



# D10.2

## Business models and market plan

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## Document history

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|         |            |  |  |

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## Summary

Within the FC-District Project, in WP10, a task has been set for performing a techno-economic and market assessment of the SOFC unit. The work performed earlier in the FlameSOFC project has been used as a starting point for this assessment study, that has been updated with existing newer results. The present document shows the main results of this updated study.

Chapter 1 is intended to show some  $\mu$ -CHP market potential estimations made in the past, in order to be considered as a reference.

Chapter 2 describes  $\mu$ -CHP market situation according to a recent study made in 2011. In this section, current solutions and new offering of  $\mu$ -CHP technology are mentioned, and domestic heating market barriers and policies in key EU markets are also included. Additionally, this chapter provides a 2015-2020 perspective related to durability, reliability and energy outputs for  $\mu$ -CHP.

Technical potential market and payback period estimations are shown in Chapter 3, describing the methodology for these calculations, as well. UK and Germany markets were chosen for this study.

## 1. Market potential estimations in the past

Many market potential studies have been produced in the past, both for generic  $\mu$ -CHP system and for the particular case of Fuel Cell based  $\mu$ -CHP systems. The discrepancies between them are remarkable and some of them are included as reference. Figure 1.1 shows a comparison between different forecasts for future cumulative fuel cell capacity in Europe and Germany according to estimations made by United Nations Energy Programme (UNEP), Frost & Sullivan consulting firm, and German companies Vaillant, RWE and E.On.

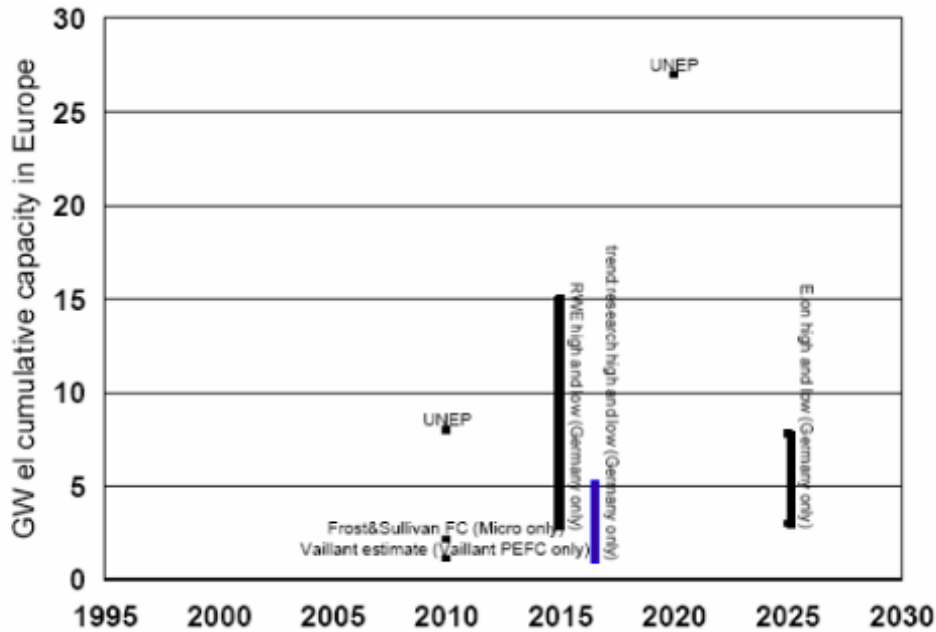


Figure 1.1 Forecasts for future cumulative fuel cell capacity in Europe and Germany according to some estimates

In the following image (Figure 1.2), estimations of total cogeneration capacity in the European Union are represented according to different market policies assumptions. It is important to remark that this graph also contains UNEP estimations for fuel cell capacity in 2010, 2015 and 2020.

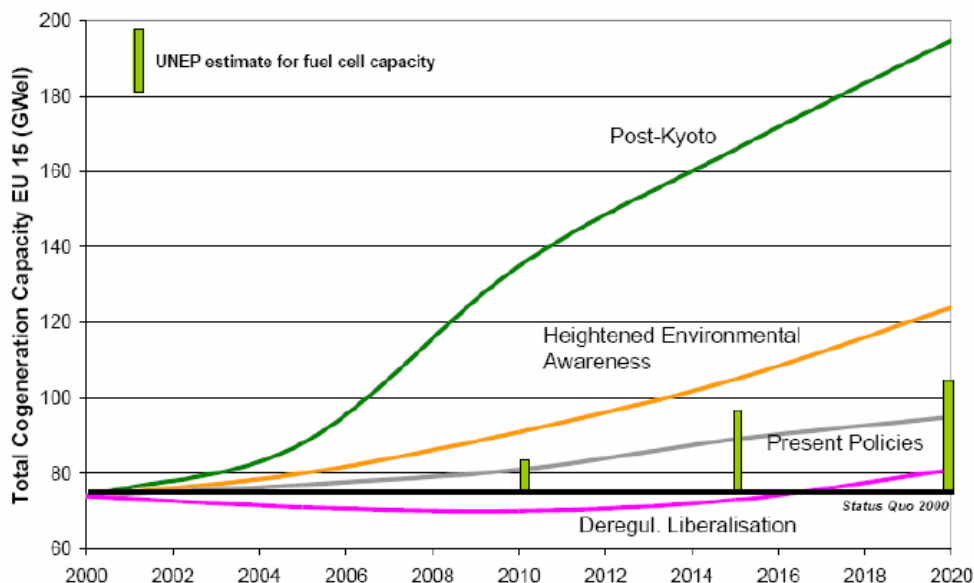


Figure 1.2 Total cogeneration capacity in the EU, including UNEP estimations for FC capacity

MICRO-MAP1 (Mini and Micro CHP Market Assessment and Development Plan) European Project, developed an econometric model to estimate the potential size of the micro-CHP market in Europe under various scenarios for the period from 2001 and 2020. The scenarios chosen were:

- the ‘business as usual’ approach where current conditions are assumed
- the “medium effort” scenario where reasonable efforts are made with regard to legislation, policy and financial incentives
- the “maximum effort” scenario whereby considerable initiatives are taken to promote microCHP systems.

Figures 1.3 and 1.4 show the potential micro-CHP sales estimations according to scenarios 1 and 3 respectively.

