Micro CHP

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Introduction

Governments are in the process of organising the change-over to sustainable energy supplies for the future. They have identified a multitude of country-specific measures relevant to achieving their climate aims.

A number of factors, such as legislation, initiatives or other measures (more or less strongly pronounced in the different countries) influence the residential and commercial markets.

These markets are going through transformations and the competition between energies has never been so keen.

The gas industry is facing new challenges in a bid to address the new situation brought about by the legislative impact and the needs and expectations of consumers and clients.

The gas industry, together with its market partners, the appliance manufacturers, must initiate further developments and offer technical alternatives to its customers, supplying technology options which best meet the heat requirements of buildings while reinstating the clean and innovative image of natural gas as a fuel for the future by demonstrating that gas technology is indispensable if the targets of global climate protection are to be attained.

CHP technology is regarded as an interesting option at political level and is therefore included in funding programmes.

The main potential of µCHP systems is seen mainly in buildings with central heating systems. This generally means that conventional heating systems are replaced by electricity generators with heat exchangers. The generated heat is used for space and water heating, while the electricity is used within the building or fed into the grid.

This paper is an extract from the detailed Study Group Report focusing on the theme of micro CHP.

It summarises the framework conditions as they exist in a number of countries represented in Study Group 5.2 (legislation, funding programmes etc.), lists the most important technologies and their manufacturers, and discusses activities being undertaken by the international gas industry in support of µCHP technology.

In this context it goes into some depth on one of the largest European field tests with motorised µCHP units, the "µCHP user group" in Germany.

Background

The energy world is about to change rapidly following the tragic natural disaster in Japan. But global warming too and the reduction of greenhouse gas emissions is again of primary importance in this post Kyoto period. Very many countries are meeting their CO2 emission targets. The impact of the consequences of these megatrends – particularly on power production (nuclear power and its safety) – varies widely in different continents and regions. The gas industry is very much affected in many ways by the emission regulations and the energy transition acts in the aftermath of Fukushima. Once again natural gas is being seen as an option for large-scale power production in place of nuclear power but with the disadvantage of the CO2 emissions.

Electricity is the driving vector today in the energy debate, and one with a huge impact on the domestic and small commercial sector. On the one hand the energy demand of this sector has risen to 30-40% of the primary energy demand in Germany and the EU; electricity consumption in particular continues to rise, and with it the sector's carbon footprint. On the other hand space heating and air-conditioning consume more and more fossil fuels and electrical power as well. Many countries have adopted new building standards and have capped the maximum use of non-renewable energies for heating/domestic hot water production/air-conditioning. The use of natural gas is then often restricted to high efficiency applications. The gas condensing boiler becomes the standard heating appliance often in combination with solar hot water production and/or heating support in new buildings. Efficiency standards are in place in Japan and Europe for new dwellings. An increasing number of energy laws regulate the building sector in regard to efficient energy use.

Natural gas with its unique properties as the cleanest burning fossil fuel transported through a modern efficient pipeline infrastructure offers many advantages in the domestic and small commercial sector, e.g. it is cost efficient, compact, energy efficient, low emission, no PM emissions, versatile, and will play a dominant role in the future energy supply of buildings provided there is a clear strategy for enlarging the product portfolio with new technologies. Two major development thrusts have emerged in recent years: The use of environmental heat and decentralised small power production. Micro-cogeneration is one of the most promising technologies when it comes to securing the position of natural gas in the domestic and commercial sector. In the IGU Triennium 2006-2009 most of these appliances were still in the pre-production or field trial phase and could not readily be presented as marketable products, but the last two years have seen these new applications becoming high end heating appliances for the domestic sector. The forerunners were the Japanese and European gas industries, promoting the technologies, helping through all the field test phases and preparing the market rollout. The products are now commercially available in one of the most profitable markets, the heating sector, but there are new appliances for air-conditioning too. At least 5 volume-produced micro-cogeneration units are available in some of the big European gas countries and in Japan. Two heat pump models have come onto the market in recent years: the adsorption heat pump for single family homes and the absorption heat pump for multifamily homes and commercial buildings. All the products and appliances, often sold as a package or system solution with hot water storage, pump and valve groups

and the control module were well absorbed by the markets when promoted and assisted by marketing programs.

