PACE

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

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Clean Hydrogen Partnership

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Pathway to a Competitive European
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This document (D2.13) is the second of three reports analysing the customer attitudes to fuel cell micro-CHP installations. The analysis is based on data from pre-operation and during operation questionnaires completed by customers of FC mCHP installations. Building upon the first iteration of the report (D2.11), this iteration sets out the general profiles of customers, their motivations for purchasing a mCHP unit, their expectations compared to actual experiences of the technology, and the problems and breakdowns they have experienced.

Motivation

Overall energy savings is the main motivation for buying of FC mCHP (23%), followed by cost savings (20%) and CO_2 emissions reduction (18%).

Motivation varies slightly depending on the application:
- Customers in residential and non-residential applications are mostly concerned by energy savings.
- Customers in residential applications are more concerned with the aesthetics of their FC mCHP than non-residential.

Appraisals

Customers were, on the whole, very satisfied with the performance and features of their FC mCHP unit.

- Nearly 80% of respondents reported having a positive overall experience with their FC mCHP unit.
- No non-residential respondents reported having a negative overall experience with their unit.
- Austria reported the highest number of "very positive" responses, and only Belgium and Germany were the only two countries to report any "very negative" experiences.

Improvements

Respondents were generally positive regarding the improvements needed to FC mCHP units.

- Most parameters were consistently found to be "already sufficient" by the majority of respondents

- The following three parameters were considered most in need of improvements:
  - Cost of repair and maintenance
  - Effort of the installation process
  - Public visibility of FC mCHP

Content of document

Introduction to PACE and D2.13

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Pathway to a Competitive European
Fuel Cell micro-CHP Market

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

10	**> 2,800**	**>500**	**10**	**4**	**€90m**
Partners	Fuel Cell micro-Cogeneration units	Systems per manufacturer	Countries	Countries	Total budget
Representing manufacturers, utilities & research community	To be deployed across Europe between 2016-2022	Established production capacity per manufacturer	Where the units will be installed	Selected for policy & market development (Belgium, Italy, Netherlands and UK)	Including €33.9m Horizon 2020 funding via the Clean Hydrogen Partnership (previously FCH JU)
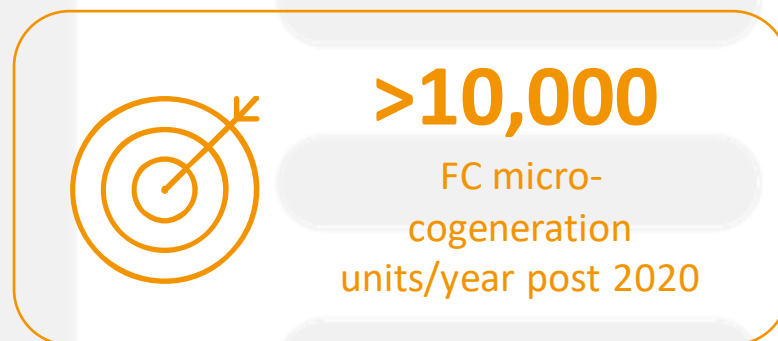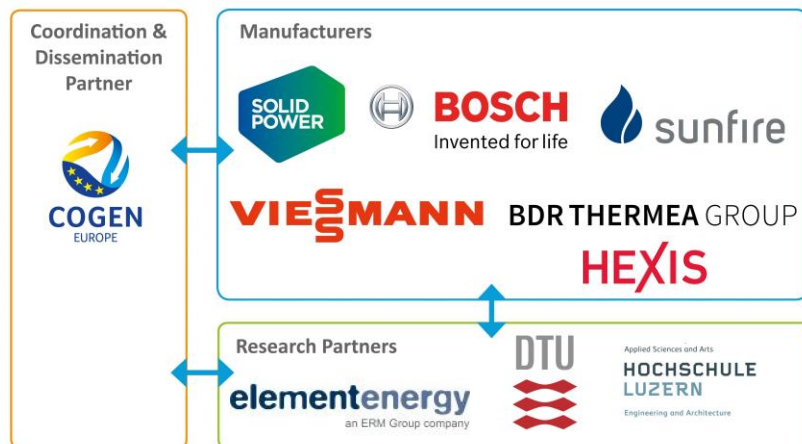
Field trial + installer training + targeted market & policy development activities