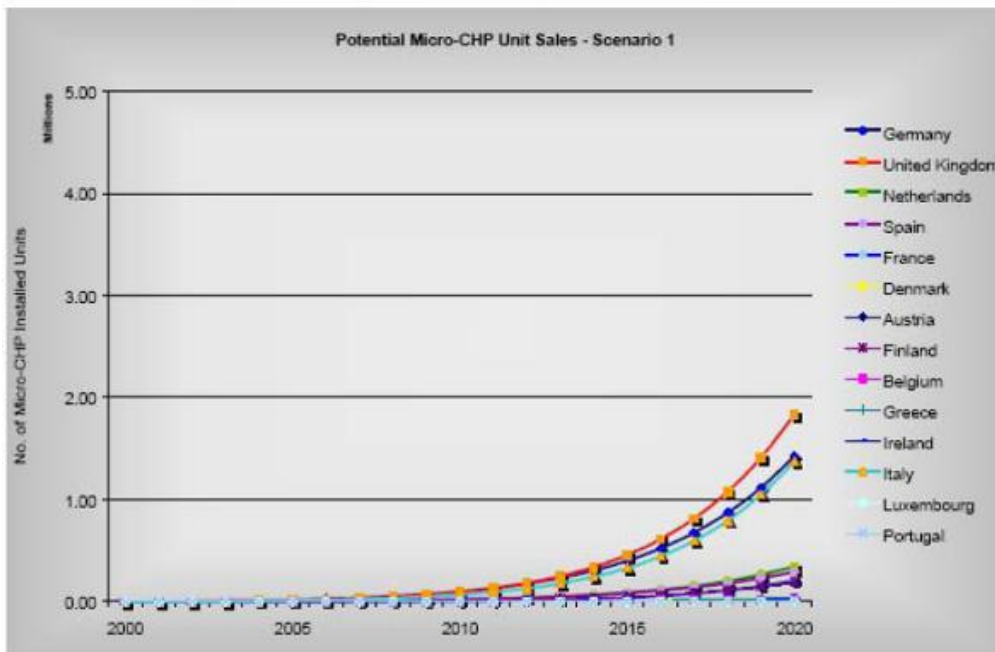


Figure 1.3 MICRO-MAP European project scenario 1 estimation for Potential micro-CHP sales

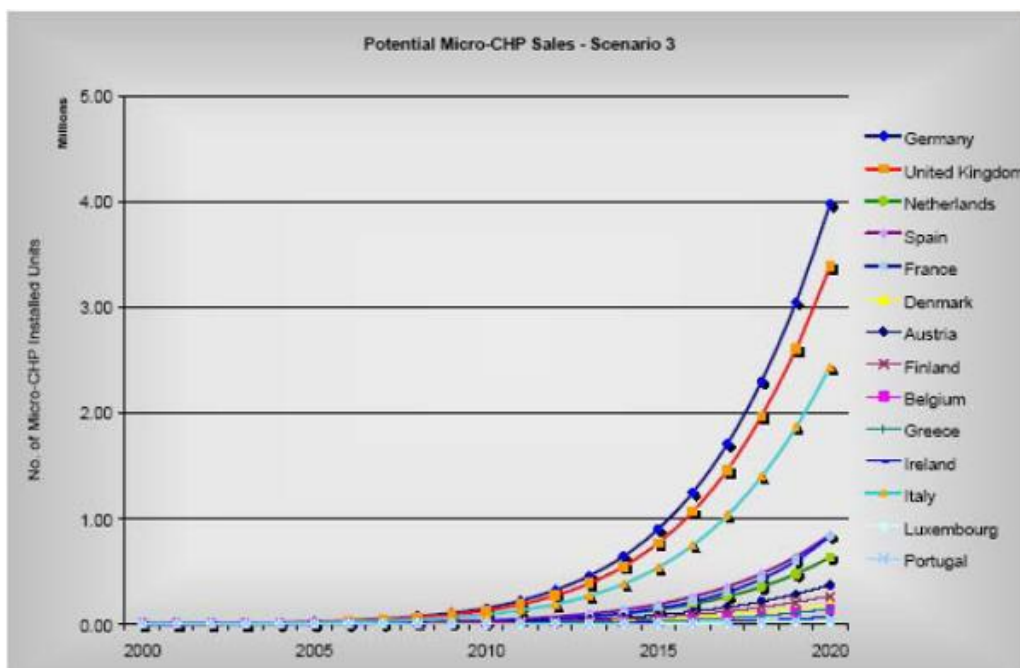


Figure 1.4 MICRO-MAP European project scenario 3 estimation for Potential micro-CHP sales

McKinsey & Co. consulting firm released in 1997 “Micro CHP European Market Study”<sup>2</sup>. This document considers UK, Germany and Netherlands as the key markets in Europe, and estimates the potential micro-CHP annual sales taking into account the forecasted increment in gas demand (Figure 1.5)

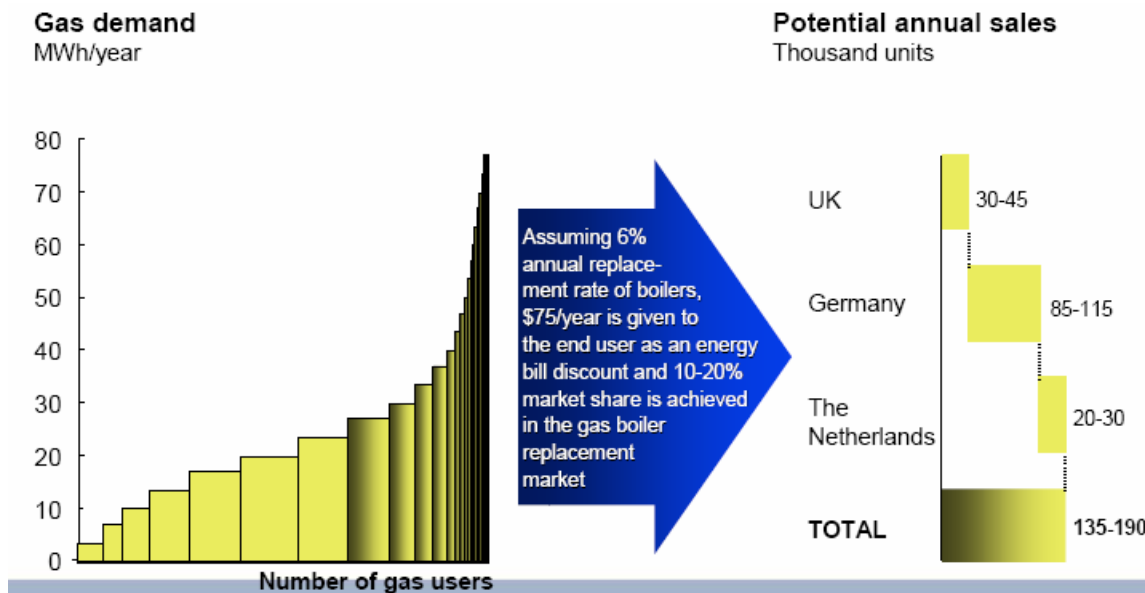


Figure 1.5 Micro-CHP potential annual sales according to McKinsey & Co. market study