It is likely that the biggest impact will come from micro-cogeneration. This compact modular power supply technology will come in at low cost in the future, and is a technology with the potential to become smart. With the arrival of smart meters on the electricity and gas side, the micro-cogen unit can feed electricity into the electricity grid at peak times, avoiding the full import of electricity. Future modulating appliances will respond to power consumption in the home by producing the right amount just in time. Many other options for distributed power production can be considered with the arrival of the smart grid.

Governments – compliance with CO_2 reduction targets

In keeping with the goals of saving energy, reducing CO_2 emissions and enlarging the share of renewable energies in the energy mix, many EU countries are setting up their own energy efficiency action plans. Organising their fuel and energy supply for the future, research and development on µCHP is gaining increased favour at national (government) level. Government policy support mechanisms which are designed to promote µCHP market introduction vary considerably between countries. These measures include sales subsidies paid by governments to home owners or µCHP manufacturers, bonus payments for exported/generated electricity and other country-specific bonuses such as energy tax exemptions or similar.

Germany:

1) Building Directive

- New energy conservation law in 2012 will require the reduction of primary energy consumption for new buildings by 30% compared with 2009
- Long term plans for zero-energy homes in 2020

2) Renewable Energy Heat Act

Regulates the technologies which should be installed in new buildings and specifies that renewable energy must be used, CHP technology is a compliance option

3) Renewable Energy Source Act

Increase the share of renewable energies in the electricity supply by at least 30% by 2020

Switzerland :

1) Energy Law:

- 20% renewable energies for space heating

2) Building code:

- Defines energy limits for heating demand/ domestic hot water for new buildings

Japan:

- 3Es

  Energy security + Environmental protection + Efficient Energy
  CO2 reduction aims by 2030 by focussing on zero-emission-power = 20% renewable energies and 50% nuclear after nuclear disaster.

- 3ES + S (Safety + Security)

- increased volume of imported LNG (+10% in 2011)

- government is promoting a “Shift to Natural Gas” and therefore encouraging the greater use of µCHP

Poland:

“Colourful certificate” is an energy certification system which supports the use of CHP and renewable energies (buildings/heating appliances)

Denmark:

1) All energy must come from renewable energy by 2050

2) All power must come from renewable energy by 2035

3) Coal power plants to be phased out by 2030

4) Climate plan to be launched in 2012:

a. 50% of power generation by wind in 2020

b. Comprehensive strategy for creating smart grid

c. Funding scheme for development of anticipated green energy technologies.

Europe (Brussels)

Energy-related Products - ErP

In 2005 the EU published its Directive on the ecodesign requirements for energy-using products (EuP) - Directive 2005/32/EC. In 2009 this was replaced by an extended directive, the ErP (Energy-related Products) – Directive 2009/125/EC. In this recast version, the scope of the directive has been extended to include all energy consumption relevant products, so all products which can have an impact on energy efficiency are incorporated and regulated.

The ErP Directive is supposed to lay down lifecycles for the products. In its current form the ErP has 27 product groups, the so-called 'Lots'. CHP technology is part of the boilers and combi boilers, and comes under Lot 1.

Products are graded by efficiency and placed in efficiency classes.

As well as efficiencies, emission limits are also set (e.g. NOx limits).

The measures put in place by the EU within the framework of the directive are intended to enable consumers to compare the efficiency of the product types on offer (µCHP, electric heat pump, gas heat pump, condensing boiler, oil-fired boiler, pellet boiler etc.). The EU has also given consumers an opportunity to rate the products in terms of the fuels they use, as the efficiencies are considered in terms of primary energy sources.

The form and content of the label have not yet been finalised.

A system can earn bonus points with a so-called "Package Label" and so moved up the ratings. A bonus is awarded if for example a good control system is used (e.g. an outside-temperature controlled heating system).