Field trial + local installer training

Coordination & Dissemination Partner
COGEN EUROPE

Manufacturers
SOLID POWER · BOSCH Invented for life · sunfire
VIESSMANN · BDR THERMEA GROUP
HEXIS

Research Partners
elementenergy an ERM Group company · DTU · HOCHSCHULE LUZERN Applied Sciences and Arts Engineering and Architecture

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

PACE Work Package 2 – 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.

- Surveys are collected from customers at 3 times, both in pre- and during-operation (typically 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.

- Fewer responses are expected for the during-operation questionaries as fewer participants are eligible to respond to these at the time of writing.

D2.13 - Report 2 on customer attitudes to mCHP installations

- D2.13 is the second of three reports analysing the customer attitudes to fuel cell micro-CHP installations.

- Since the submission of the first report, the 'during-operation' questionnaires have been launched, allowing customers to provide feedback after 12 months of operation and 24 months of operation. This enables an assessment of how attitudes have changed over time, comparison between expectations for FC mCHP against actual experiences, and details on operational issues and maintenance of the units.

- As of January 2022, 911 pre-operation questionnaires have been completed out of 1,775* customers with units commissioned, representing a 51% completion rate for the overall trial.

- In addition, 422 during-operation questionnaires have been completed out of 1,452 customers* with units in operation for over 1 year, representing a 29% completion rate for the overall trial.

- 1,020 additional questionnaire responses have been included in the analysis compared to Report 1, strengthening the quality of analysis possible in this report.

2021-nov

Location of installed PACE units as of November 2021

*Note that this figure is adjusted to account for customers with multiple cascaded units in a single building.

Customer and building characteristics

Customer characteristics

The majority of the respondents having completed the questionnaires were located in Germany (46%) or Belgium (45%). Viessmann is the most represented make of FC mCHP in these results.

Which make of FC mCHP do you have installed in your building?

- SenerTec/Remeha 8%
- Bosch 8%
- SOLIDpower 8%
- Viessmann 76%
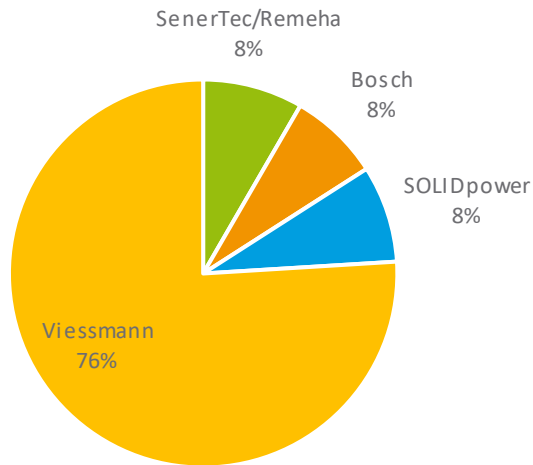
SOLIDpower units that have been installed by Bosch are included in Bosch figures.

