard meters. However, industry infrastructure limitations have led to the use of export sub metering in the short term and exports are not traded in the wholesale market. Considerable effort is currently being applied to developing agreed metering, settlement and trading standards for micro cogeneration.

In the short term however, it is still possible to operate micro cogeneration, it is just that the export has no tradable value. Even before the advent of micro cogeneration, the metering industry was facing considerable technical and operational challenges. The competitive market had raised innumerable issues relating to meter reading accuracy particularly regarding change of supplier (which can occur every 28 days), change of tenancy and change of tariff. The use of pre-payment meters for debt recovery and for fuel poor also raised difficulties in ensuring that these groups were not denied access to energy in emergencies. This, combined with the recent separation of metering as a business entity, has forced suppliers to review the type of metering, their ownership of metering assets and operation procedures. Currently the meter is owned by the DNO (Distribution Network Operator) and maintained by a MOP (Meter Operator) on behalf of an energy supplier who pays a daily charge for the use of the meter. This means that the meter can only be changed on the instruction of a supplier, a situation favoring micro cogeneration manufacturers who partner with an energy supplier.

As the NHH meter only registers total kWh consumed and the wholesale market is traded on a HH basis, it is necessary to apply agreed (assumed) demand profiles to all customers. As a short term solution the import profile for micro cogeneration is assumed to be the same as for standard customers, and a simplified export profile has been agreed. Current monitoring work is aimed at identifying actual profiles before micro cogeneration is widespread.

Considerable progress has been made in establishing industry processes and it is hoped that, by the end of 2005, suppliers will be able to install import/export meters and trade both in the existing settlement process, against agreed profiles.

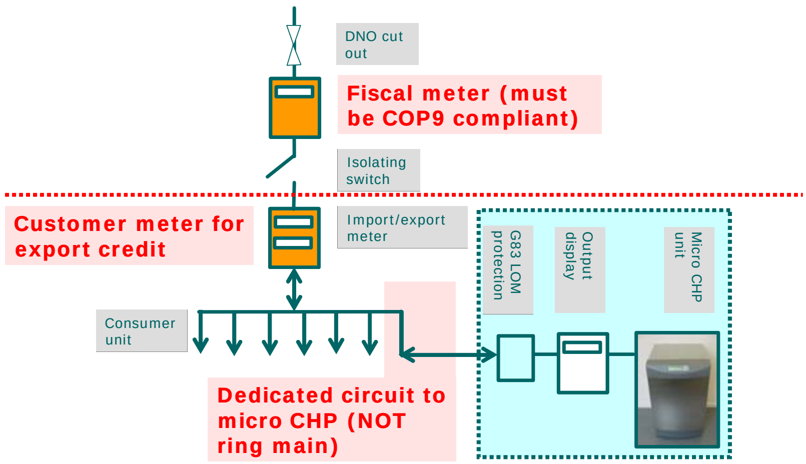

Fig. 12.5. Current connection arrangement to comply with P81 (metering) and G83/1 (network connection)

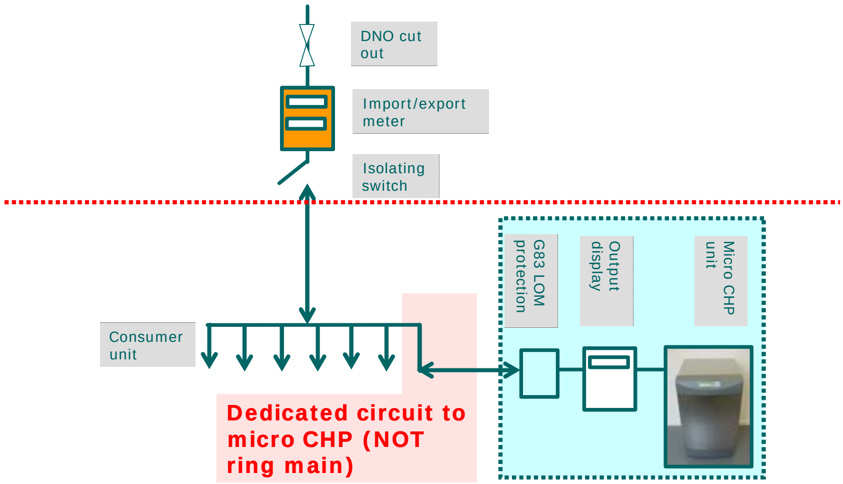

Fig. 12.6. Proposed connection arrangement with import/export meter registered for settlement