This study<sup>2</sup> also describes the estimated changes in domestic energy supply to achieve a 60% reduction in CO<sub>2</sub> emission (Figure 1.6)

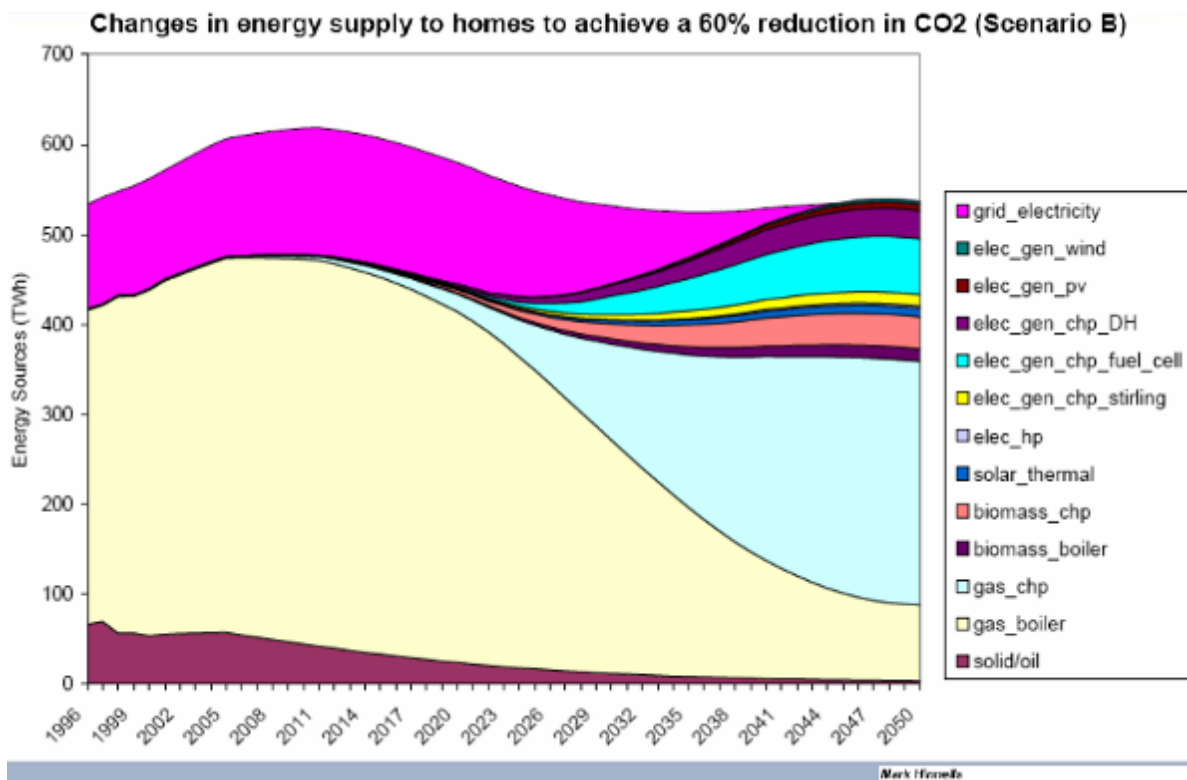


Figure 1.6 Changes in energy supply to achieve 60% CO<sub>2</sub> reduction

## 2. $\mu$ -CHP market situation

### 2.1 $\mu$ -CHP overview of technology

According to a 2011 analysis<sup>3</sup> (Delta Energy & Environment Ltd, “Opportunities for solid oxide fuel cell applications”) about  $\mu$ -CHP (1-4 kWe), the following overview of technology between 2011-2020 has been observed:

#### 2011:

##### a) Boiler

- Light, compact and inexpensive with a wide variety of product choices.
- Can be integrated with a microgeneration product such as solar thermal, solar PV and ASHP.

##### b) $\mu$ -CHP

- Under controlled market introduction with 6 products currently available – 4 ICE and 2 Stirling engine.

#### 2015-2020:

##### a) Boiler

- Integrated system with solar thermal, biomass,  $\mu$ -CHP or ASHP.
- As evidenced in the German market, integrated boiler and microgen systems will be part of new build and boiler replacement building regulations requirement (in some regions).

##### b) $\mu$ -CHP

- Retail price must be comparable to that of an integrated boiler and microgen system.
- Consumers will have a wider choice of  $\mu$ -CHP technologies to choose from as there is a selection of PEM (mostly Japan and S. Korea), Stirling engine and SOFC (mostly Japan and Europe) products will be available as a replacement for domestic boiler systems.

### 2.2 $\mu$ -CHP current solutions

According to Delta Energy & Environment study<sup>3</sup>, the key features of current applications are:

#### a) Existing gas boiler market

- Single family dwelling heating and hot water. In Germany, there are examples of two family homes sharing a single boiler room with daily requirement of 18-24 kWth
- Inexpensive, mature, proven and wide product choice.

#### b) New and emerging $\mu$ -CHP market

- Single family dwelling heating, hot water and electricity generation. At the high end (4kWe) can be either a large family dwelling or a multi dwelling unit.

However,  $\mu$ -CHP has to compete with current solutions as:

- Low carbon solutions (ASHP, solar PV, solar thermal). They represent a growing market with government incentives back growth in most European countries.
- Traditional gas boiler. Low cost, most familiar technology in the market today.



- Combination of gas boiler + low carbon solution. Already evident in Germany, where new building regulations specify that for all new builds there must be a low carbon solution and a boiler installed.

According to this same analysis, the following technology trends have been observed:

- A new 1 kW product appeared in Europe on 2010 but is still expensive, so it represents a niche (not mass) market at least today.
- Only two companies with volume manufacturing plant in place, and a wave of companies involved in trialling / developing product.
- Most energy companies are dipping their toes in the water at best, just a few diving in, many watching.
- Concerning heating industry, one or two companies are driving  $\mu$ -CHP growth, for others it is more about having a stake in case the market takes off, or having a low carbon portfolio.
- Evolutionary, not revolutionary growth to 2015, much more uncertainty 2015–2020.
- UK, Netherlands, Germany the key markets through to 2015. Belgium, Spain, Italy and possibly France following.
- Key market uncertainties: product performance, future product cost, policy support, customer reaction to  $\mu$ -CHP, and degree to which market players will drive growth.

Two commercialised products (Efficient Home Energy-Spain, and BDR Thermea-Netherlands) were launched in 2010, in their first year both companies sold around 1,000 units each across all markets. First year sales were below what the companies forecast, but the market is slowly being prepared for a more assertive launch of the  $\mu$ -CHP brand.



