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Pathway to a Competitive European Fuel Cell micro-CHP Market

The bridge to large scale market uptake

European-wide field trials for residential Fuel Cell micro-Cogeneration

Report on customer attitudes to fuel cell micro-CHP

Deliverable: D2.11
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Version: Final

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Context and overview of document

- This document (D2.11) is the first of three reports analysing the customer attitudes to fuel cell micro-CHP installations. The analysis is based on data from pre-operation questionnaires completed by customers of FC mCHP installations. The report sets out the general profiles of customers, their motivations for purchasing a mCHP unit, and their attitudes to, and expectations of, the technology prior to installation.
- It was found that the general profile of the customer appears to have above average household income, and lives as a couple or family in large detached housing. The customers are generally positive of the technology as 'early adopters' willing to purchase new technologies to reduce carbon emissions.
- Expectations of the FC mCHP systems are high, with customers expecting heating and electricity needs to be met by the system, with energy consumption and costs reduced. The majority of customers expect to receive financial benefits in the form of reduced energy bills as well as additional government incentives such as subsidies and feed-in tariffs.
- The following iterations of this deliverable (D2.13, D2.15) will use during-operation questionnaire data to explore how expectations are met by actual experiences of FC mCHP, and to analyse how attitudes to the technology change over time and with use of the system.

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Introduction to PACE and D2.11

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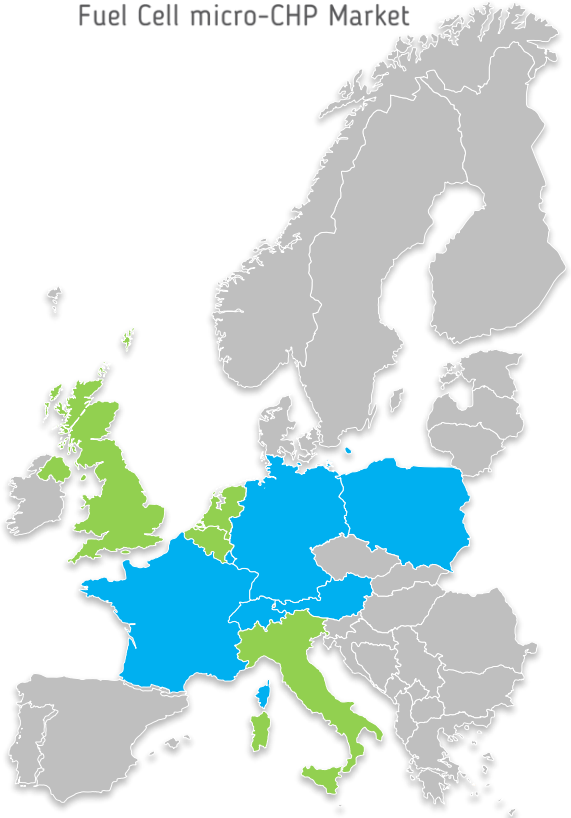
Introduction to PACE

Promoting a successful transition to the large scale uptake of Fuel Cell micro-Cogeneration across Europe



Field trial + installer training + targeted market & policy development activities

Field trial + local installer training

9 Partners

Representing manufacturers, utilities & research community

> 2,800 Fuel Cell micro-Cogeneration units

To be deployed across Europe between 2016-2021

>500 Systems per manufacturer

Established production capacity per manufacturer

10 Countries

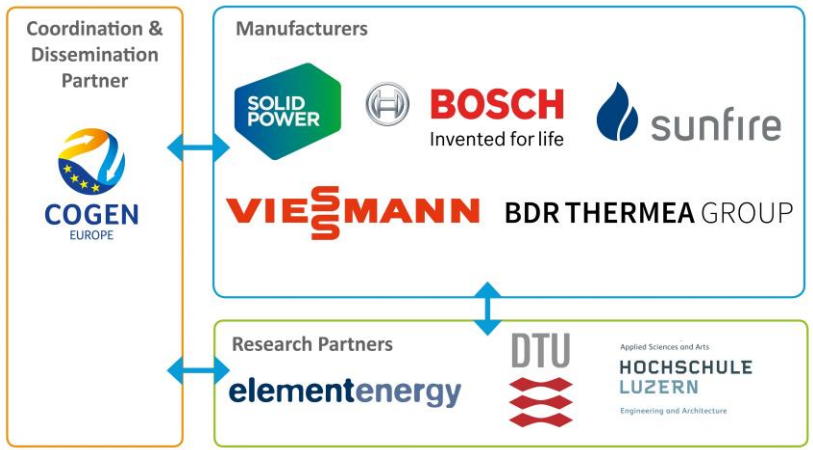
Where the units will be installed

4 Countries

Selected for policy & market development (Belgium, Italy, Netherlands and UK)

€90m Total budget

Including €33.9m Horizon 2020 funding via FCH JU



>10,000 FC micro-cogeneration units/year post 2020

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Introduction to WP2 and Task 2.5

WP2 – Performance Validation

- WP2 sets out the data collection protocols, and involves the process of data collection and management throughout the project.
- Technical operational data on the performance of units as well as customer feedback survey data is collected as part of the project.
- Task 2.5 encompasses the customer feedback survey, which collects qualitative and quantitative data on the satisfaction of customers with their units, positive and negative aspects of their interaction with the units, as well as their perception of the savings being made by the units and their willingness to pay for future equivalent products.
- It is expected that surveys are collected from customers at 3 times, both in pre- and during-operation (after 12 and 24 months of operation), in order to carry out longitudinal analysis of the way attitudes to the units may change through time.

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Overview of D2.11

D2.11 - Report 1 on customer attitudes to mCHP installations

- D2.11 is the first of three reports analysing the customer attitudes to fuel cell micro-CHP installations.
- Only pre-operation questionnaires have been launched at the time of submission of this deliverable. 313 pre-operation questionnaires have been completed out of 821 units commissioned as of 17th September 2019. This represents a completion rate of 38%.
- Sets out the general profiles of customers, their motivations for purchasing a mCHP unit, and their attitudes to, and expectations of, the technology prior to installation.
- The following iterations of this deliverable (D2.13, D2.15) will expand on this deliverable, with a larger proportion of the units having been commissioned, and longitudinal analysis will be possible after the during-operation questionnaires have been launched.

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Customer and building characteristics

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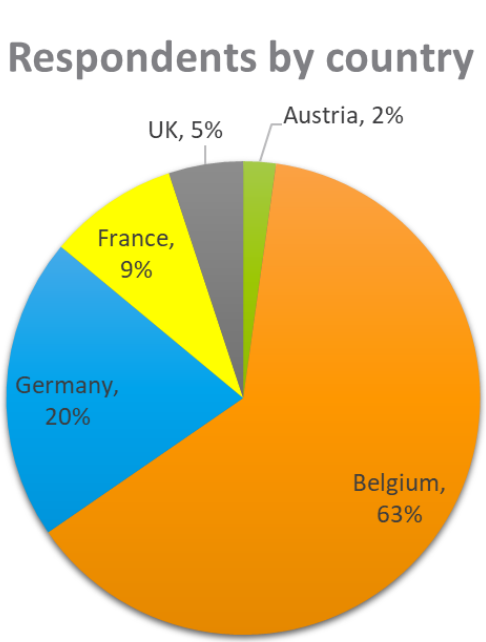
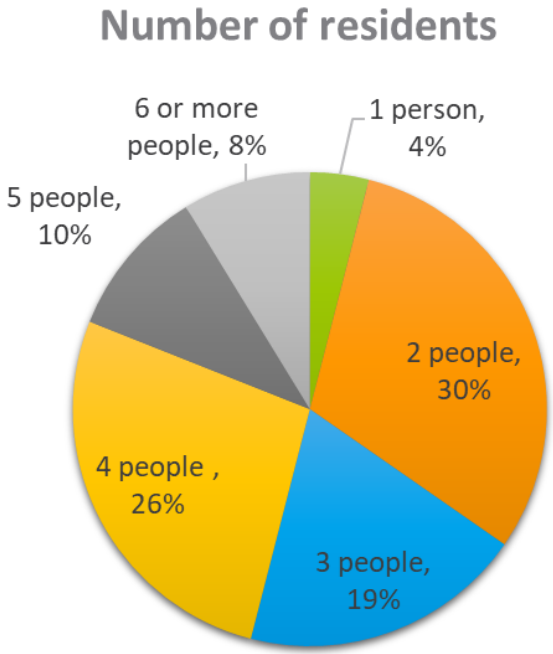
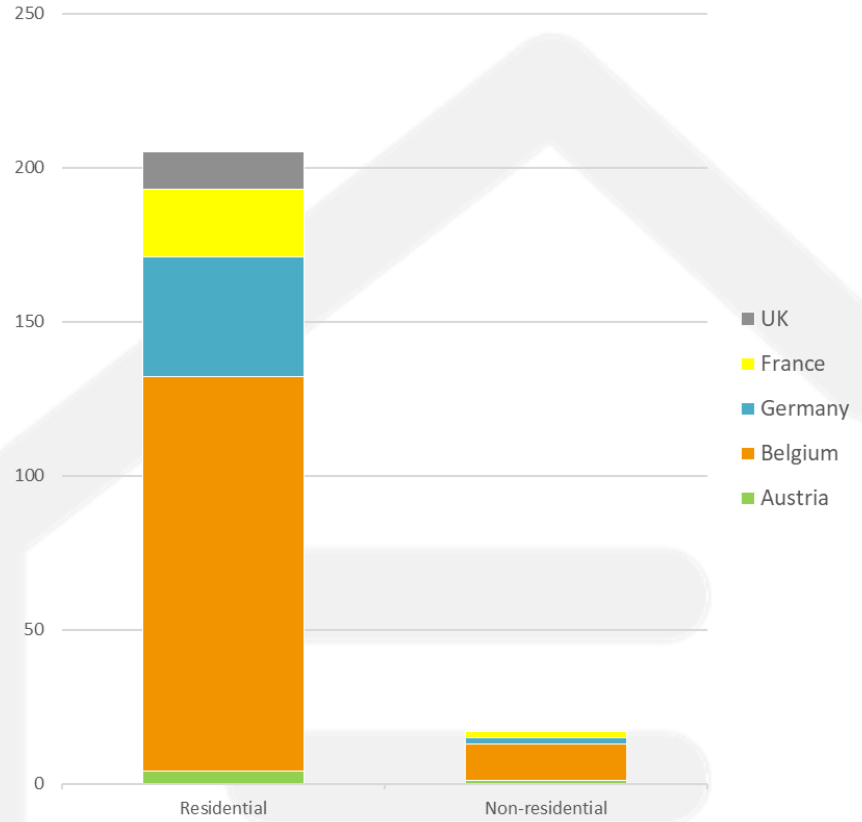
Customer characteristics

The majority of the respondents having completed the questionnaires were located in Belgium. 94% of respondents have units that are deployed in residential buildings.







The number of non-residential units may be underestimated here, as larger non-residential buildings often use multiple cascaded units, yet will only register as a single response to the customer survey. These have however been treated as one response as they reflect the perspective of one respondent.