Climate								
Energy Efficiency	Country	CO2 reduction [%]	by/compared to	PE reduction [%]	by/compared to	Share of REN [%]	until	share of PE-consumption in residential area
-	Germany	20%	2020/ 1990	20%	2020 1990	20%	-	>40%
20% via insulation or building	France	20%	2020/	-	-	20	2020/	33%
-	Japan	20-30%	2020/ 1990	-	-	-	-	-
		80%	2050/ 1990	-	-	-	-	-
-	DK	40%	2020/ 1990	-	-	-	-	-

Table 1: Overview of climate protection objectives

Funding Schemes

Germany:

1) Combined Heat and Power Act:

- The act aims to increase the share of CHP power production to up to 25% of total power generation
- Operators of CHP systems receive money for the power energy produced
- Tariffs are graded according to power classes e.g. CHP up to 50kWel. = tariff 5.11.ct/kWhel besides what the operator gets.
- In addition, a bonus price for µCHP electricity exported to the grid is paid for avoiding the use of transmission and distribution networks. This has to be set by the local grid operator, the average value is 0,8ct/kWh + energy tax will reimbursed for natural gas which is used in µCHP, currently 0,55 ct/kWh.

2) Impetus programme

- Investment grant from government for CHP systems up to 20kW. The amount of grant depends on the power class.

power min. [kWel]	power max [kWel.]	Fundings [€/kWel.]
>0	<=1	1500
<1	<=4	300
>4	<=10	100
>10	<=20	50

Table 2: Levels of funding in the impetus programme

Japan:

As part of encouraging the use of µCHP, the Japanese government pays householders a subsidy for saving energy if they install a high-efficiency boiler.

Honda's gas engine (Ecowill) is considered to be such a high efficient boiler and so is eligible for a subsidy.

The householder receives half of the difference in investment cost between a conventional boiler and a high-efficiency boiler.

The installation costs are also partly offset by the subsidy.

OEMs – mass market opportunity, with government and energy supplier backing

For gas appliance OEMs, demand for distributed generation solutions provides a new product line, enables them to stand out from competitors, and follows company philosophy committed to innovation, careful use of resources and efficient energy use. OEMs realise the opportunity to enlarge the product portfolio based on energy saving and environmentally friendly technologies hoping/expecting to get support from the government and/or energy suppliers.

The following table indicates which products are on the market in which countries, which are knocking on market doors and which are just in the R&D phase:

Manufacturer	Status	Country	
Ecopower 1.0 (Vaillant/Honda)	on market	JP GE	 Source 1: www.vaillant.de
Evita (Remeha) EcoGen (Baxi/Brötje) Dachs Stirling (SenerTec)	on market	NL GE UK	 Source 2: www.remeha.de
Vitotwin 300-W '(Viessmann)	on market	GER	 Source 3: www.viessmann.de

Vaillant (Stirling)	R&D		 Source 4: www.vaillant.de
WispherGen	on market	NL GER UK	 Source 5: www.2g-home.de
Kirsch	R&DD	GER	 Source 6: www.Kirsch-HomeEnergy.de
Yanmar	on market	USA JP	 Source 7: www.energ.co.uk

Table 3: µCHP Technologies / Manufacturers / Markets

Drivers for energy suppliers – own business advantages

Energy suppliers are looking to position themselves for a potentially new market opportunity. For energy suppliers, CHP offers the means to increase the value of their portfolios, to enhance efficiency and portfolio diversification and to secure new customers.

In general we can state that across Europe and in Japan, the depth of commitment of the utilities and the measures that are taken vary widely.

Commitment can be divided into

- Status of trials
    - Lab test only
    - Proof of concept or sheltered field trials
    - Demo field trials to end customer
    - Find product to customer
- Quality / commitment with technology partner
    - Partnering for lab trials
    - Partnering for field trials
    - Direct investment in company on product development
    - Product exclusivity on orders
- Securing value with specific strategies/business cases

There are a number of ways in which energy suppliers can secure value from the µCHP value chain. They can

- Become involved in creating intellectual property through research and development by investing in a start-up hoping to gain a return on investment when the developer introduces the product on the market;
- Invest in product manufacture, working closely with a technology developer to bring the product to market;
- Sell products to customers, possibly including financing packages;
- Sell fuel or energy;
- Provide warranty and service packages;

NETHERLANDS:

2006: Setup of "Smart Power Foundation" (Gas Terra & 7 manufacturers),

development and promotion of technologies in terms of installation, regulations, subsidies, codes and standards.