Figure 2.1  $\mu$ -CHP commercialized products in 2010

### 2.3 $\mu$ -CHP new offerings

‘Smart’  $\mu$ -CHP is starting to see commercial applications and more field testing, particularly in Germany. It can be used for either managing local distribution networks or for helping to manage supply and demand imbalances (as a ‘virtual power plant’). The ‘smartening’ of  $\mu$ -CHP can be undertaken without the need for much new technology or great expense. With fuel cells in particular, most are suited to the virtual power plant application.

As indicated in Delta Energy & Environment study<sup>3</sup>,  $\mu$ -CHP (Stirling and fuel cell) will offer carbon savings over gas condensing boilers until 2030 and beyond in some markets. This can be extended by 5+ years with increased electrical and overall efficiency of  $\mu$ -CHP, paired with decarbonising of the gas grid. Beyond 2040,  $\mu$ -CHP may no longer be a low carbon alternative but could still have a role in balancing supply and demand (regionally) and managing local distribution networks.



Figure 2.2  $\mu$ -CHP new offerings

### 2.4 Variable efficiency of the main $\mu$ -CHP technologies (Stirling engine, Rankine cycle, ICE, PEMFC, SOFC)

Delta consulting<sup>3</sup> has identified Stirling engine, Rankine cycle, Internal Combustion Engine (ICE), Proton Exchange Membrane Fuel Cell (PEMFC) and Solid Oxide Fuel Cell (SOFC) as the main micro-CHP technologies. Figure 2.3 shows that Stirling engines and Rankine cycle provide the higher thermal efficiency (70-90%) with an overall efficiency above 85%. On the other hand, SOFC exhibits the highest electrical efficiency values (35-50%) with an overall efficiency close to 85%.

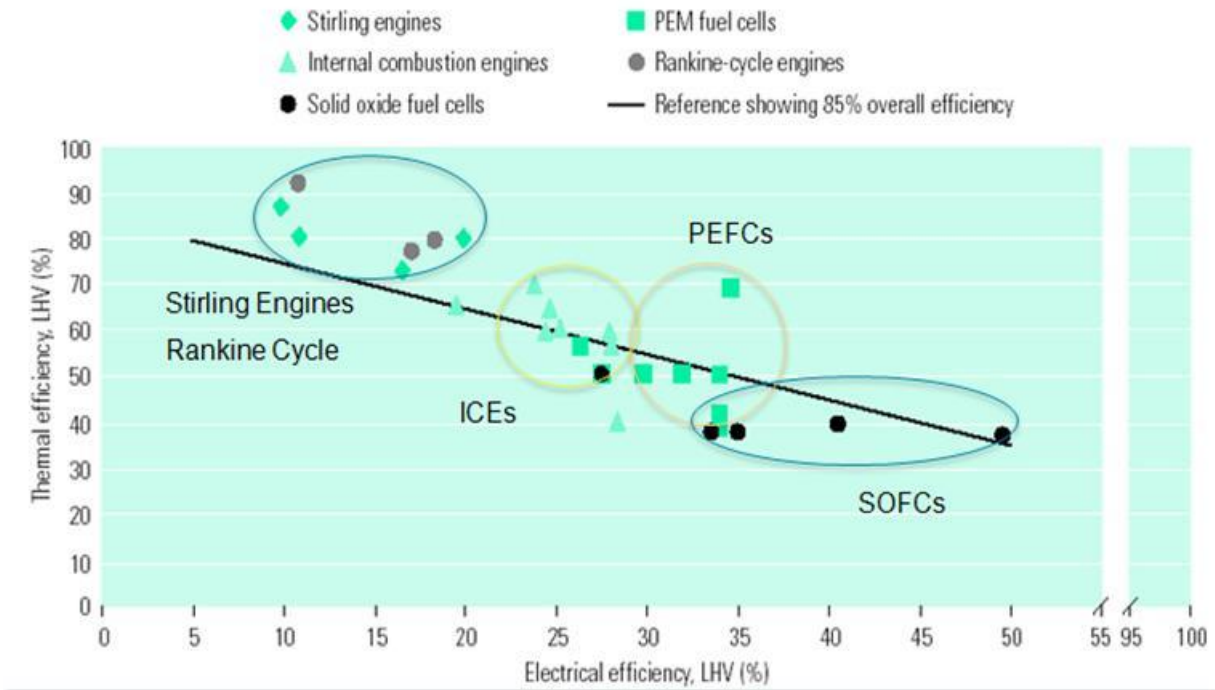


Figure 2.3 Electrical vs. Thermal efficiencies of the main μ-CHP technologies

### 2.5 Current costs and targets from μ-CHP manufacturers

“Opportunities for solid oxide fuel cell applications” market study<sup>3</sup> also forecasts a 20,000€ reduction of installed costs in the residential market between 2011 and 2020 (Figure 2.4). Internal combustion and Stirling engines were identified as technologies with the higher maturity, and considering that fuel cells are not an extended commercial product.



Figure 2.4 Estimated capital costs of the main μ-CHP technologies

## 2.6 Reliability and durability<sup>3</sup>

### 2.6.1 Situation at 2011

While some  $\mu$ -CHP technologies are mature and proven (reciprocating engines), others are still in their infancy with little data on product reliability or durability (eg Stirling engine). It is possible that future  $\mu$ -CHP solutions will be benchmarked against existing boiler markets.

| Reliability   | Durability  |
|---|---|
| <ul style="list-style-type: none"> <li>Gas reciprocating engine <math>\mu</math>-CHP (~4kW) typically have maintenance intervals of at least once a year.</li> <li>Whereas for conventional gas boilers, it is recommended that they are serviced once a year.</li> <li>Boiler failure for conventional gas boilers is expected to be less than once every five years.</li> </ul> | <ul style="list-style-type: none"> <li>Conventional boilers expected to have a maximum 15 year lifespan. Assuming a winter heating season lasting 6 months, with an all day heating regime of 12 hours, the boiler will need to run for 32,850 hrs.</li> <li>Boiler replacements occur at malfunction, increased heating requirement (home extensions) or at the end of the boiler's life.</li> </ul> |

### 2.6.2 Perspective 2015-2020

Reliability and durability will inevitably improve for the products in (or soon to be in) the market.

| Reliability   | Durability   |
|---|--|
| <ul style="list-style-type: none"> <li>Future product reliability and durability will need to meet current boiler expectations as a bare minimum.</li> <li>Fuel cells can operate as base load or as load following.</li> <li>During periods of low electricity demand, production can be scaled back (minimum output overnight, or reverting to hot idling or dumping excess heat).</li> <li>Start up times vary from 1 hr (PEMFC) to more than 24 hrs (SOFC can suffer stresses with full shut down so hot idling is required when no power demand).</li> </ul> | <ul style="list-style-type: none"> <li>Again 10-15 year operation as a minimum but will be challenging if SOFC have to run baseload amounting to around &gt;87,600 hrs of operation.</li> <li>Cell degradation may be an issue, currently at 1 – 3% (lifetime) but for it to be competitive with the boiler replacement market it needs be around the 0.1 – 0.3%.</li> </ul> |

## 2.7 Energy outputs<sup>3</sup>

### 2.7.1 Situation at 2011

#### A) Boiler

- Traditional single dwelling boiler system operating range 14 – 24 kWth (1-4 kWe  $\mu$ -CHP equivalent).