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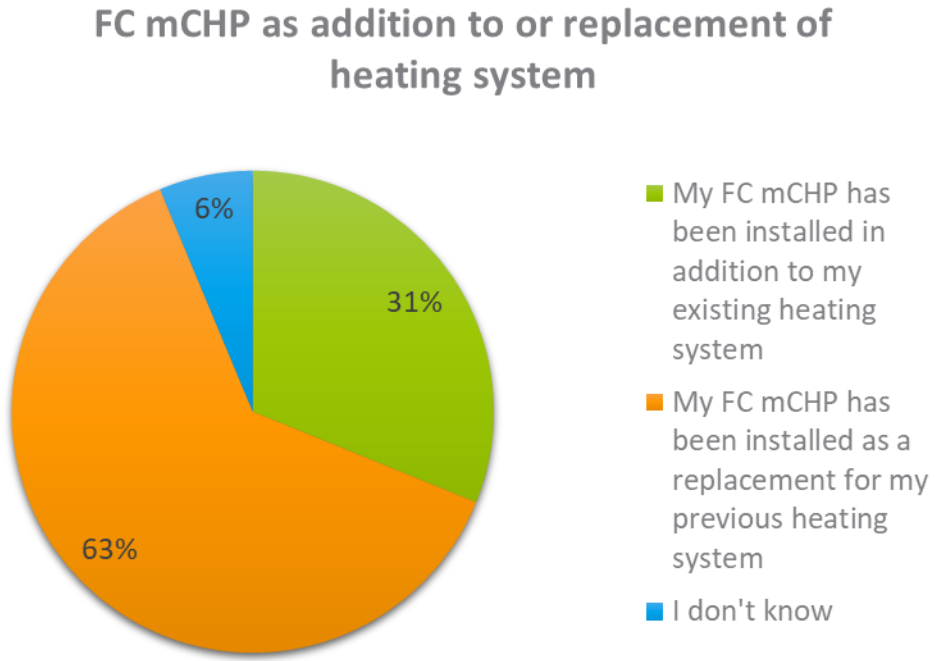
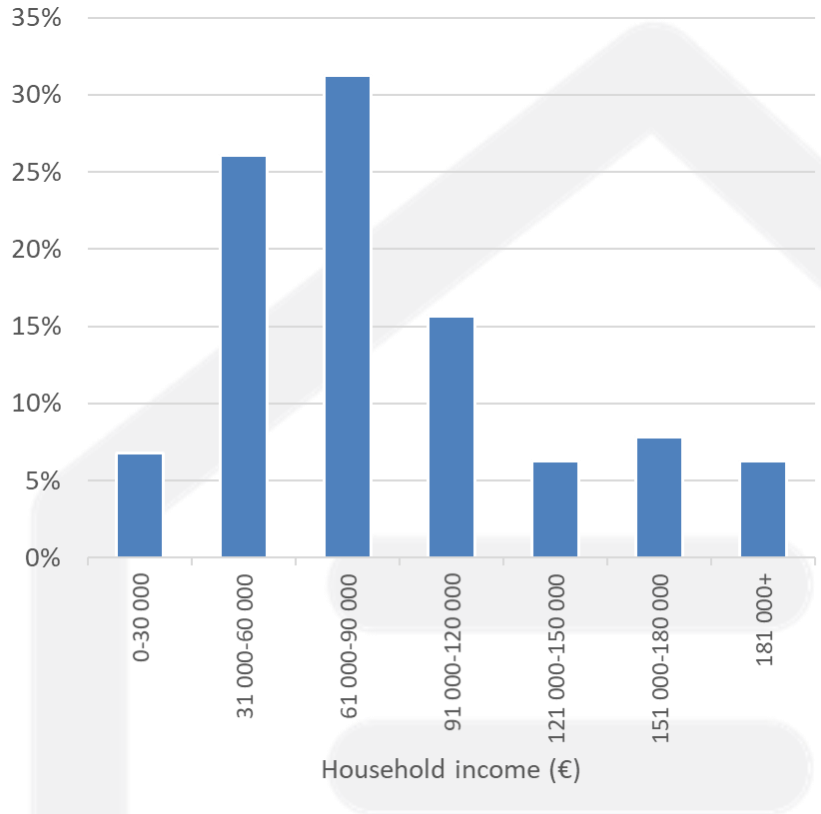
Customer characteristics

The majority of customers have FCmCHPs installed as a replacement to their existing heating system. However 31% of the respondents are installing FCmCHP in addition to their existing heating systems.



Many customers with addition units have 'cascaded' systems with multiple integrated units. Therefore, the number of addition units may actually be underestimated, as only one survey is completed for each customer, even if they have multiple units



At least 93% of the respondents have an income above the European average income and generally above the average income of their respective countries (median EU household income is € 16,943 and median income for Belgium, France, Germany and the UK range from € 27,500 – € 31,000).

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Customer characteristics

Summary

- Nearly two thirds of respondents to date are based in Belgium.
- Respondents generally have higher than the national average household income. 93% of respondents have a household income (before tax and social security) greater than € 30,000 (in Belgium the national average is € 27,761). 36% of respondents have a household income greater than € 90,000.
- The majority of customers are therefore likely to be couples and families with disposable income. Indeed, 64% of respondents in residential buildings had more than 2 people in their household.
- The high proportion of affluent customers could reflect their ability to take the financial risk, where high initial costs of the infrastructure may be prohibitive for those with less disposable income. Additionally, this may also be influenced by the characteristics of the building enabling the technology (see next section).
- Most respondents' FC mCHP units are replacement units, with 31% being installed in addition to the customer's existing heating system. These are typically electricity-led systems installed with the objective to produce electricity and that do not have an integrated boiler. For clarity, heat-led units are usually installed as a replacement to existing heating appliances due to their end of life and have a boiler integrated. Most customers (84%) who are installing their units in addition to their existing system are based in Belgium.
- It is likely that the number of addition units and the number of non-residential customers are underestimated in the responses to surveys. This is because customers with 'cascaded units' only fill out one questionnaire when in practice there are multiple integrated units (up to 5 units). Most non-residential customers have multiple cascaded units.

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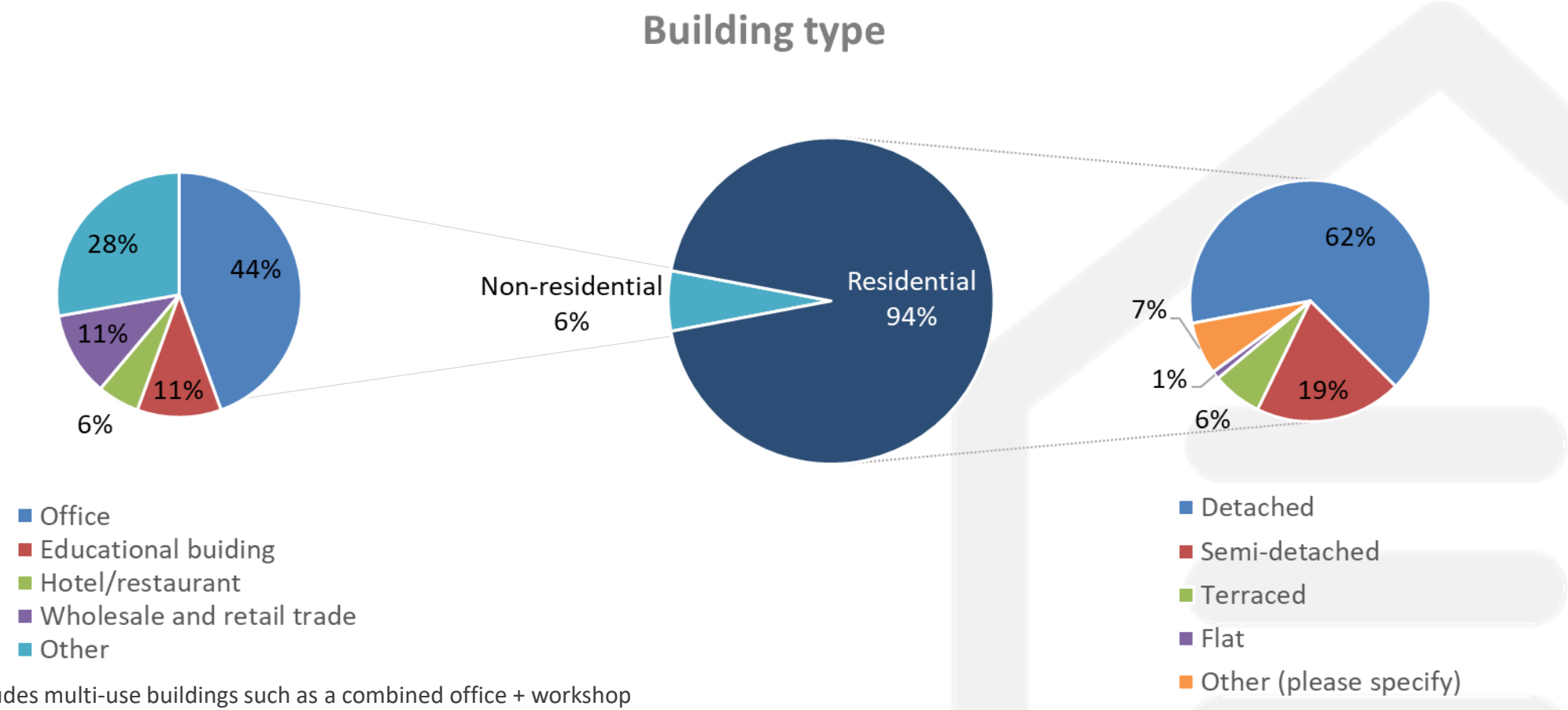
Building characteristics

FCmCHPs have in majority been installed in detached homes (residential applications) and offices (commercial applications)



'Other' includes multi-use buildings such as a combined office + workshop

'Other' includes primarily combined residential + commercial building uses

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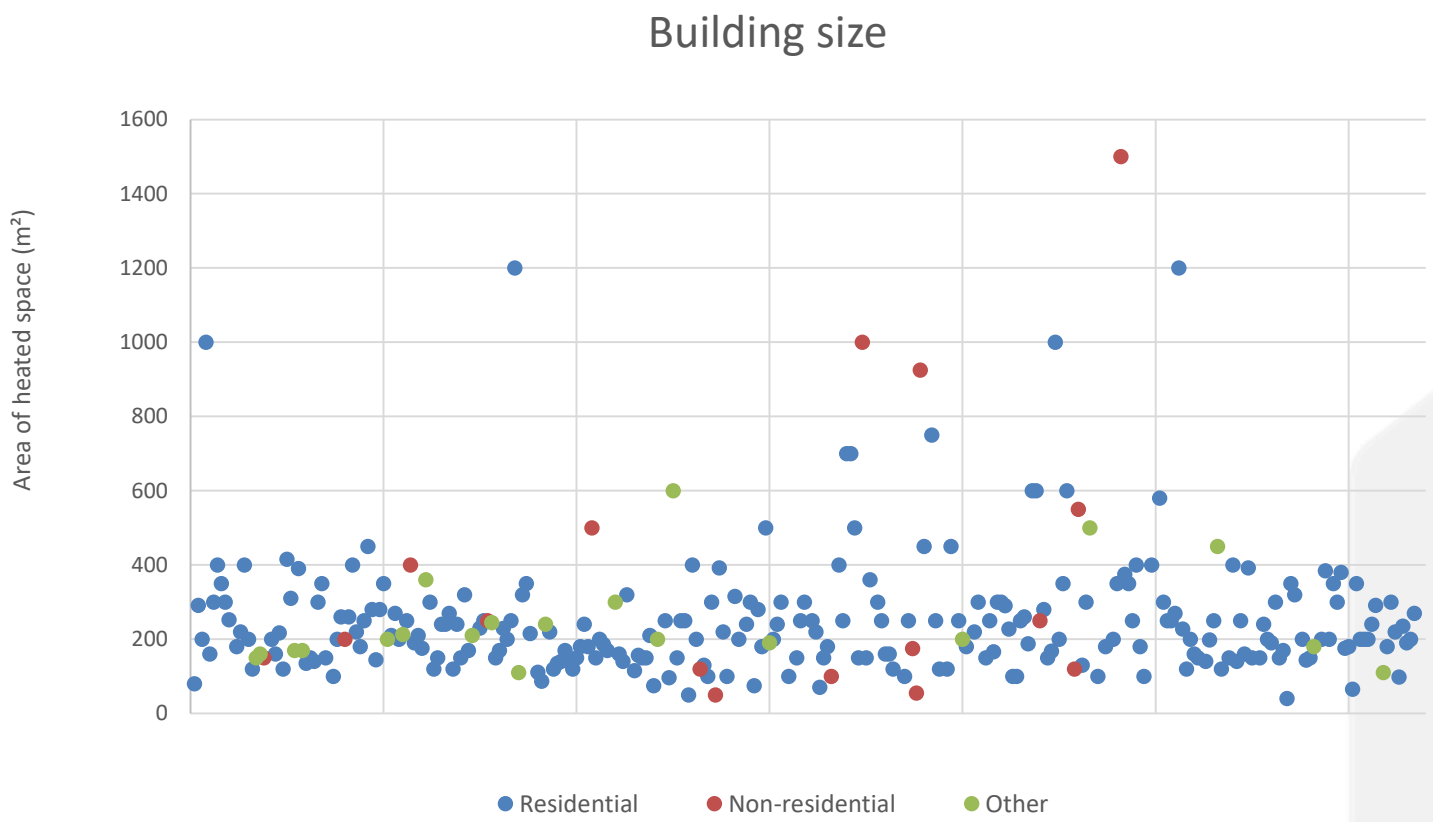
Building Size

Non-residential applications for FC mCHP on average have a larger heated space than residential applications.