*Other includes: Czech Republic, Denmark, Italy, Luxembourg, Netherlands, Poland, Slovakia, Slovenia and Switzerland

Respondents by country

- France 4%
- UK 3%
- Other 1%
- Austria 1%
- Belgium 45%
- Germany 46%

Legend: Austria | Belgium | Germany | France | UK | Other

Surveys: Pre-operation survey, During operation survey

Customer characteristics

Total annual household income
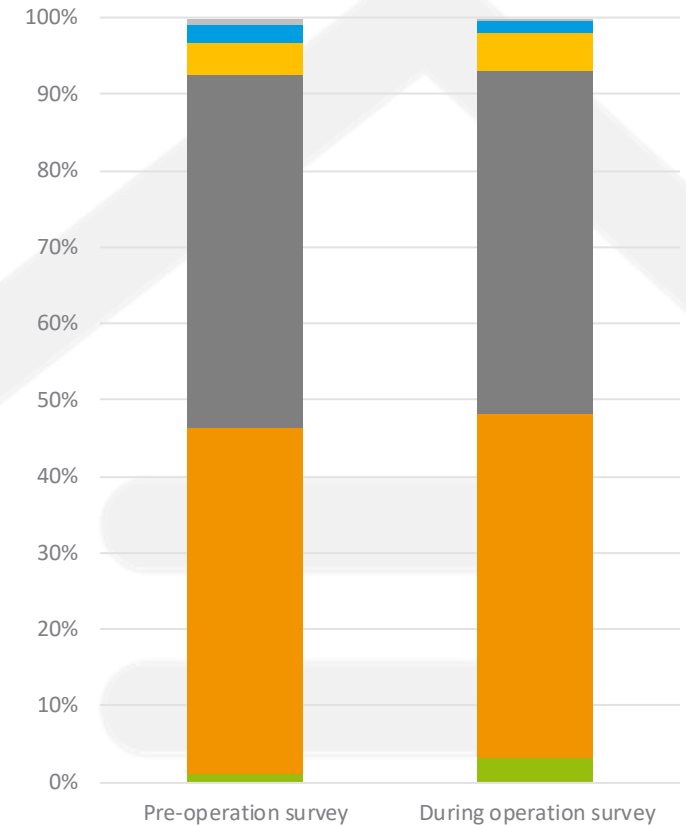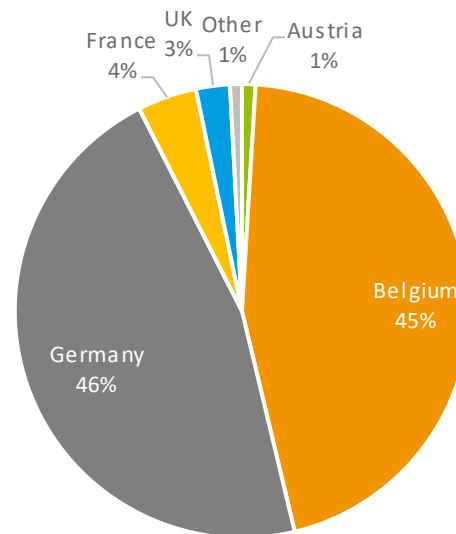
The majority of customers are likely to be couples and families, as 66% of respondents in residential buildings had more than 2 people in their household.

Number of residents

- 1 person 5%
- 2 people 29%
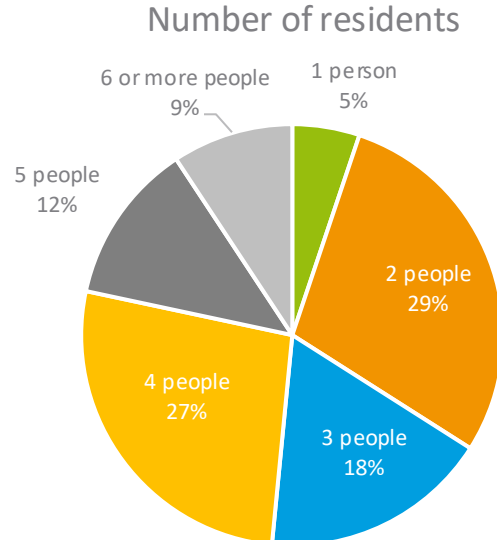- 3 people 18%
- 4 people 27%
- 5 people 12%
- 6 or more people 9%