#### B) $\mu$ -CHP (ICE or SE)

- ICE  $\mu$ -CHP typically with electrical output of around 4kW, although recently Honda introduced a 1kW system in partnership with Vaillant

- Stirling engine 1 kWe systems now on market, with several more expected in the market in the next 1-2 years.
- Current electrical efficiencies depend on the technology, ranging between 10 % and 60%.
- Heat to power ratios up to 1:1 with supplementary boiler for peak heat demand periods

### 2.7.2 Perspective 2015-2020

A) Boiler, as today in existing buildings (new homes will have significantly lower heat demand, maybe more suitable for SOFCs).

- Boiler + solar thermal systems (supplying around 40% of hot water demand)
- Boiler + photovoltaic panels



B)  $\mu$ -CHP (ICE, SE, Rankine cycle, or Fuel cell)

- Expectation is a gradual increase in efficiencies for fuel cells, Stirling engine, and Rankine cycle units as achieve increased market penetration.
- SOFC higher electrical efficiencies should become the aspirational target for all  $\mu$ -CHP systems.
- No change expected in heat to power ratio, likely to remain close to 1:1 for competing technologies.

### 3. Technical potential market and payback period estimations

The following results are included in the 2011 report “Opportunities for Solid Oxide Fuel Cell Applications” made by Delta Energy & Environment Ltd.

UK and Germany were chosen for this study because (also with Netherlands) they were identified as the key markets through to 2015, considering Belgium, Spain, Italy and possibly France following.

|                            |                             |  European Union  |  Netherlands   |  Germany  |  United Kingdom  |
|----------------------------|-----------------------------|---|---|--|---|
| Boiler market (units / yr) |                             | 6-8 million   | 0.4 million   | 0.6 million  | 1.6 million   |
| Key constraints / barriers |                             | Low thermal demand in southern Europe. District heating in Scandinavia / Eastern Europe. Elec. heating / renewable heating  | Cheap boilers, mainly combi, installed in attic   | Combi has significant market share   | Combis, boilers in living space, low quality installers   |
| Policy                     | Current policy & regulation | Current Directives (CHP Directive, Energy Services Directive, Energy in Buildings Directive) put micro-CHP on the agenda, remove some barriers, but do very little to oblige Member States to drive the market.                                 | €4,000 subsidy was agreed until Nov'11. However, only €4 million of the €10 million originally granted may now be released. Net metering still available. | Exemption on Ecotax on fuel, bonus price on all CHP electricity (5.11c), Renewable Heat Law, Callux Programme. Installation subsidy was ended in 2010 and still unknown if could be re-introduced this year. | Micro-CHP exempt from VAT, bonus price of 10p (12c). Bonus price part of wider FiT (feed-in tariff) package, m-CHP very nearly left out of FiTs.  |
|                            | Delta View                  | Energy efficiency is high on the EU agenda – new Energy Efficiency Directive proposal. 'Hard' 2020 energy efficiency targets are a possibility in 2013. If so, they will drive the wider energy efficiency sector, in which micro-CHP competes. | Uncertainty over future of subsidy post 2011. Government has less aggressive low carbon energy policy, new nuclear, 'belief' in micro-CHP not strong.     | Strong 25% cogen target (for all electricity produced). End of 2010, energy policy was looking weak on fossil fuel. Recent announcements on nuclear may bring focus back on cogeneration again.              | Government talks a good decentralised energy game, but confidence in micro-CHP is weak / fragile, FIT only for 30,000 units or until 2013. A new focus on cost effective carbon savings for FIT is an encouraging sign. |
| Today                      |                             | ★ ★ ★ ★ ☆ ☆   | ★ ★ ★ ★ ☆ ☆   | ★ ★ ★ ★ ☆ ☆  | ★ ★ ★ ★ ☆ ☆   |
| 2013-2015                  |                             | ★ ★ ★ ★ ☆ ☆   | ★ ★ ★ ★ ☆ ☆   | ★ ★ ★ ★ ☆ ☆  | ★ ★ ★ ★ ☆ ☆   |

★ = Very Poor Outlook   ★★ = Poor Outlook   ★★★ = Moderate Outlook   ★★★★ = Good Outlook   ★★★★★ = Excellent Outlook

Figure 3.1 Market barriers and policies in key EU markets

### 3.1 Fuel cell value chain breakdown

The numbers provided are Delta’s best view on the ‘typical’ or average prices and costs for each element of the value chain, and they were used in the modelling. These were collected from conversations with suppliers and industry experts. Delta believes that these figures were conservative as confirmed by its sources.

Fuel cell (1kWe, 1.5 kWth FC + balance of plant + inverter) value chain breakdown for the **UK**:

|  | 2011 -2013 | 2014 – 2016 | 2017 – 2020 |
|--|------------|-------------|-------------|
| Fuel cell module manufacturer selling price (€)    | 15,000     | 13,000      | 9,000       |
| Distributor selling price for fuel cell module (€) | 17,250     | 15,000      | 10,350      |
| Customer price for fuel cell module (€)            | 18,100     | 15,750      | 10,850      |
| Customer price for the boiler 20 kWth (€)          | 1,090      | 1,090       | 1,090       |
| Customer price for hot water storage tank(€)       | 1,600      | 1,380       | 1,150       |
| Installation cost (€)                              | 3,000      | 2,000       | 1,500       |
| Fully installed price (€)                          | 23,790     | 20,220      | 14,590      |

Fuel cell (1kWe, 1.5 kWth FC + balance of plant + inverter) value chain breakdown for **Germany**:

|  | 2011 -2013 | 2014 -2016 | 2017 – 2020 |
|--|------------|------------|-------------|
| Fuel cell module manufacturer selling price (€)    | 17,000     | 14,500     | 10,000      |
| Distributor selling price for fuel cell module (€) | 20,400     | 17,400     | 12,000      |
| Customer price for fuel cell module (€)            | 24,500     | 20,900     | 14,500      |
| Customer price for boiler 20 kWth (€)              | 2,600      | 2,600      | 2,600       |
| Customer price for hot water storage tank (€)      | 2,000      | 1,750      | 1,500       |
| Installation cost (€)                              | 5,000      | 4,000      | 3,000       |
| Fully installed price (€)                          | 34,100     | 29,250     | 21,600      |

Source: Delta, 2011

Figure 3.2 Fuel cell value chain breakdown for UK and Germany

### 3.2 UK market

#### 3.2.1 Payback period

Delta used the calculated technology payback periods of fuel cell  $\mu$ -CHP to inform its view on the anticipated market penetration of fuel cells in UK.