	Average area (m²)
Residential	248.47
Non-residential	396.56
Other	247.90

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Building characteristics

Summary

- Building type for residential customers is predominantly detached, which in most cases fits with the profile of an affluent customer with a large house and a higher than average disposable income. 62% of respondents live in detached houses, compared to only 38% of houses in Belgium, 26% in Germany, 25% in the UK, and 67% in France.
- Indeed, the average size of the building (measured as the total floor space of the area the FC mCHP supplies energy to) is 268m^2. The average for residential applications is 248 m^2 and for non-residential applications is 397m^2. For context the national average house size in Belgium is 86m^2.
- The affluent profile and large house size may influence several factors such as energy usage (i.e. a larger house may need more energy to heat the space), and energy efficiency (i.e. quality of insulation, number of appliances).
- A larger house may improve the financial benefits (payback period) of FC mCHP, due to the higher energy usage.

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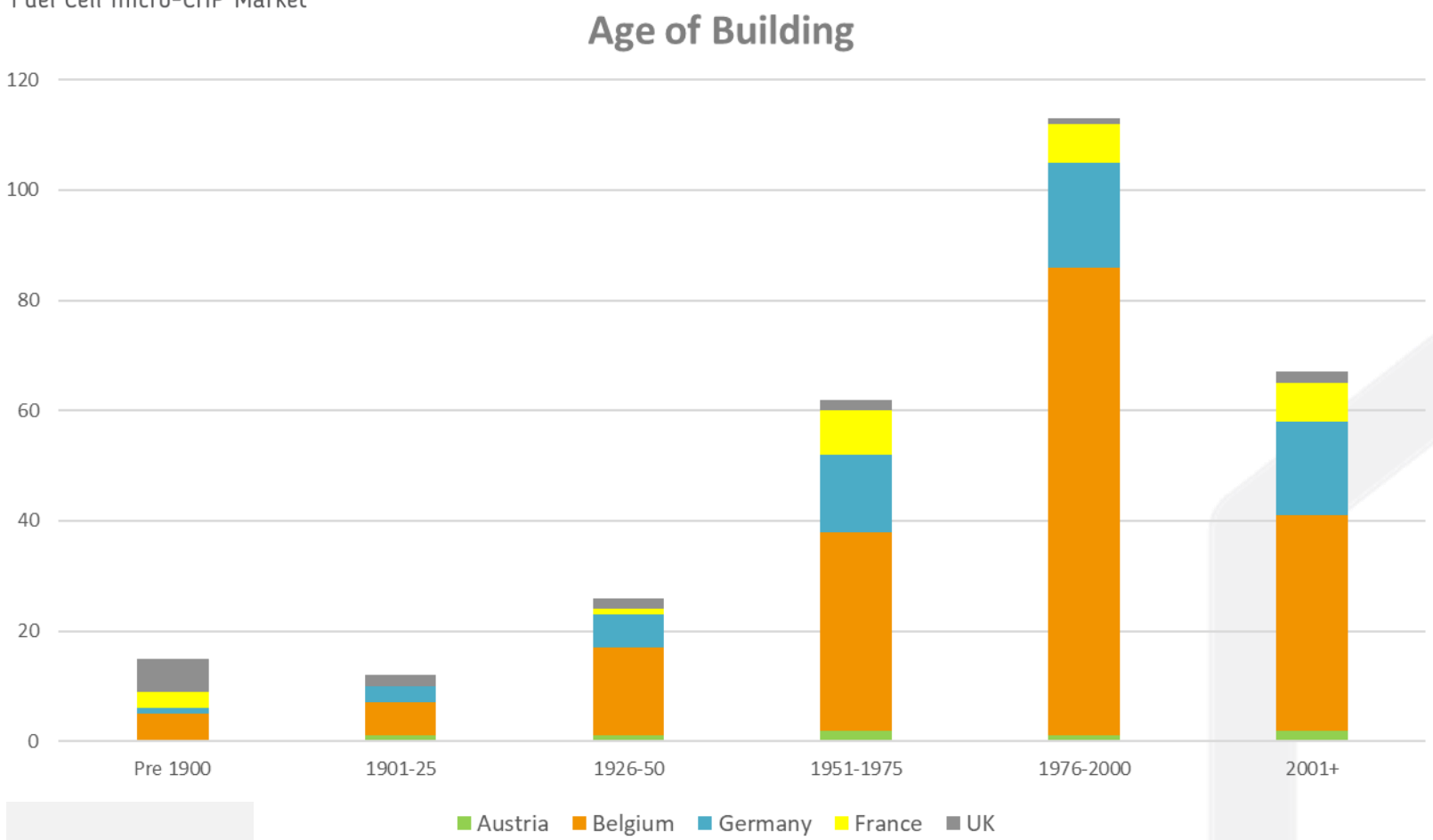
Building characteristics



- Most FC mCHP units are being commissioned in relatively modern buildings built within the last 50 years.
- However, this varies with country – for example, the majority of units in the UK are in houses built pre-1900.

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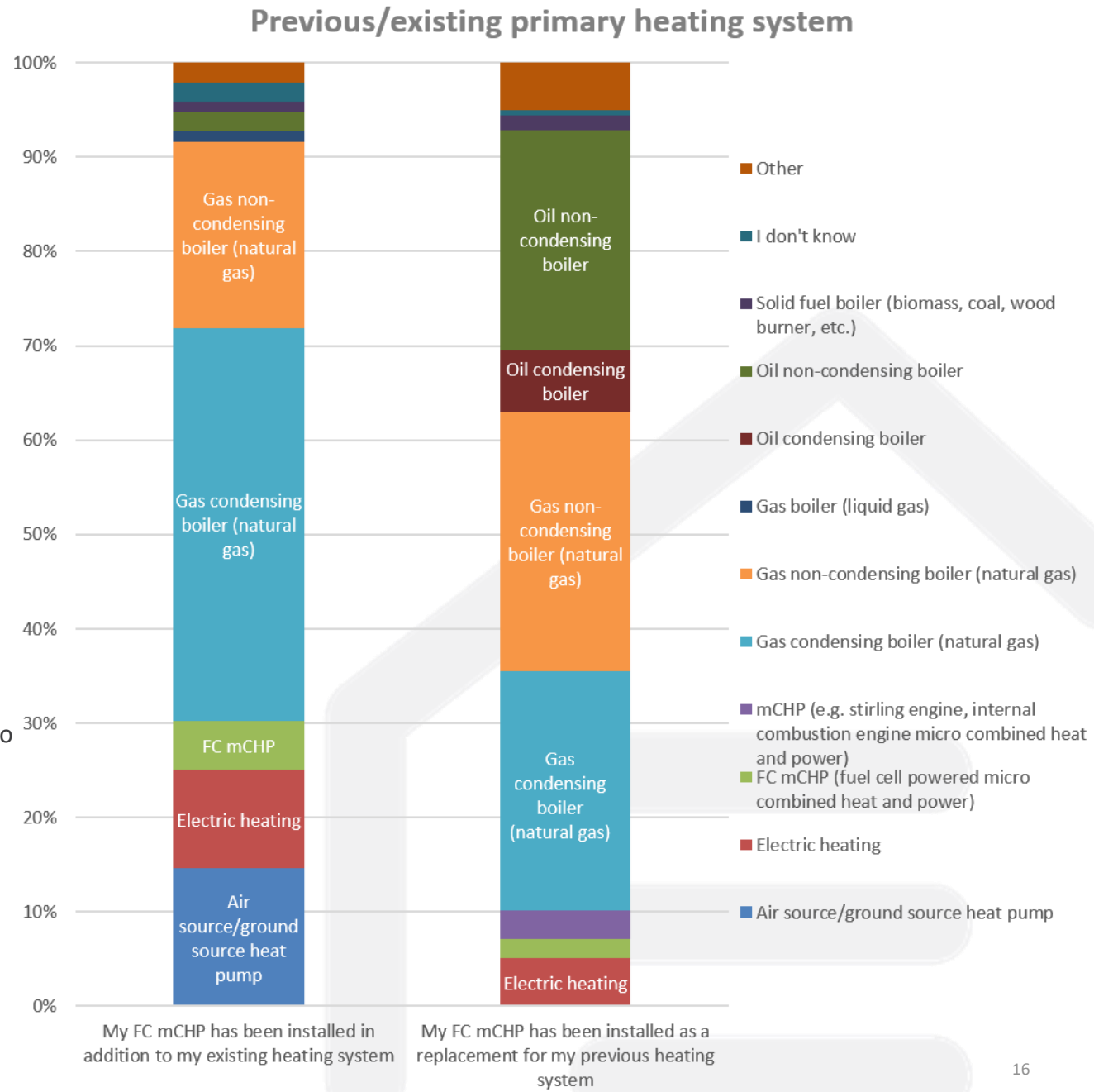
- Where customers are using FC mCHP as an addition to their existing heating system, there is a variety in the type of existing heating system.
- Where customers are outright replacing the previous system with FC mCHP, the previous system is largely conventional gas and oil boilers (76%). There are fewer instances of customers replacing 'greener' technologies (e.g. FC mCHP, air source/ground source heat pump), presumably with customers upgrading the systems to a newer or more suitable technology.
- This indicates that replacement vs. addition units may have different motivations for purchasing FC mCHP that reflects different operating modes:
  - Electricity-led units are installed in buildings with important electricity needs to meet the electricity consumption of the building. In a residential building, this could be due for example to an existing electrical heating systems (e.g. air source heat pumps or electrical heating) or to increased electricity needs (smart home, electric vehicles charging etc.). In a commercial building, this would be linked to the operational needs of the building.
  - Heat-led units are usually installed as a one for one replacement to previous heating appliances (usually conventional gas/oil boilers) that have reached the end of life. For these products, heat is produced as was the case for their previous heating technology and electricity is generated as a by-product as an additional benefit.