2007: Setup of "Smart with Gas Foundation" (Gas terra & 3 other energy suppliers)

to stimulate the utilisation of effective, innovative gas technologies, lobbying with housing corporations, installers, manufacturers, regional and central government

More recently:"µCHP in a higher gear" (Gas Terra & Dutch Government)

to boost market demand and sales of µCHP, big intensive promotion, introduction of µCHP with housing developers & installer companies

Field trials: conducted demo projects - feedback to manufacturers, target was reached in 2010 when the first appliances entered the market

FRANCE:

In anticipation of the upcoming new regulation standards (RT 2012) for new housing – strict energy laws limiting primary energy consumption – in 2009, energy suppliers (mainly GDF SUEZ) and manufacturers' associations (UNICLIMA) decided to establish a technological roadmap to show the authorities how natural gas could contribute to sustainable development. The roadmap is not only a communication tool but also a technical tool which synthesises many R&D projects in touch with new gas technologies, thermal regulation, studies on insulation and new ways of using it, ventilation and air quality, and - of course - renewables.

Further lab tests to underpin this approach:

Aim: to optimise the consumption of electricity:
auto-regulated combination of µCHP with hot water storage - dishwasher/washing machine increases overall efficiency

DENMARK:

µCHP utilisation in Denmark is seen as very doubtful, stakeholders are very sceptical:

arguments:

- too expensive, too complicated to install compared with conventional condensing boiler or electric heat pump,
- consumers don't know the product,
- plumbers and electricians don't know the product,
- there are no coordinated standards or rules,
- there is no training for plumbers,
- consumers tend to buy conventional technologies, they don't like to take on the financial risk.

Stakeholders are in favour of fuel cells as this might be the technology for new buildings, where energy demand is low and can be supplied by the fuel cell system alone.

JAPAN:

Strategic policies for the future gas industry were discussed by the "*Study group on desirable gas utility business in a low-carbon society*" in 2010. Mid- to long-term scenarios for the gas utility business and action plans are described in the following four schemes:

1) Deployment of distributed energy systems

2) Creation of a hydrogen-based society

3) Advanced use of natural gas in industry

4) Introduction of renewable energy sources

Also, the working group "WG1: *Shift to and advanced use of natural gas*" discussed detailed action plans for accelerating the shift to natural gas in three ways.

- Accelerating the switch from other fossil fuels

- Expanding the use of cogeneration systems (including fuel cell systems)

- Expanding the use of renewable energy sources

These policy proposals are handled by the Urban Heat Energy Committee, which is an advisory body to the METI.

GERMANY:

Large field trial with µCHP technology

"µCHP user group" – E.ON Ruhrgas encouraging innovation

Innovative technologies based on natural gas will continue to be indispensable. As electricity-generating heating systems, µCHP appliances can be an attractive alternative to proven gas condensing appliances in combination with solar heat. Today, virtually all major appliance manufacturers are involved in the development of µCHP heating appliances.

The first units were offered on the market in relatively low numbers in 2011. Manufacturers will continue to expand the range of products. More technically mature appliances are expected to be launched in 2012. As a supporting measure E.ON Ruhrgas is currently conducting the largest µCHP heating appliance field test throughout Germany in cooperation with many market partners. At the same time the appliances tested in the field are also put through comprehensive testing in the laboratory.

Strong arguments in favour of µCHP

Protection of the climate and the environment

Decentralised combined generation of heat and power based on natural gas can contribute to reducing CO_2 emissions by up to 40%. This helps to protect the environment and to promote the image of natural gas as a clean fuel. Energy suppliers can benefit from the situation and adopt a more aggressive marketing approach to promoting the innovative technology in the single- and two-family home segment (in particular existing buildings).

Acquisition of new customers

Energy suppliers with a proactive approach and specific activities also have convincing arguments. This is a good opportunity to expand product portfolios and win new customers.

Customer retention

Energy users have growing expectations of modern energy supplies, as confirmed by rising growth rates in the renewables sector. Companies supporting innovative energy saving technologies are using the opportunity to present themselves as innovative and modern players.

Energy consumption and natural gas sendout

Active commitment means setting trends. The less-is-better concept also applies to energy consumption: with total efficiencies of more than 90%, µCHP heating appliances are very attractive energy saving options. Compared with the conventional generation of heat in a boiler and electricity supplied from the grid, the primary energy consumption of a residential building can be reduced by up to 40%, and that includes the additional consumption of gas for generating electricity.