They generated these payback curves by:

- Using its experience of UK heating market evolution in the last 10 years, particularly of condensing boiler introduction in the UK
- Analysis of heat pump uptake in the UK
- Testing these curves with heating industry experts in the UK

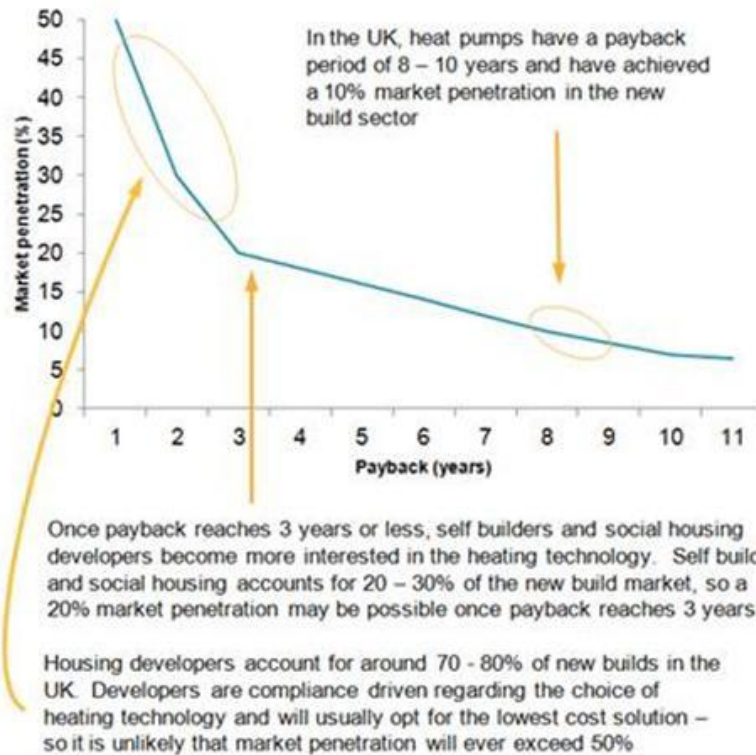


Figure 3.3 Anticipated market penetration of fuel cells versus payback curve for the new build market in the UK

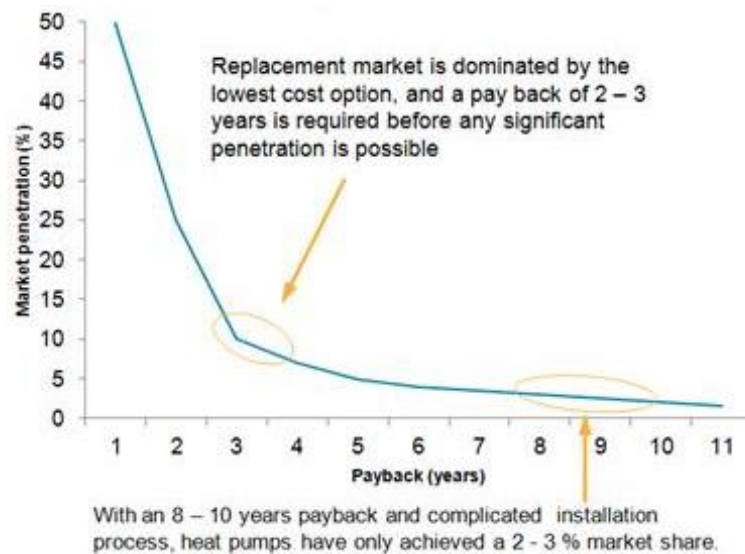


Figure 3.4 Anticipated market penetration of fuel cells versus payback curve for the replacement market in the UK

### 3.2.2 New build market

UK represents a potential addressable market in the new build sector.

Suitable homes were considered those with:

- Hot water storage tanks (around 50 – 60% of all new build installations are with a hot water tank)
- A natural gas supply (85 – 90 % of all new builds)
- Sufficient space for a fuel cell unit (30 – 40% of all homes in the UK)
- Maximum addressable market = 30,000 – 40,000 installations per year



| Heating system                            | Installations/yr |
|---|------------------|
| Wall hung gas (WHG) boiler (combi)        | 50,000           |
| WHG boiler (non combi)                    | 48,500           |
| WHG boiler (non combi) with solar thermal | 4,000            |
| Floor standing gas boiler                 | 5,000            |
| Heat pump (on gas)                        | 1,400            |
| Heat pump (off gas)                       | 11,500           |
| Oil boiler                                | 1,000            |
| Other (solid, LPG)                        | 5,000            |
| <b>Total</b>                              | <b>126,400</b>   |

|  | 2011 - 2013 | 2014 - 2016 | 2017 - 2020              |
|--|-------------|-------------|--------------------------|
| Baseline technology                              | Gas boiler  | Gas boiler  | Gas boiler plus solar PV |
| Fully installed price of baseline technology (£) | 3,023       | 3,023       | 8,423                    |
| Fully installed price for fuel cell system (£)   | 20,687      | 17,583      | 12,687                   |
| VAT benefit on fuel cell price (15% saving)      | 3,103       | 2,637       | 1,903                    |
| Marginal price for fuel cell, with VAT benefit   | 14,561      | 11,923      | 2,361                    |
| Net benefit from fuel cell (£ / yr) <sup>1</sup> | 628         | 647         | 267                      |
| Payback (years)                                  | 25          | 20.2        | 13.2                     |
| Market penetration (%)                           | < 1         | < 1         | 5 – 10                   |
| Anticipated sales of fuel cell mCHP per year     | Few 10s     | Few 100     | Few 1,000                |

1) Net benefit per year = (electricity savings due to fuel cell + financial incentives for fuel cell mCHP) – (marginal running cost + marginal maintenance cost + financial incentives for solar PV).

Figure 3.5 Anticipated market potential for the new build segment in the UK

### 3.2.3 Replacement market

UK also represents a potential addressable market in the replacement sector.