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Motivations for purchasing FC mCHP

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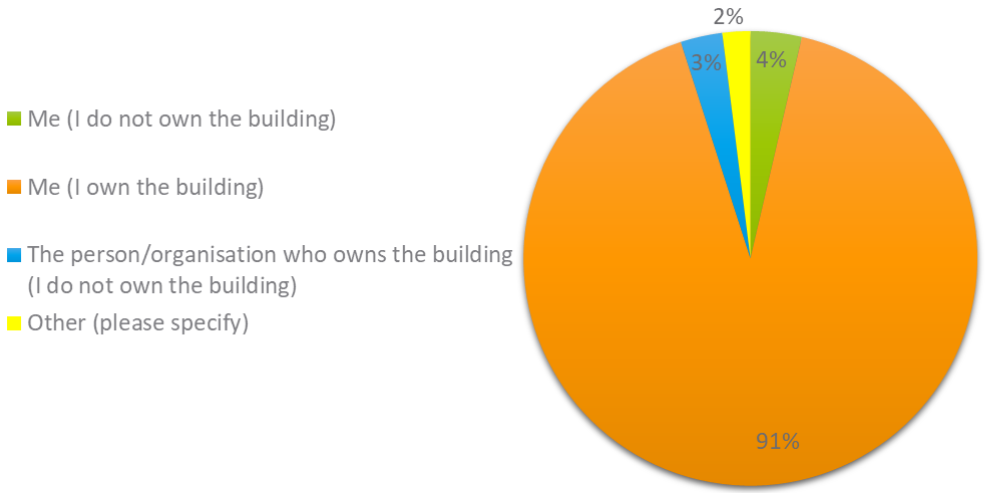
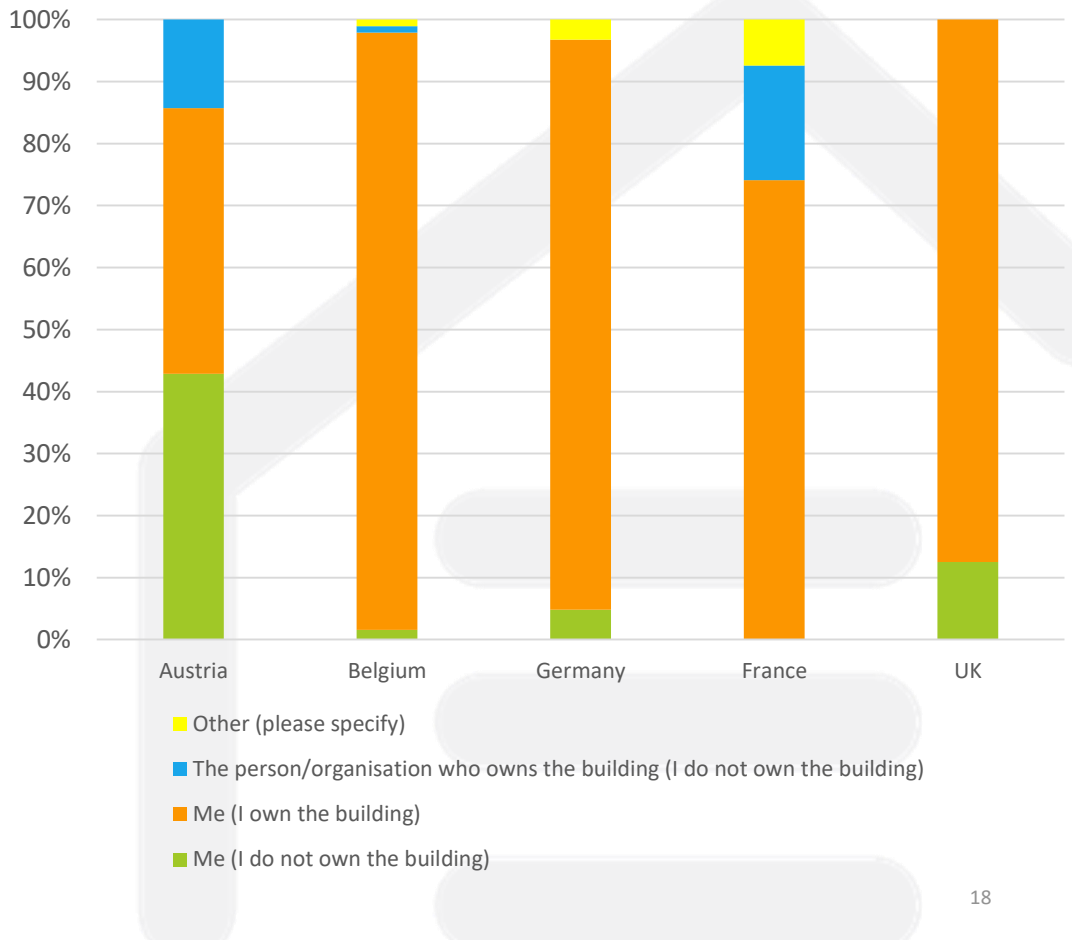
Who decided to purchase the FC mCHP?





- 95% of all customers who responded chose to purchase the FC mCHP themselves : 91% of all customers own the building.
- Only 3% of the respondents have had a FC mCHP installed following a decision from the building owner. This is a result of the affluence of the respondents as set out previously who typically own the building they live in, however, this may also indicate a barrier to implementing the technology into rented housing.

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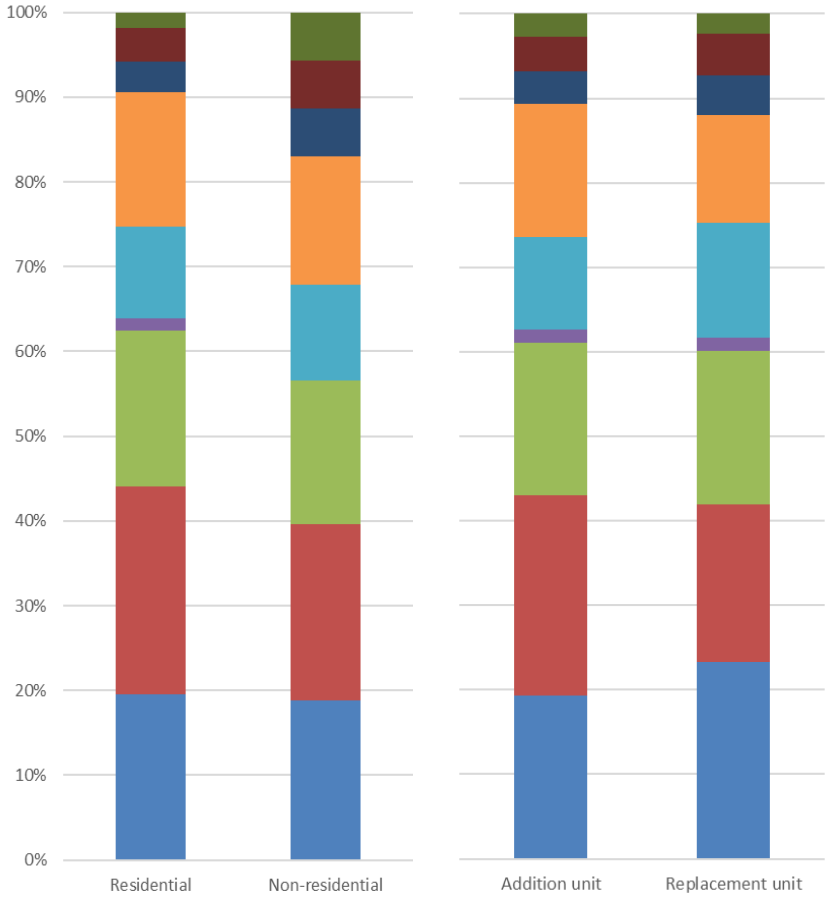
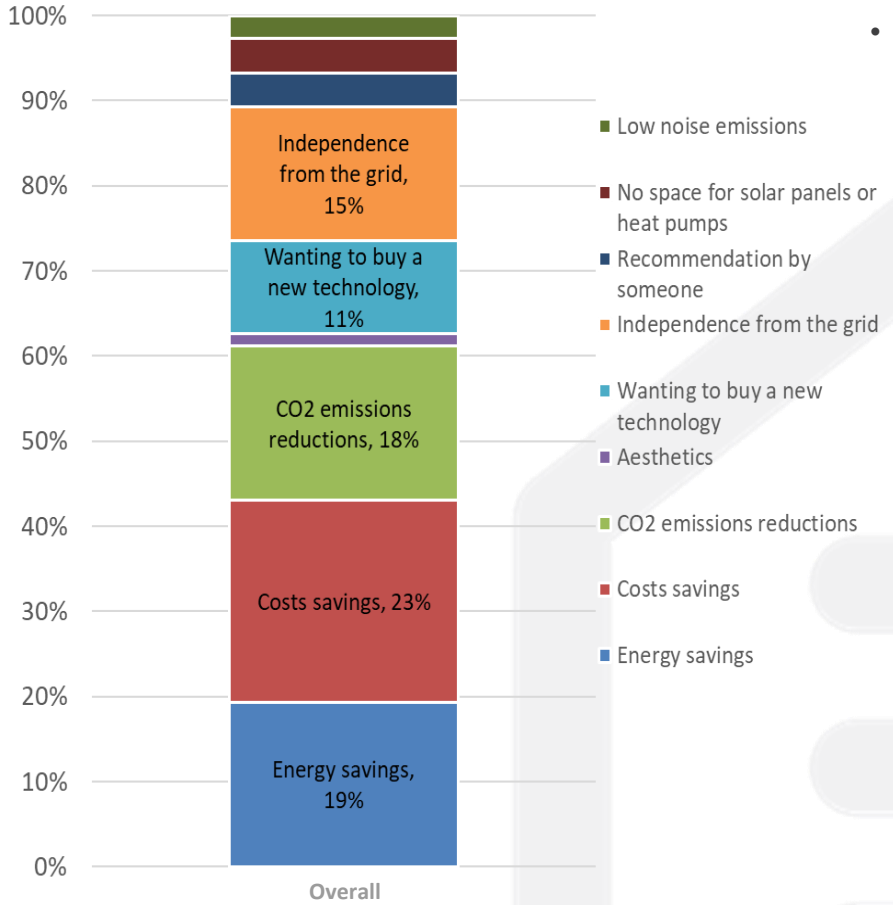
Motivations for purchasing FC mCHP

Overall cost savings is the main motivation for buying of FCmCHP (23%), followed by energy savings (19%) and CO2 emissions reduction (18%).





- Motivation vary slightly depending on the application:
  - Customers in residential applications are mostly concerned by cost savings (25%).
  - Customers in non-residential applications were also convinced by the low noise levels offered and as a result of lack of space for other low carbon heating technologies.
  - Slightly higher interests were reported in having a new technology as well as in energy savings for units installed as a replacement.
  - Slightly higher interests were reported in reaching independence from the grid as well as in costs savings for units installed in addition to current heating system.