In September 2009, E.ON Ruhrgas established the µCHP user group. In taking this step, the E.ON Ruhrgas Marketing Services Department created a basis for the most comprehensive

µCHP heating appliance field test throughout Germany conducted together with the company's reselling customers. The members of the user group exchange information about appliance developments, results from field and laboratory tests, experience from practical operations and current trends on a confidential and regular basis following discussion with the appliance manufacturers. This approach ensures direct and prompt exchange of experience among the members of the user group, keeping individual input to a minimum.

The common goal is the efficient market introduction of technically reliable appliances. More than 200 µCHP heating appliances of different manufacturers and designs are being put to the acid test in comprehensive field trials as well as in the laboratory. For this purpose, the members select appropriate residential buildings in their supply areas where the new appliances are installed. Experts monitor operations using comprehensive measurement equipment and submit regular reports on the results obtained. The data are made available to the manufacturers providing them with a reliable knowledge base for technical optimisation.

The most important benefit energy suppliers derive from the µCHP user group is constantly up-to-date information about the status in µCHP heating appliance developments. The user group members can use this knowledge to gain a competitive edge, helping them make decisions and enhance selective end user communication in the field of µCHP heating appliances.

An ever increasing number of energy suppliers make use of this interesting offer of E.ON Ruhrgas. The µCHP user group now (October 2011) has more than 57 members, including municipal utilities, gas transmission companies and E.ON marketing companies.

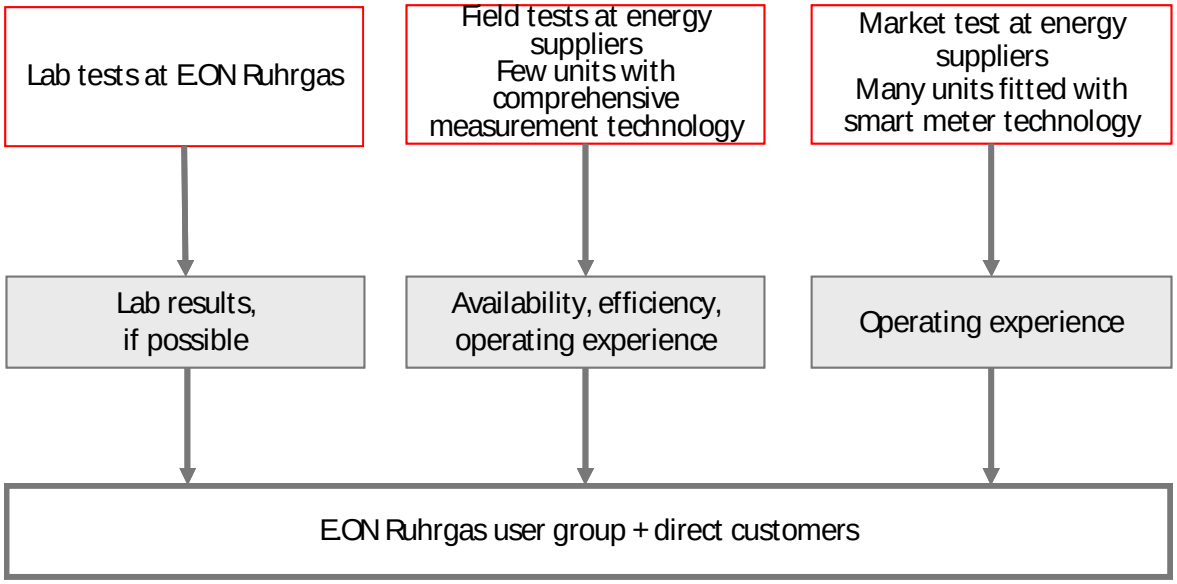

Figure 1: Innovation support: µCHP user group

Markets

Potential for the application of µCHP systems is seen primarily in buildings with central heating systems. Basically this means that conventional heating systems will be replaced by electricity generators with heat exchangers. The heat that is generated is used for space heating and hot water production. The electricity that is generated is consumed on site or fed into the electricity network.