12.3 Major Commercial Activities and Actors in the Country

12.3.1 UK Energy Industry Structure

Privatisation of the UK energy market began in 1990 and is now fully competitive for all customers. At the retail level this allows customers to change supplier every 28 days, although the practicalities involved often lead to much longer change times. However, suppliers are constantly aware of the choice their customers face and strive to offer the most competitive tariff or service.

The transmission grid remains a monopoly operated by NGT and central plant, operated by a number of major companies, is connected to that grid. All system users are subject to the same use of system (TUoS) charges. The distribution network (33kV and less) is operated by regulated distribution companies (DNO), vestiges of the original local electricity boards prior to privatisation. Again use of system charges (DUoS) are regulated and the same for all users. Supply licences exist for 13 regions in Great Britain, aligned with the DNO franchise areas. However, these licences are owned by an increasingly small number of energy supply companies. These companies supply direct to individual homes and it is generally considered that a critical mass of 5 million customers is required to justify the infrastructure costs. This is quite different from other markets, such as Germany, where the major suppliers' customers tend to be municipalities or smaller local suppliers who own the end-user relationship.

It should be clear from this that the only margin in the value chain which is truly competitive is the suppliers' margin; wholesale energy is a market open to all, use of system is the same for all. In this environment, micro cogeneration offers a considerable competitive advantage to any supplier owning it, or with customers using it. This is primarily due to the beneficial generation profile (Fig. 12.6) of micro cogeneration which aligns well with peak wholesale prices, which is itself strongly influenced by domestic demand, in turn responding to peak heating periods.

Although regulated and separated, most energy companies are becoming vertically integrated to the extent that they have matched generation access and supply to mitigate risk. Also, after a decade or more of aggressive acquisition and competition, the supply market appears to be stabilising with a recognition that it is unprofitable to constantly acquire new customers only to lose existing customers, a process known as "churn". In the UK, this can be as much as 25 % annually, compared with the German market with almost insignificant churn rates below 5 %.

12.3.2 Routes to Market

The two major energy suppliers, Powergen and British Gas (Centrica) have both made arrangements to commercialise micro cogeneration to their energy customers. British Gas, the former monopoly gas supplier, has an established business offering service and installation of gas boilers, so has a ready made network.

Recent developments in the wholesale energy market, which have caused both players to raise prices to end-users, have had a serious impact on British Gas which has lost several hundred thousand customers to its rivals.

Micro cogeneration offers companies such as these an opportunity to improve the profitability of their energy trading portfolio (micro cogeneration reduces the amount of high cost electricity a supplier needs to obtain on behalf of its customer, improving margin), to offer very competitive tariffs and to offer an energy saving technology which reduces the number of kWh purchased (further saving customer bills) and maintains total margins for the supplier.

The only product commercially available in the UK for individual homes is the WhisperGen unit from Powergen. This is being offered to individual householders on a fully installed basis using Powergen's approved installer network, and by direct sale from a dedicated team. This strategy is aimed at overcoming the major obstacles which prevented the widespread introduction of high efficiency boilers to the UK market.

The UK faces a chronic skill shortage in the heating industry and Powergen has established training courses to ensure installations are of an appropriate standard and that service support is available. The lack of service support had been identified as one of the key obstacles to the uptake of condensing boilers, and all involved are anxious to ensure that micro cogeneration is implemented smoothly and as quickly as practicable.