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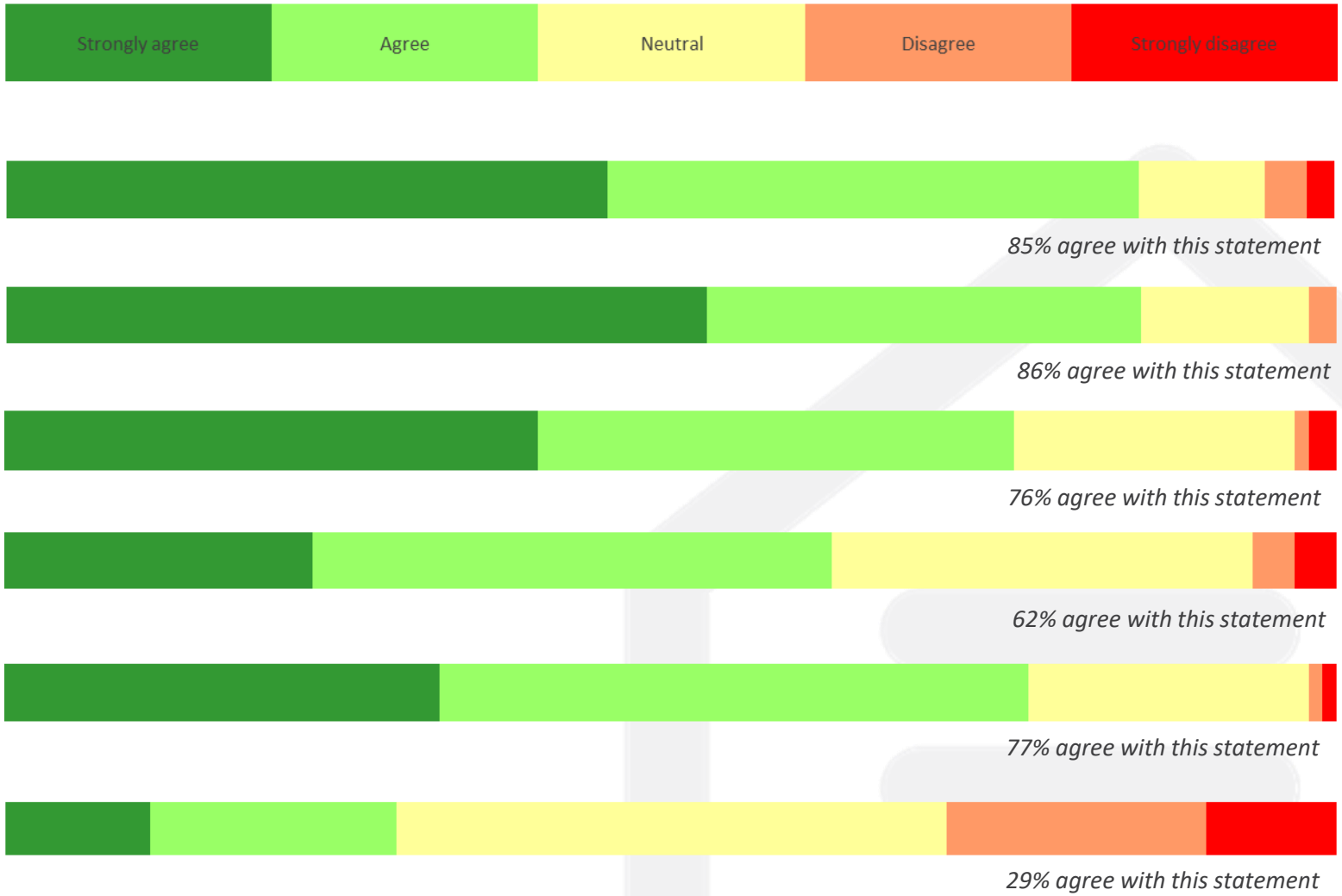
Customer attitudes



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Motivations for purchasing FC mCHP

- The motivations for purchasing FC mCHP are similar for both residential and non-residential customers, with cost savings, energy savings and CO2 emissions reduction the most-cited reasons for purchasing FC mCHP.
- Cost savings appear to be a greater priority for residential customers. The reason for this greater importance could be that the individual has to bear the cost for energy bills and for the mCHP system, rather than an organisation for non-residential customers which may have greater financial flexibility.
- Customers with addition units are more motivated by potential cost savings than customers whose FC mCHP will replace their existing technology, who tend to place more importance on actual energy savings. Often electricity-led systems are installed in addition to existing heating systems to reduce electricity bills in households with high electricity consumption.
- Almost all respondents display positive attitudes towards 'green' climate change agendas as well as towards new technologies, products and brands. This may indicate the general profile of these customers as 'early adopters' of the technology, keen to advance the technology and less averse to the financial and operational risks involved.
- Despite this, not all customers are willing to take on a larger financial risk, with only 29% willing to pay significantly more for an energy system if they knew it was less harmful to the environment. However, 77% would be willing to a little more. This shows that cost remains a significant factor, for this group of early adopters despite the positive attitudes and affluent nature of the majority of the respondents.
- The attitudes and motivations of the customers is likely to have a large impact on how they respond to the technology. Customers may be more lenient to any disadvantages or issues compared to conventional technologies. This will be explored further after responses are collected for the during-operation questionnaires, to show how attitudes are changing with use of the technology.

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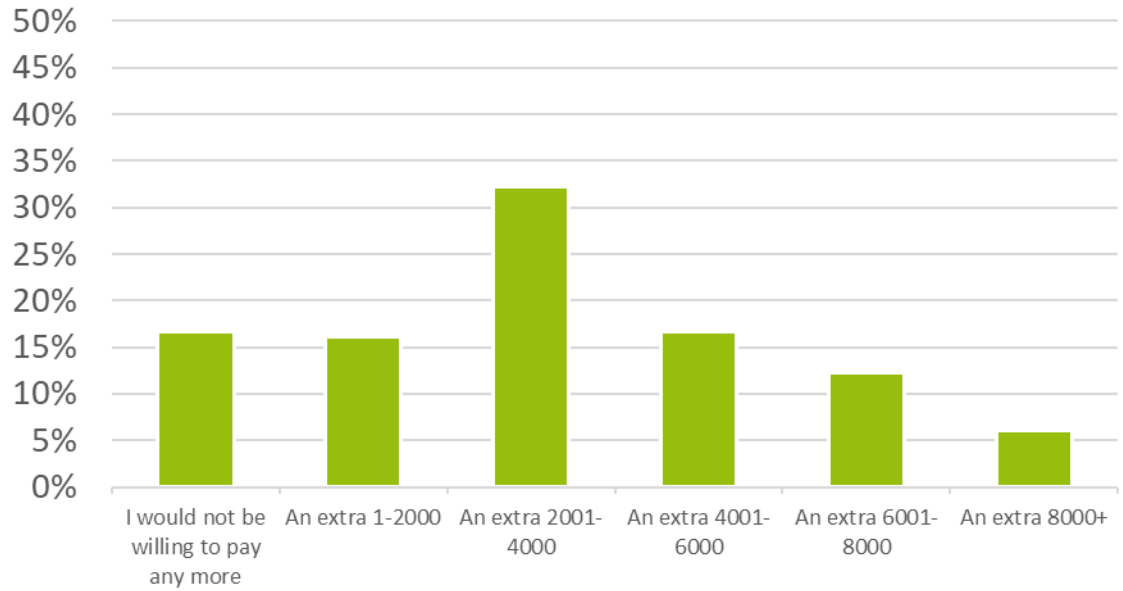
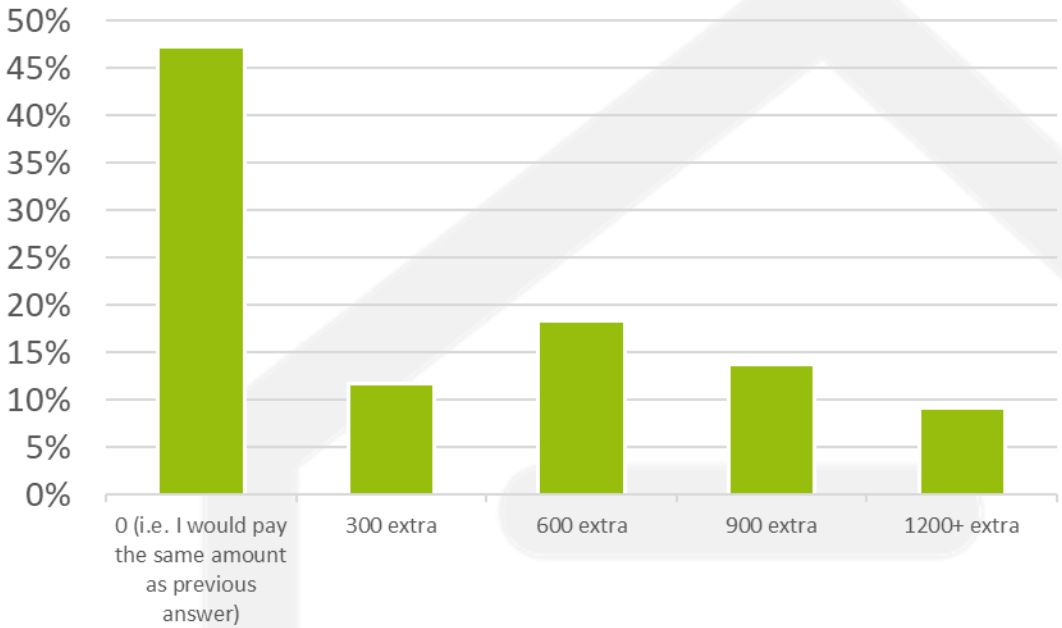
Willingness to pay for FC mCHP

Compared with a conventional boiler, how much more would you be willing to pay for a FC mCHP, assuming you made a total saving of €30/month (€360 a year) and reduced your carbon emissions by 20%.



Based on your answer to the previous question, how much more would you be willing to pay for a FC mCHP that reduced your household carbon emissions by 40% rather than 20%?



- 72% of respondents would be willing to spend more money on a FC mCHP compared to a conventional boiler, assuming cost savings of €30 per month and carbon emissions reductions of 20%, > 50% of them would be willing to pay an additional €2,000 or more and close to 15% an additional €4,000 or more. However, only 50% of customers would be willing to pay any extra to reduce household carbon emissions by 40% rather than 20%. The answers provided by the respondent confirmed the earlier statement on their willingness to pay for an energy system if I knew it was less harmful to the environment (see slide 19).
- This shows that while reduction of carbon emissions are a key motivation for many customers, the cost of the technology still remains a large factor.

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Expectations of FC mCHP

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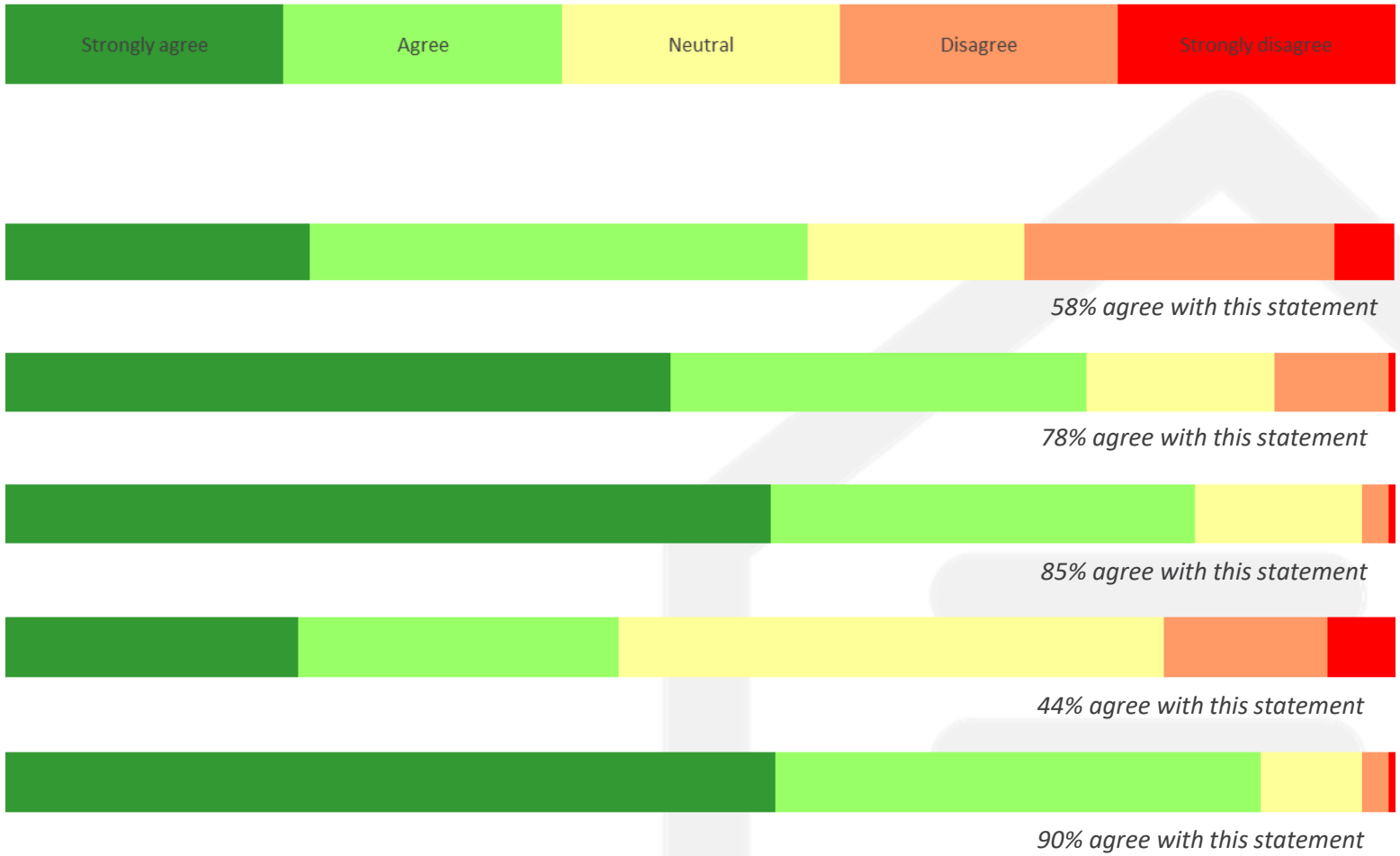
Expectations of FC mCHP