Notable manufacturers have been examining the technical side of µCHP for quite some time but the technical solutions available so far, based on the technologies mentioned in this paper, are just about to enter the market. Fuel cell-driven µCHP, for example, will probably take several years before the first appliances are launched. (In Germany, the Callux demonstration project was initiated in 2008. The systems being tested under the project are not expected to be launched until 2015. In Japan, PEM fuel cells have successfully passed the demonstration phase. More than 10,000 PEM systems have now been installed.) The trend in Europe seems to be clearly towards Stirling engines. The units already available on the market have so far mostly been operated in field trials designed to provide reliable results as to functional capability and use in practical operations. In Japan, the Ecowill gas engine has proved successful on the market; more than 100,000 appliances have been sold so far. Vaillant launched the Ecopower 1.0 (Honda unit) in the middle of 2011.

Table 4 shows the sales figures for 2010 in Europe and Japan for ICE and Stirling technology.

Europe: In Europe around 4000 Stirling µCHP and just under 1000 ICE µCHP were sold in 2010.

	Europe		Japan	
Market sales in	Stirling	ICE	ICE	Fuel Cells in Ene Farm
2010	4000	<1000	10000	8000

Table 4: Total sales figures in Europe and Japan to 2010

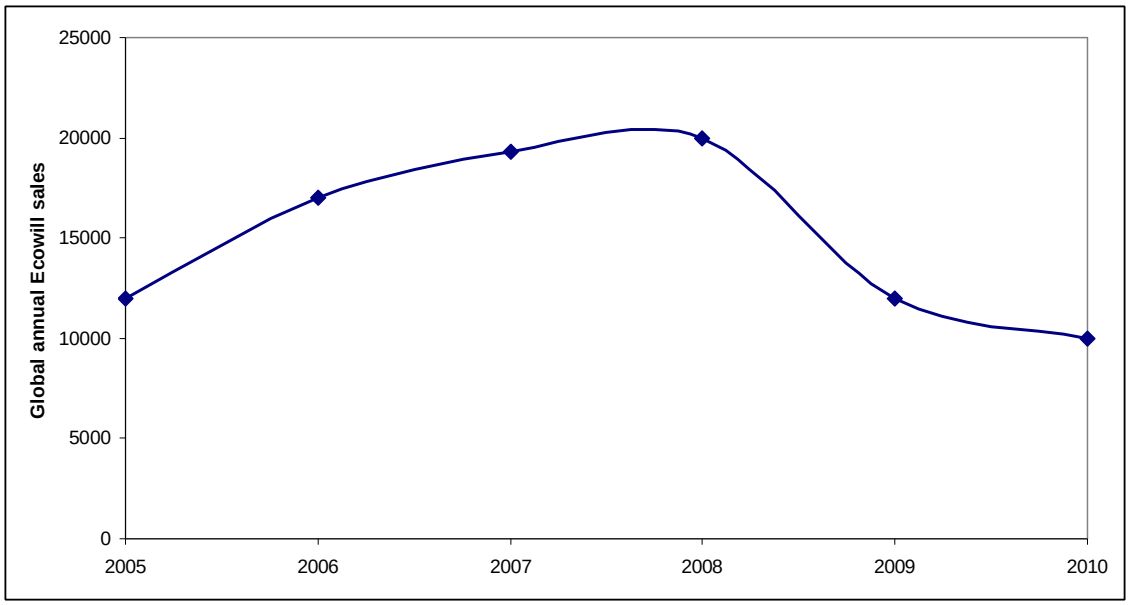

Figure 2: Ecowill sales figures worldwide, [1]

Japan: Gas engine driven residential CHP “Ecowill” establishes market position

In 2010, total sales of Ecowill reached 100,000 units, and sales of 10-20 thousand units p.a. have been constant over the past 5 years. The last 2 years have seen a decline in Ecowill sales rates (because of a strong competition from electrical applications, e.g. heat pumps) but this is offset by fast growing sales of the EneFarm fuel cells, especially after the nuclear disaster.

A number of studies have been conducted and many predictions made to determine/gauge the potential of micro CHP units in Europe. The issue of potential market growth is highly controversial, and there is often an order of magnitude between conservative and optimistic scenarios.

A market scenario of Delta is given here by way of example.