The other obstacle faced by condensing boilers was the structure of the boiler distribution and installation market. Distribution through major national merchants disconnected the manufacturer from the installer and products were often selected only on the basis of cost or availability, rather than appropriateness for the application. The installers effectively became the specifier, providing advice, again on less than objective grounds, and were naturally reluctant to upgrade their skills or take on the challenges of condensing boiler technology.

British Gas are expected to use a similar route to market, making use of their existing network of installers and service engineers, although it is possible that BG MicroGen (their supplier) may make products available through the merchant route as well.

The other potential player in the UK is a boiler manufacturer, Baxi, who have acquired the German Dachs unit as well as European Fuel Cells (developing a 1 kW_{el} fuel cell) and the rights to the Inergen (1 kW_{el}) organic-Rankine cycle unit. This latter development, which may reach market by 2007/2008, promises low cost manufacture and compatibility as an add-on module to Baxi's range of boilers. Baxi seem committed to the existing delivery chain and it will be interesting to see how they manage installation (which can legally only be carried out by G83 accredited installers) and after sales support with a relatively complex product.

12.3.3 Market Status

There are a number of products currently undergoing various stages of development and trials. MicroGen expect to launch their 1 kW_{el} unit in 2007, following their current field trial, Baxi Inergen and Disenco (a 3 kW_{el} Stirling engine based on the Sigma unit) are both under development and a number of early stage prototypes are being tested within the Carbon Trust sponsored trial programme. This is aimed at validating manufacturers' performance claims prior to confirmation of government support schemes and as a means of accreditation for compliance with Building Regulations.

Powergen are in market test phase and are offering WhisperGen units installed for £3000 (including VAT) for individual homeowners and for £1350 (plus VAT) to house builders. House builders have proved surprisingly keen to install micro cogeneration given their reluctance to embrace any new technology, particularly with a relatively high initial cost. However, the prospect of increased building standards and the potential to "trade-off" insulation against heating system enhancements may contribute to this enthusiasm.

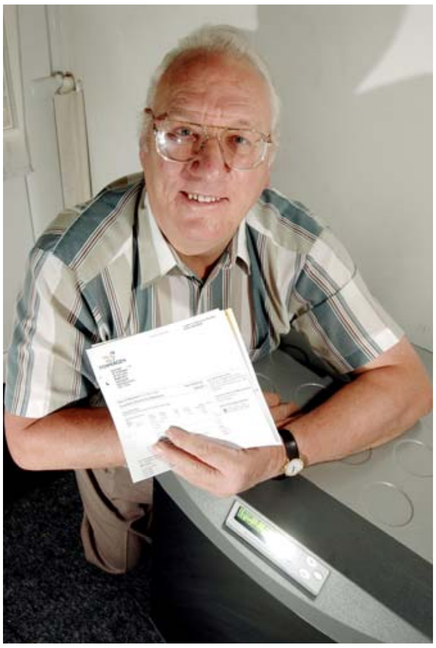

Fig. 12.7. The first of Powergen's 80,000 micro cogeneration customers, with a WhisperGen unit installed in an existing 1930's home in Nottingham

A condition of the sale is that customers must also purchase their energy (gas and electricity) from Powergen as well, although they are at liberty to subsequently change to any other supplier 28 days later. This is an indication of Powergen's motivation to enter this market. The energy package includes gas and electricity at exactly the same price as for standard customers, but with the addition of an export tariff of approximately 3p/ kWh (about 50 % of import tariff). This is in line with the actual value of export which will be obtained once the requisite infrastructure is in place.

Powergen recently announced their intention to install a minimum of 80,000 units by 2010 as a result of the positive market response. However, the exact timing will be subject to the implementation of agreed industry and regulatory changes referred to earlier. In particular, the metering and settlement issues must be resolved in order to obtain the full value of micro cogeneration.

There are also numerous issues regarding commercial agreements between DNO and supplier (connection terms) which may impact the timing of mass market launch. However, overall the UK market seems an ideal environment for existing micro cogeneration technologies, which may be further exploited by fuel cell and other technologies as they become available.