My FC mCHP will…



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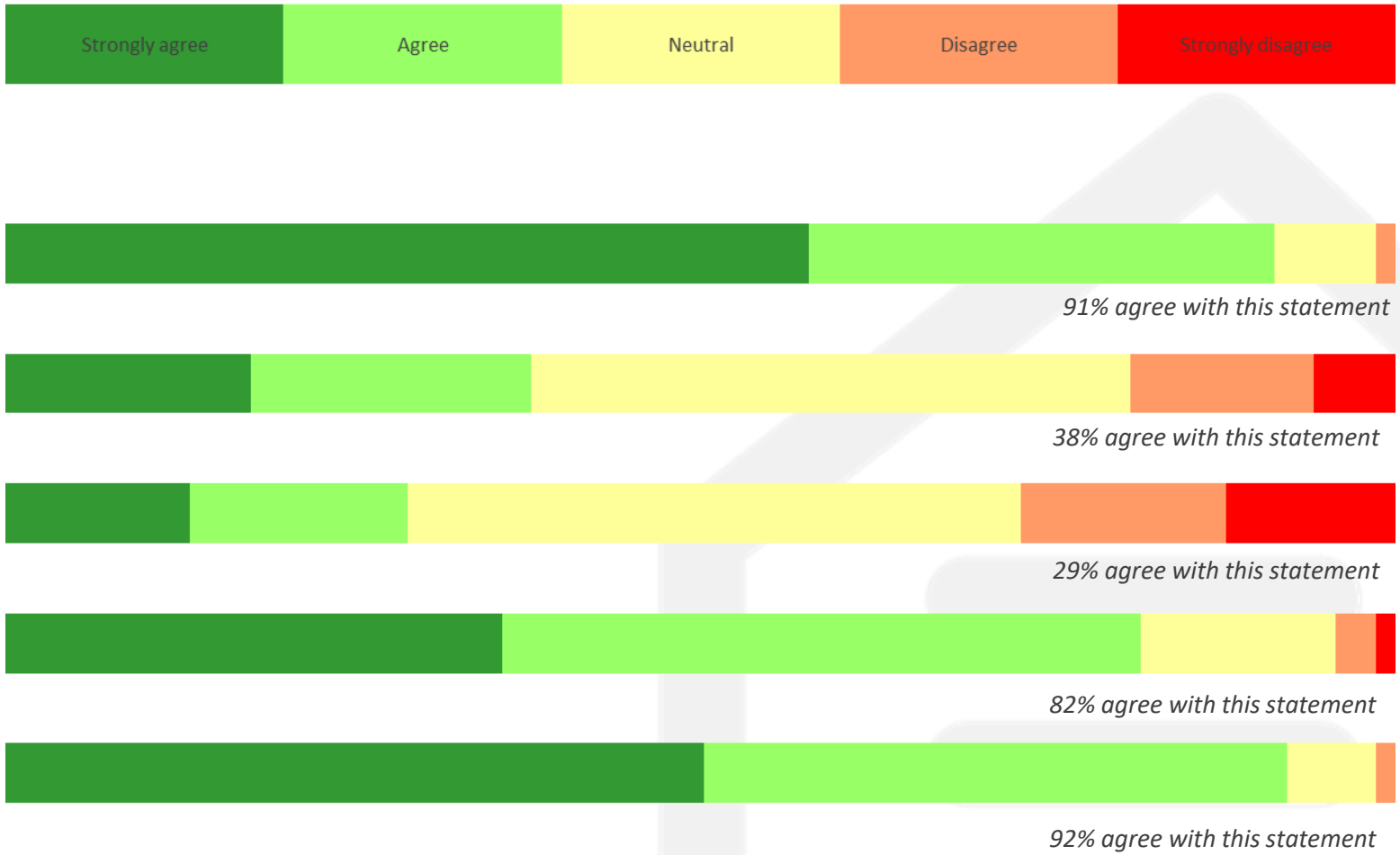
Expectations of FC mCHP

My FC mCHP will…



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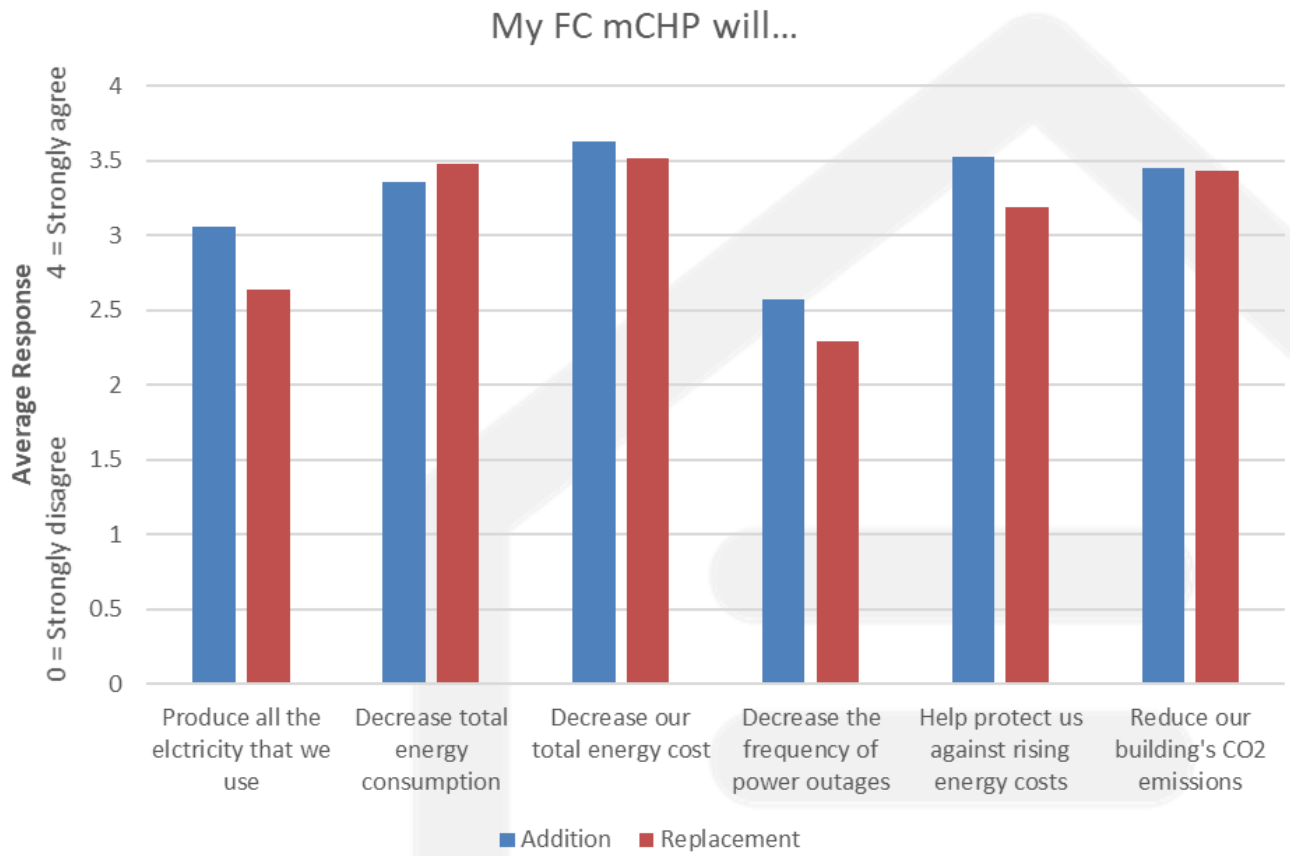
Expectations of FC mCHP

Comparison between units installed as addition to existing heating system and as replacement

- Expectations of FC mCHP are generally high, particularly regarding the reduction of CO2 emissions, energy consumption and energy cost. Many customers do not expect any improvements regarding power outages with their FC mCHP unit compared to their existing heating system, with only 29% of respondents expecting the frequency of power outages to decrease. This does not necessarily imply a distrust in the reliability of the new system, as a customer's existing system may have performed flawlessly in this regard, meaning that improvement may not be possible.
- Customers who have FC mCHP as an addition to their existing system generally have higher expectations than those who have FC mCHP as a replacement to their previous system. This may be as they are not relying solely on the mCHP unit.