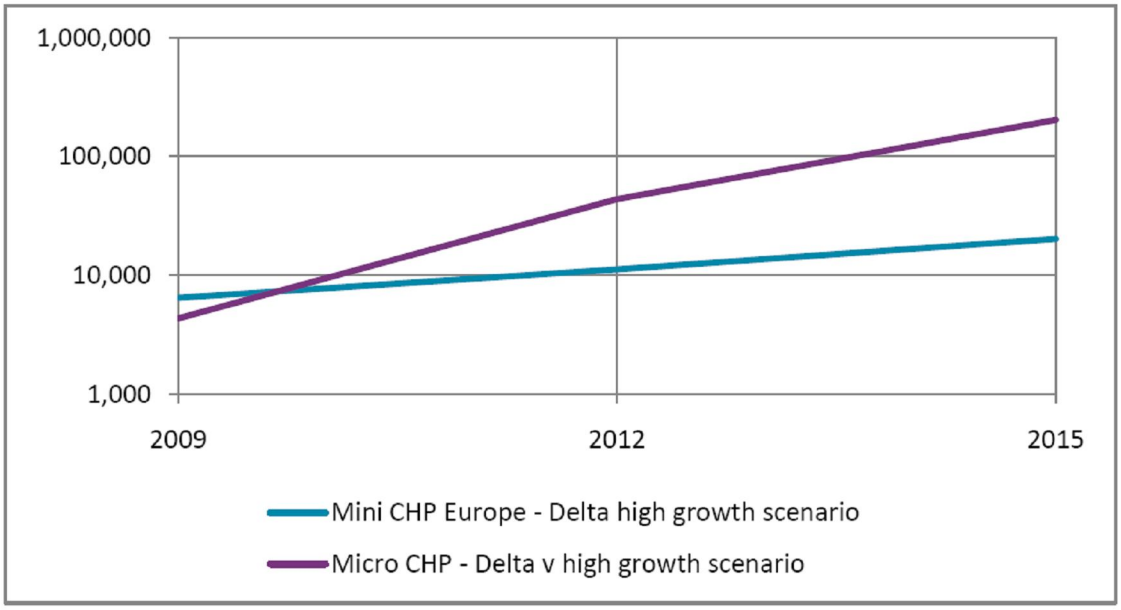

Figure 3: Growth markets for Mini and Micro CHP (including Germany and 2-3 central / eastern European countries) [2])

The success of CHP will also depend on capital expenditure and technical developments (need for compact, quiet and reliable appliances). CHP technology is considered an interesting option at political level and therefore included in funding programmes. Some manufacturers see CHP as the technology that will supplant condensing technology in residential applications. For natural gas suppliers, µCHP is a new outlet on the market.

µCHP is very suitable as a new natural gas technology in residential appliances:

- New buildings
  Engine-driven µCHP is not considered a reasonable option (low electrical efficiency); a low-rated fuel cell should be used instead (high electrical efficiency).
- Existing buildings
  In this case, engine-driven µCHP is a reasonable option because of high thermal output which can be used to meet higher space heating requirements.

How the market develops will depend on a number of factors:

- The difference between gas and power prices (spark spread)
- Production costs and prices to the consumer (can production costs be reduced, and can the margin on resale be influenced?)
- Incentive schemes, regulations, codes & standards, policy

Conclusion

Considerable efforts are now under way to profitably tap the heating demand of single-family and multi-family homes using 1 to 2 kW CHP systems.
In Europe, numerous providers, mainly from among the ranks of heating appliance manufacturers, are successfully field trialling their products to ready them for the market.

Many micro-CHP systems with ratings below 5 kWel were available from the autumn of 2011.
CHP system providers will gain a considerable market opportunity if they can succeed in competing with conventional home heating options in this segment.
Market forecasts predict sales of 40,000 to 70,000 units p.a. in 2015 depending on the scenario, with a rising trend.

µCHP can make a valuable contribution to achieving climate protection targets. It will help cut CO2 emissions and reduce primary energy consumption.
The commercial potential of µCHP will not materialise by itself however, it will require above all a consistent political framework in the long term as a basis on which investment decisions can be taken with confidence.
Micro-CHP will enjoy growing importance going forward so long as providers can make their systems truly commercially competitive. The higher the percentage of self-used electricity that is achieved, the sooner this will happen.

References

[1] Internet Information from METI, NEDO

[2] Delta´s Micro CHP Service, market projection 2011