Suitable homes are considered those with:

- Hot water storage tanks (around 20 – 30% of replacement market installations are with a hot water tank)
- A natural gas supply (90 – 95% of replacement market)
- Sufficient space for a fuel cell unit (30 – 40% of all homes in the UK)
- Maximum addressable market = 200,000 – 300,000 installations per year

| Heating system                            | Installations/yr |
|---|------------------|
| WHG boiler (combi)                        | 1,000,000        |
| WHG boiler (non combi)                    | 333,500          |
| WHG boiler (non combi) with solar thermal | 4,000            |
| Floor standing gas boiler                 | 45,000           |
| Heat pump (on gas)                        | 200              |
| Heat pump (off gas)                       | 2,900            |
| Oil boiler                                | 64,000           |
| Other (solid, LPG)                        | 44,000           |
| <b>Total</b>                              | <b>1,493,600</b> |

|  | 2011 – 2013 | 2014 - 2016 | 2017 - 2020 |
|--|-------------|-------------|-------------|
| Baseline technology                              | Gas boiler  | Gas boiler  | Gas boiler  |
| Fully installed price of baseline technology (£) | 1,850       | 1,850       | 1,850       |
| Fully installed price for fuel cell system (£)   | 20,687      | 17,583      | 12,687      |
| VAT benefit on fuel cell price (15% saving)      | 3,103       | 2,637       | 1,903       |
| Marginal price for fuel cell, with VAT benefit   | 15,734      | 13,096      | 8,934       |
| Net benefit from fuel cell (£ / yr) <sup>1</sup> | 628         | 647         | 679         |
| Payback (years)                                  | 25          | 20.2        | 13.1        |
| Market penetration (%)                           | < 1         | < 1         | ~1          |
| Anticipated sales of fuel cell mCHP per year     | Few 10s     | Few 100     | Few 1,000   |

1) Net benefit per year = (electricity savings due to fuel cell + financial incentives for fuel cell mCHP) – (marginal running cost + marginal maintenance cost).

Figure 3.6 Anticipated market potential for the replacement segment in the UK

### 3.2.4 Forecasted Market Size for Fuel Cell μ-CHP in the UK

|  | 2011 - 2013 | 2014 – 2016 | 2017 – 2020    | Key for the table |               |
|--|-------------|-------------|----------------|-------------------|---------------|
| Sales per year in new build market       | Few 10s     | Few 100     | Few 1,000      | ~                 | approximately |
| Sales per year in the replacement market | Few 10s     | Few 100     | Few 1,000 +    | Few               | 3 – 4         |
| Total sales per year                     | Several 10s | Several 100 | ~6,000 – 8,000 | Several           | 5 - 10        |

+ Upside potential to low 10,000s per year due to the UK Green Deal financing fuel cell micro-CHP in return for annual payments from the customer, and if energy companies lease fuel cell systems to residential customers.

Figure 3.7 UK market forecast for fuel cell μ-CHP

## 3.3 German market

### 3.3.1 Payback period

Delta used the calculated technology payback periods of fuel cell μ-CHP to inform its view on the anticipated market penetration of fuel cells in Germany.

They generated these payback curves by:

- Using its experience, and Frey & Scholer’s experience of German heating market evolution in the last 10 years
- Analysis of heat pump uptake and of the transition from non-condensing to condensing boilers in Germany
- Testing these curves with heating industry experts in Germany

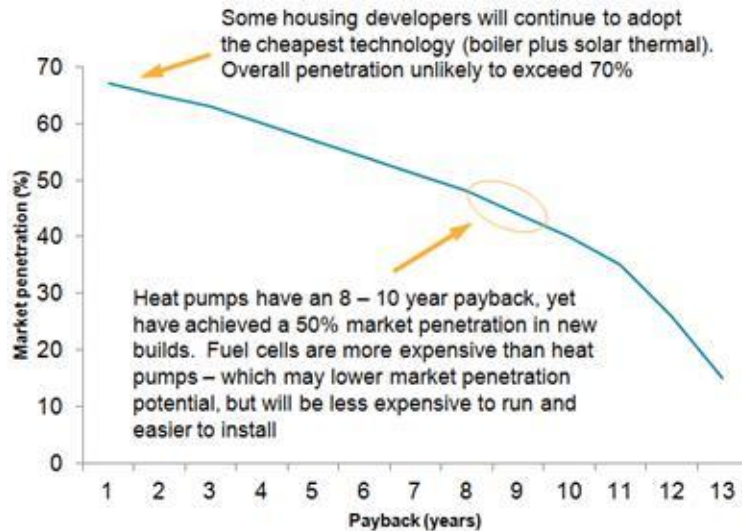


Figure 3.8 Anticipated market penetration of fuel cells versus payback curve for the new build market in Germany

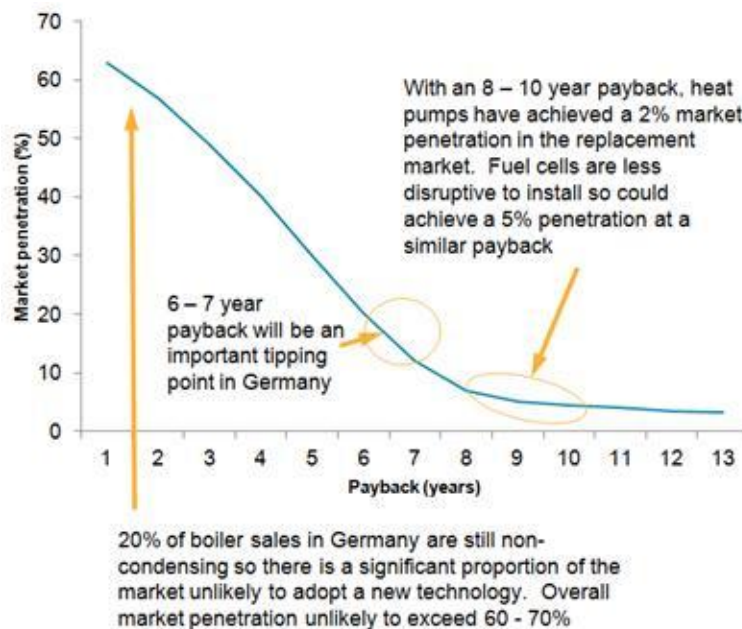


Figure 3.9 Anticipated market penetration of fuel cells versus payback curve for the replacement market in Germany

### 3.3.2 New build market

Germany represents a potential addressable market in the new build sector.

Suitable homes are considered those with:

- Hot water storage tanks (90 – 100% of all new builds)
- A natural gas supply (40 – 50% of all new builds)
- Sufficient space (basement / utility room) and heat demand for a fuel cell unit (60 – 70% of domestic buildings)
- Maximum addressable market = 30,000 – 50,000 installations per year

| Heating system  | Inst / yr |
|---|-----------|
| WHG boiler (combi, condensing)                        | 0         |
| WHG boiler (non combi, condensing)                    | 0         |
| WHG boiler (non combi, non condensing)                | 0         |
| WHG boiler (non combi, condensing) with solar thermal | 40,000    |
| Floor standing gas boiler                             | 0         |
| Heat pump   | 20,000    |
| Heat pump with solar thermal                          | 30,000    |
| Other (solid, LPG)                                    | 10,000    |
| Micro CHP   | 500       |
| Total   | 100,500   |

|   | 2011 - 2013               | 2014 - 2016               | 2017 - 2020               |
|---|---------------------------|---------------------------|---------------------------|
| Baseline technology                               | Gas boiler with solar th. | Gas boiler with solar th. | Gas boiler with solar th. |
| Fully installed price of baseline technology (€)  | 8,500                     | 10,000                    | 11,500                    |
| Fully installed price for fuel cell system (€)    | 34,100                    | 29,250                    | 21,600                    |
| Upfront subsidy available (€)                     | 0                         | 5,000                     | 3,000                     |
| Marginal price for installed fuel cell system (€) | 25,600                    | 14,250                    | 7,100                     |
| Net benefit from fuel cell (€ / yr) <sup>1</sup>  | 596                       | 565                       | 491                       |
| Payback (years)                                   | 42.9                      | 25.2                      | 14.5                      |
| Market penetration (%)                            | < 1                       | Few %                     | 10 – 20                   |
| Anticipated sales of fuel cell mCHP per year      | ~100                      | ~1,000                    | Several 000s              |