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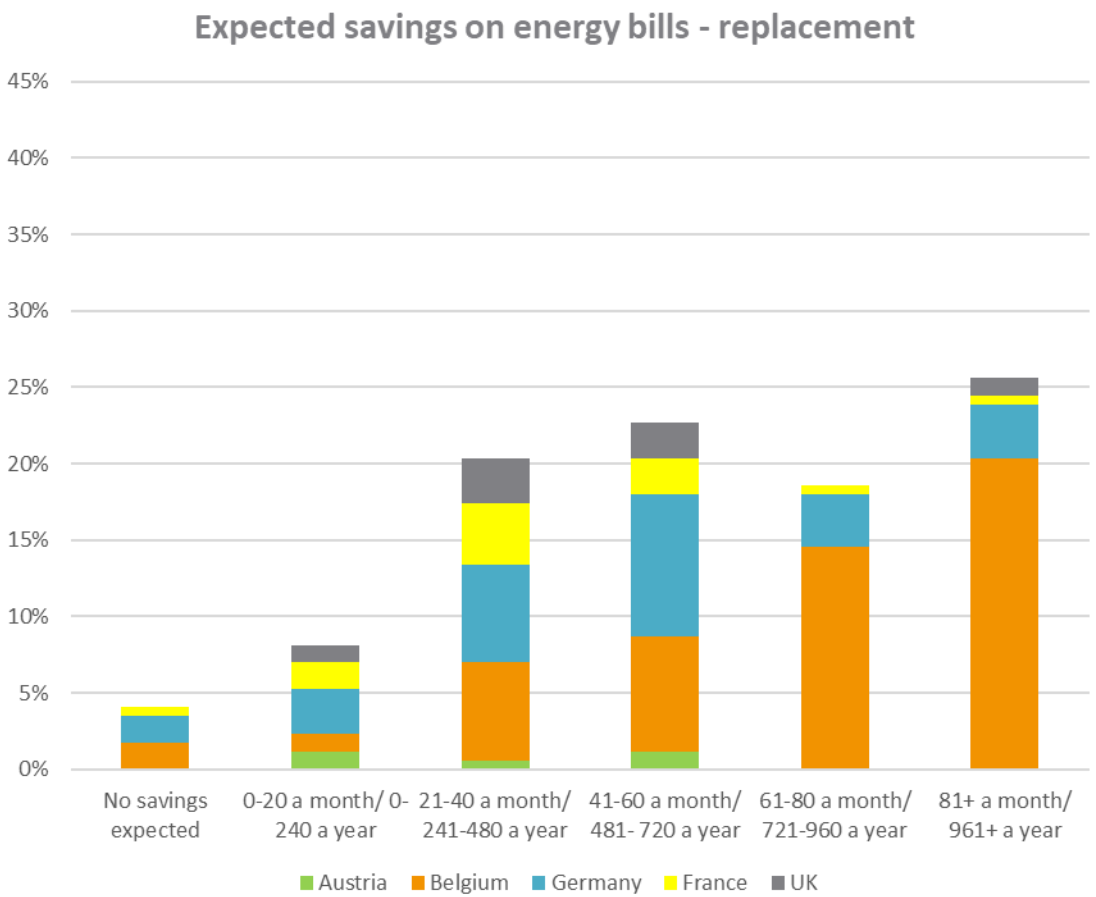
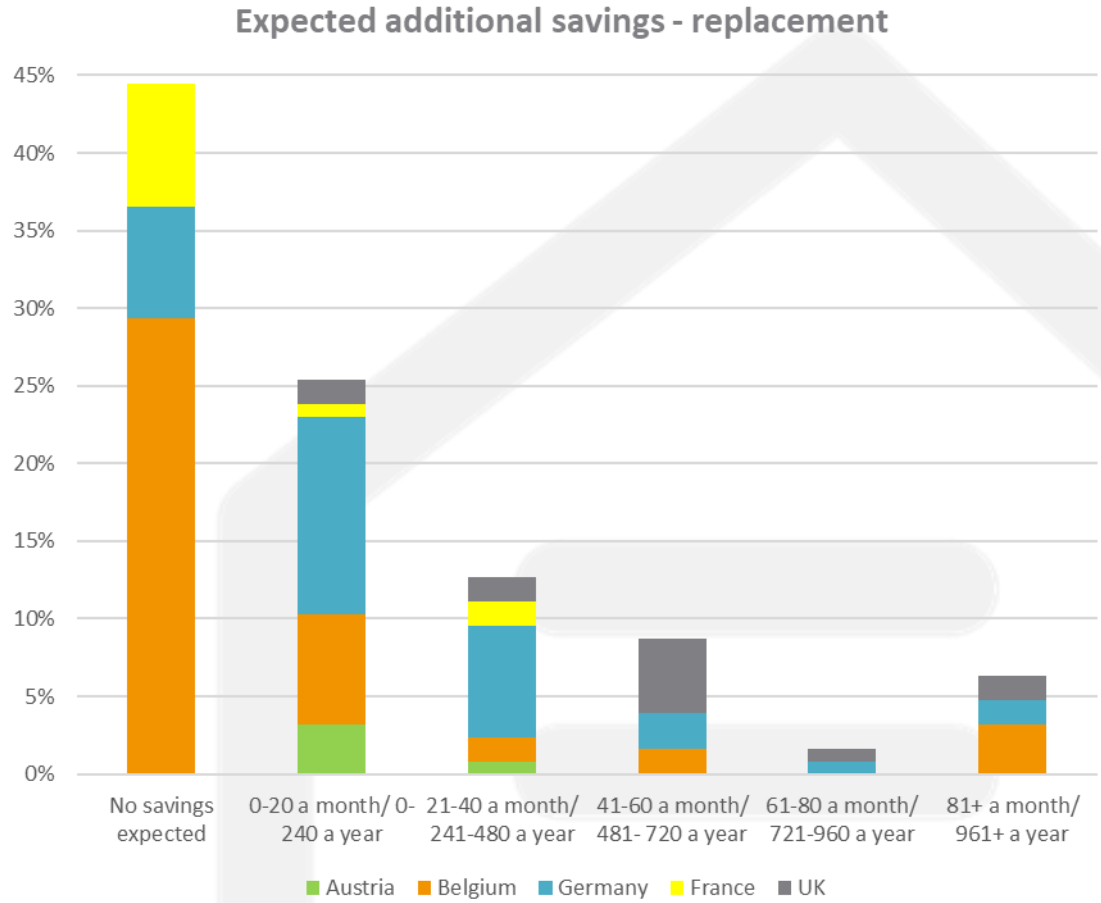
Expected financial benefits of FC mCHP installed as replacement

70% expect savings on their energy bills above €240/year and 32% expect some grant from the Government in addition to this





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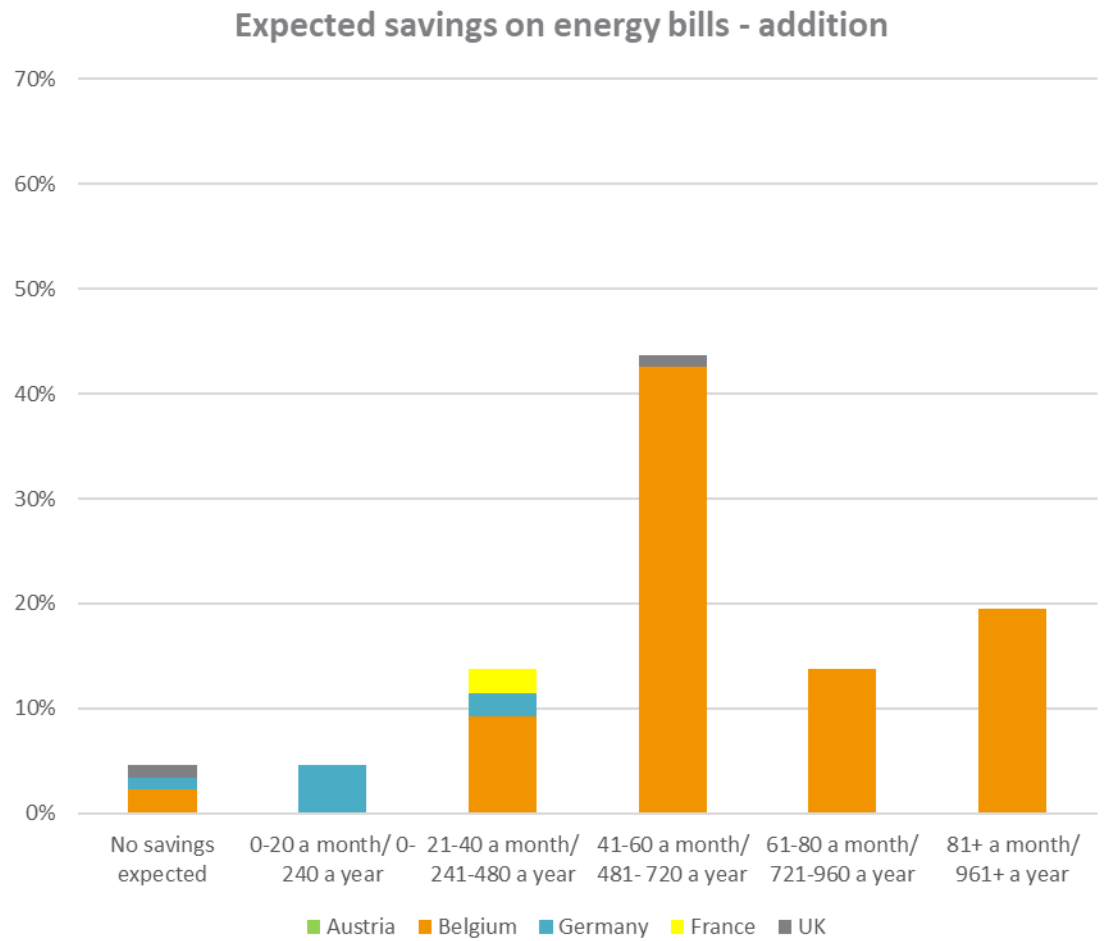
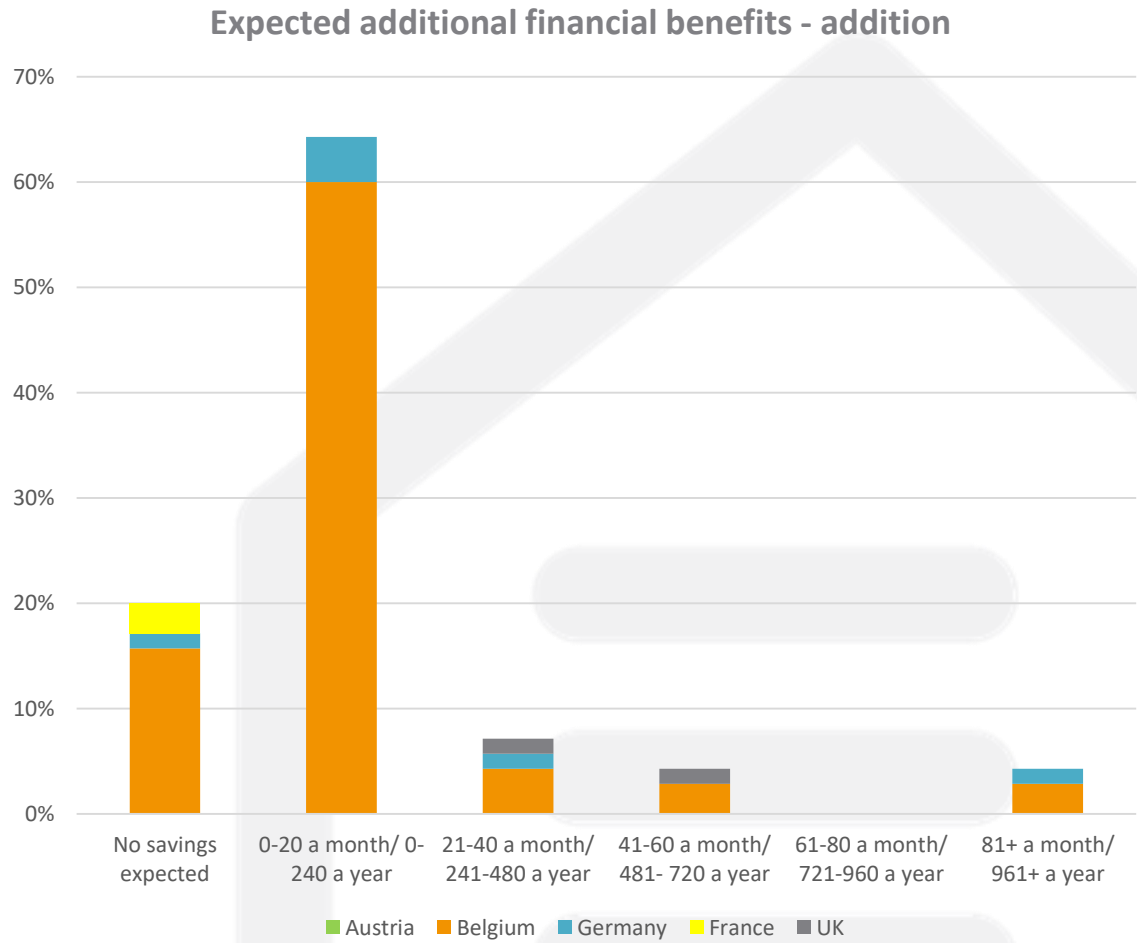
Expected financial benefits of FC mCHP installed as additional heating system