<sup>1</sup> Net benefit per year = (electricity savings due to fuel cell + financial incentives for fuel cell mCHP + ecotax saving) – (marginal running cost + marginal maintenance cost).

Figure 3.10 Anticipated market potential for the new build segment in Germany

### 3.3.3 Replacement market

Germany also can be considered a potential addressable market in the replacement sector. Suitable homes are considered those with:

- Hot water storage tanks (70 – 80% of replacement market)
- A natural gas supply (70 – 80% of replacement market)
- Sufficient space (basement / utility room) and heat demand for a fuel cell unit - 60 – 70% of domestic buildings
- Maximum addressable market = 200,000 – 300,000 installations per year

| Heating system  | Inst/ yr       |
|---|----------------|
| WHG boiler (combi, condensing)                        | 35,000         |
| WHG boiler (non combi, condensing)                    | 200,000        |
| WHG boiler (non combi, non condensing)                | 100,000        |
| WHG boiler (non combi, condensing) with solar thermal | 25,000         |
| Floor standing gas boiler                             | 35,000         |
| Heat pump   | 10,000         |
| Oil boiler  | 100,000        |
| Other (solid, LPG)                                    | 20,000         |
| Micro CHP   | 2,500          |
| <b>Total</b>  | <b>527,500</b> |

|   | 2011 - 2013 | 2014 - 2016 | 2017 - 2020              |
|---|-------------|-------------|--------------------------|
| Baseline technology   | Gas boiler  | Gas boiler  | Gas boiler with solar th |
| Fully installed price of baseline technology (€)            | 4,400       | 4,400       | 8,500                    |
| Fully installed price for fuel cell system (€)              | 34,100      | 29,250      | 21,600                   |
| Upfront subsidy for micro CHP(€)                            | 0           | 5,000       | 3,000                    |
| Upfront subsidy for solar thermal in replacement market (€) | 0           | 0           | 720                      |
| Marginal price for installed fuel cell system (€)           | 29,700      | 19,850      | 10,820                   |
| Net benefit from fuel cell (€ / yr) <sup>1</sup>            | 736         | 895         | 559                      |
| Payback (years)   | 40.3        | 22.2        | 19.3                     |
| Market penetration (%)                                      | < 1         | ~ 1         | Few %                    |
| Anticipated sales of fuel cell mCHP per year                | Several 100 | Few 000s    | ~10,000                  |

1) Net benefit per year = (electricity savings due to fuel cell + financial incentives for fuel cell mCHP + ecotax saving) – (marginal running cost + marginal maintenance cost).

Figure 3.11 Anticipated market potential for the replacement segment in Germany

### 3.3.4 Forecasted Market Size for Fuel Cell μ-CHP in Germany

|  | 2011 - 2013 | 2014 – 2016 | 2017 – 2020                  | Key for the table |               |
|--|-------------|-------------|------------------------------|-------------------|---------------|
| Sales per year in new build market       | ~100        | ~1,000      | Several 1,000s <sup>++</sup> | ~                 | approximately |
| Sales per year in the replacement market | Several 100 | Few 1,000   | ~10,000 <sup>+++</sup>       | Low               | 1 – 2         |
| Total sales per year                     | 500 – 1,000 | ~5,000      | 10,000 – 20,000              | Few               | 3 – 4         |
|  |             |             |                              | Several           | 5 – 10        |

<sup>++</sup> This assumes strong policy is in place for low carbon heating in general and fuel cell micro-CHP in particular – realistic in our view but not certain.

<sup>+++</sup> This assumes strong policy is in place for low carbon heating in general and fuel cell micro-CHP in particular – realistic in our view but not certain. Upside potential to several 10,000s due to ease of retrofitting compared to solar thermal.

Figure 3.12 German market forecast for fuel cell μ-CHP

### 3.4 Installed costs

Finally, installed costs data for boiler, stirling engine and fuel cell technologies were gathered in order to compare their status in 2011, also estimating both 2015 and 2020 perspectives.

### 3.4.1 Status 2011

|         | UK            | Germany       |
|---------|---------------|---------------|
| Boiler  | €3,505        | €4,400        |
| SE mCHP | €8,000 / kWe  | €16,000 / kWe |
| FC mCHP | €18,100 / kWe | €24,500 / kWe |

Figure 3.13 Installed costs 2011

Other requirements for  $\mu$ -CHP technology:

- Produces more electricity and more carbon savings.
- Not dependent on high heat demands.
- More expensive.
- Limited lifetime and reliability

### 3.4.2 Perspectives 2015 and 2020

|         | UK            | Germany       |
|---------|---------------|---------------|
| Boiler  | €3,505        | €4,400        |
| SE mCHP | €5,000 / kWe  | €10,000 / kWe |
| FC mCHP | €15,750 / kWe | €20,900 / kWe |

Figure 3.14 Installed costs estimation 2015

|         | UK            | Germany           |
|---------|---------------|-------------------|
| Boiler  | €10,080 (+PV) | €8,500 (+thermal) |
| SE mCHP | €4,000 / kWe  | €8,000 / kWe      |
| FC mCHP | €10,850 / kWe | €14,500 / kWe     |

Figure 3.15 Installed costs estimation 2020

Other requirements:

- FC  $\mu$ -CHP will be very suited for the smart grid due to low heat to power ratio, thus allowing more flexibility.
- Better fit with energy demands of future homes.
- Ability to be wall mounted important in large boiler markets of the UK and Netherlands.
- Parasitic load (where FC  $\mu$ -CHP uses around 5-10% of its energy in powering the unit) may need to fall.
- Expect lifetime and reliability to improve.

## References

- [1] MICRO-MAP (Mini and Micro CHP Market Assesment and Development Plan) report, 2002
- [2] McKinsey & Co. "Micro CHP European Market Study", 1997.
- [3] Delta Energy & Environment Ltd, "Opportunities for solid oxide fuel cell applications", 2011.  
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