70% expect savings on their energy bills above €1200/year and 58% expect some grant from the Government in addition to this





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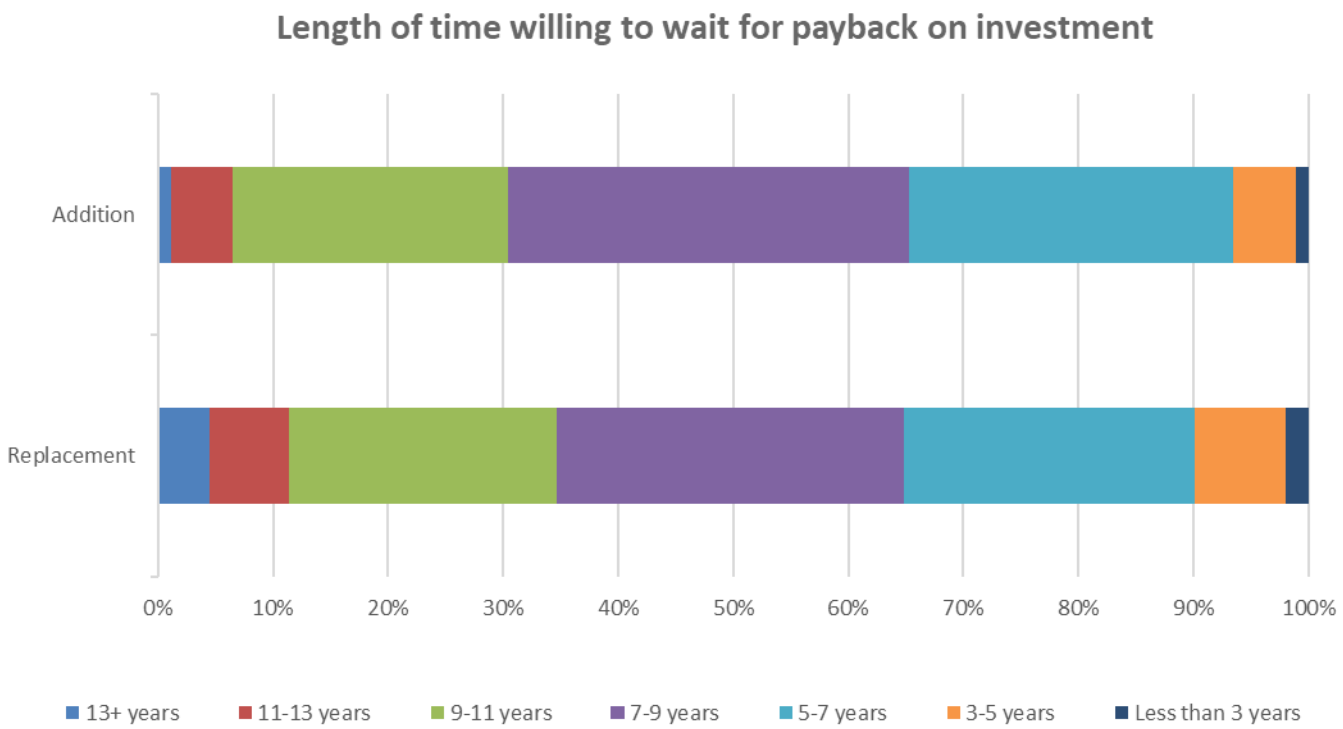
Expected financial benefits of FC mCHP
Payback on investment



- 65% of all respondents would be willing to wait for more than 7 years for payback on the money spent on a FC mCHP through energy savings.
- A higher proportion of replacement customers than addition customers are willing to wait 11 years or more for payback on investment.
- Despite this, there is a larger proportion of customers with replacement units that would only wait less than 5 years than customers with addition units.
- A similar proportion of customers for both categories are expecting payback within 7 years (34% for addition units, 35% for replacement units).

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Expected financial benefits of FC mCHP

Summary

- For replacement units, 77% of respondents expect to save money on their energy bills, and 32% of respondents expect to see further financial benefits in the form of government incentives or subsidies. Most respondents in Belgium and France expect to receive no money from additional government incentives, whereas all UK and most German customers expect additional financial benefits of some sort.
- For addition units, 86% of respondents expect to save money on their energy bills, and 58% expect additional financial benefits as well. 60% of Belgian customers with addition units expect additional financial savings through government incentives, compared to only 15% of Belgian customers with replacement units.
- Customers with addition units generally expect to see larger savings on their energy bills than customers with replacement units.
- The degree of financial support may be a key factor for these customers, for whom cost savings are one of the main motivations for installing FC mCHP.

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Conclusions and next steps

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Main findings

- The general profile of the customer is affluent couples or families living in large detached housing. It appears that these customers are active 'early adopters' who are interested in trialling new technologies in order to reduce carbon emissions.
- Expectations of the FC mCHP units are generally very high, with the majority of customers expecting the system to fully meet their heating and electricity needs while reducing energy consumption and energy costs. The lowest expectations relate to the frequency of malfunctions and power outages, and whilst most customers do not expect improvements in terms of malfunctions and power outages, this has not deterred them from purchasing a FC mCHP.
- Financial benefits are a major motivation behind purchasing FC mCHP, and the majority of customers expect cost savings as a result of the FC mCHP, including money saved through reductions to energy bills, as well as the additional benefit of subsidies and government incentives for a proportion of customers. Indeed, customers who are installing FC mCHP in addition to their existing system are more motivated by cost savings than customers who are replacing their previous system, and actually expect a higher level of financial benefit from their FC mCHP.
- Despite this, most customers are willing to pay more compared to conventional heating systems for FC mCHP systems, and are willing to have payback over 7 years or more as a result of savings on energy bills. They are however expecting savings on their energy bills and some grant from the Government in addition to this.
- Additionally, most customers expect CO2 emissions reductions, and have 'green' attitudes and motivations towards reducing carbon emissions.

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Comparison with preceding projects

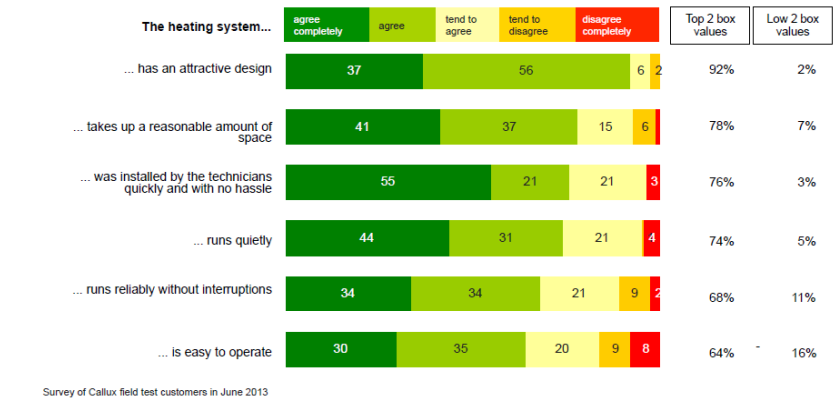
Callux

- The Callux project highlighted positive experiences with the technology during operation. This can be explored in future analysis once similar information is collected.
- Many of the participants in the Callux project appear to be early adopters keen to trial the new technology, reflected in the positive attitudes displayed. This is comparable to the general profile and attitudes of respondents so far during the PACE project.

callux (nip)
Praxistest Brennstoffzelle fürs Eigenheim

Results of the accompanying activities: AP2 market research

Experience with installing and operating the fuel cell heating system



Survey of Callux field test customers in June 2013

ıpanying activities: AP 2 market research

Almost all participants would recommend fuel cell heating as the system of the future.

- **8 out of 10** field test customers took part in the field test because they believe that fuel cell heating is **the system of the future**.
- **9 out of 10** field test customers would **recommend fuel cell heating** to other people living in a similar situation.
- **8 out of 10** field test customers say the heating system runs **quietly**.
- **9 out of 10** field test customers say the system has an **attractive design**.
- **8 out of 10** field test customers say the system was installed by the technicians quickly and with **no hassle**.
- **9 out of 10** field test customers say the **customer service department solves problems quickly and reliably**.
- **9 out 10** field test customers would be **happy to take part in a follow-up test** with a next-generation heating system.

Selected results of the survey of 103 Callux field test customers in May 2012.

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Comparison with preceding projects

Ene.field

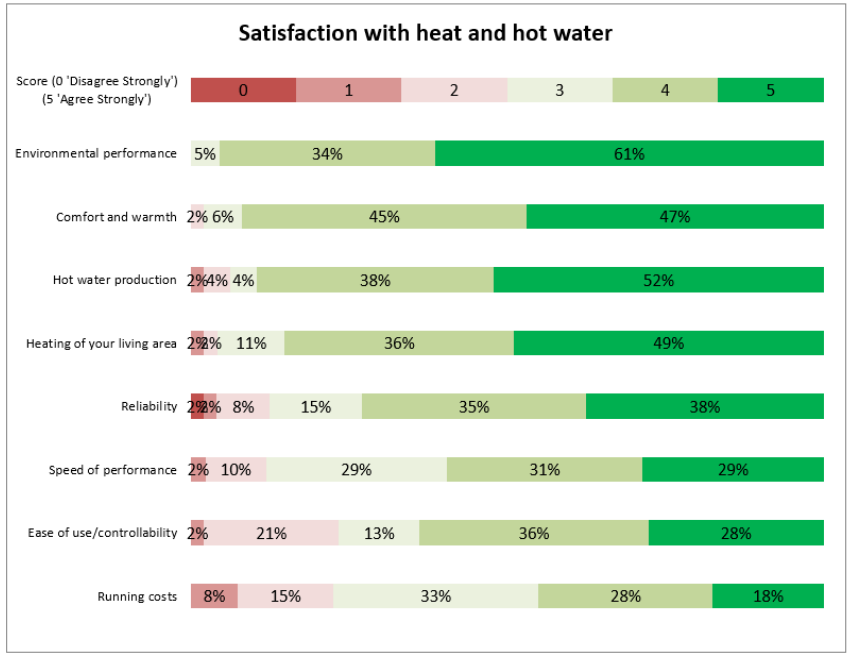
- Ene.field displayed a similar demographic to the general profile of customer displayed in the PACE project, with the majority of respondents having above average household income and living in modern detached houses.
- Experiences with the FC mCHP system in Ene.field were generally positive and customers were generally satisfied. However, customers were least satisfied with running costs. As cost savings are seen to be an important factor for PACE respondents, future iterations of this deliverable could explore the satisfaction in this respect and whether this has progressed over time.

Table 2: Property types

Property type	Proportion of properties
Detached	43%
Non-residential	25%
Semi-detached	17%
Terraced	7%
Flat	5%
Other	4%

Table 6: Household incomes

Income range	Proportion of properties
Up to €30,000	3%
€31,000-€60,000	26%
€61,000-€90,000	31%
€91,000-€120,000	14%
€121,000-€150,000	12%
€151,000-€180,000	3%
Over €180,000	12%



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Next steps

D2.13, D2.15

- The majority of the respondents to date are from Belgium. On the next iteration, a higher completion rate could be expected from other countries, as well as a higher spread of respondents from different countries. This will enable a stronger analysis between different countries to see how this impacts motivations, attitudes and expectations, as well as the actual experiences of using the units.
- A greater number of respondents with non-residential applications could also improve the analysis between residential and non-residential uses.
- Larger data sets will be available, meaning that it will be possible to differentiate between diverse customer 'profiles' outside of the generalised profile set out in this report.
- During operation questionnaires will be launched in 2019 and data from these questionnaires will be available by the time of the next report. This will enable longitudinal analysis to determine how attitudes are changing through time and with use, as well as allowing comparison between expectation and actual experience of the FC mCHP.

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