Income range	%
0-30 000	4%
31 000-60 000	20%
61 000-90 000	19%
91 000-120 000	13%
121 000-150 000	7%
151 000-180 000	4%
181 000+	5%
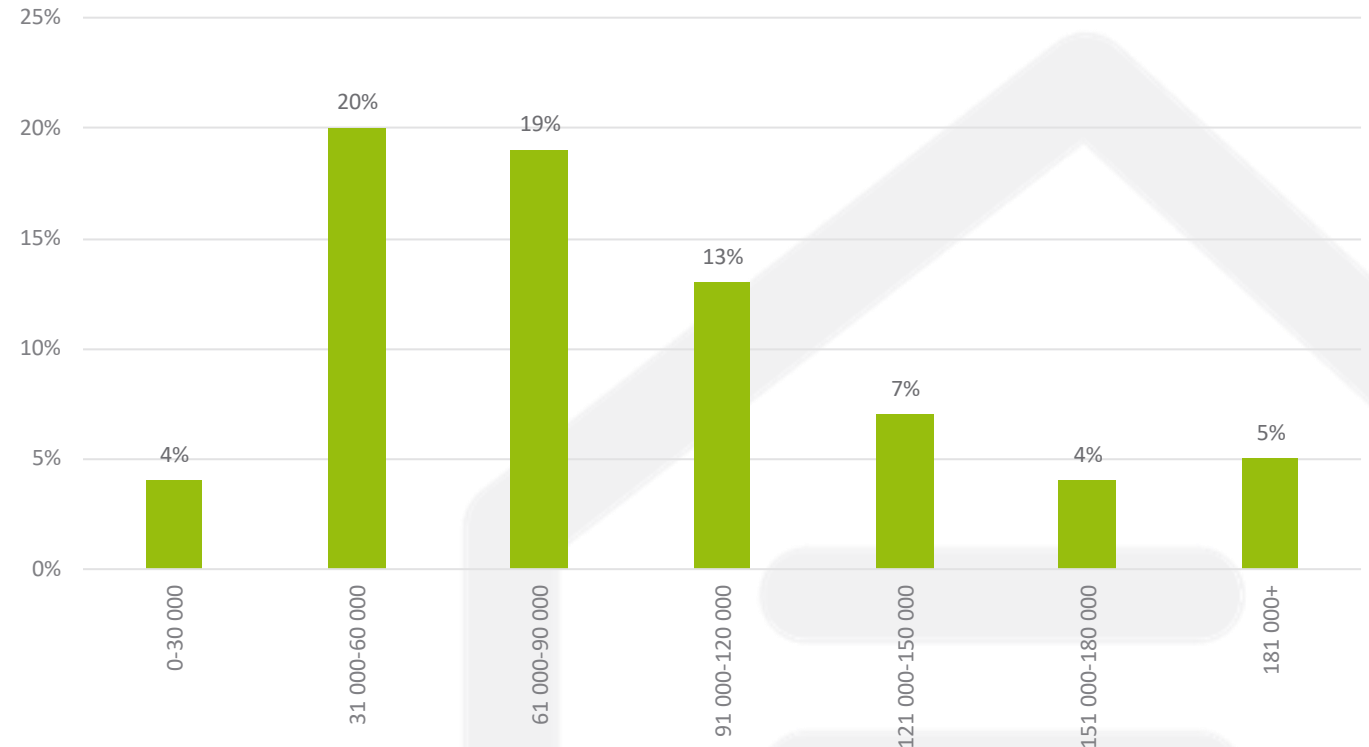
At least 95% of the respondents have an income above the European average income and generally above the average income of their respective countries (median EU household income is € 16,943 and median income for Belgium, France, Germany and the UK range from € 27,500 – € 31,000).

23/05/2022

Customer characteristics

- The vast majority of respondents are based in Germany (46%) and Belgium (45%).

- Respondents generally have higher than the national average household income. 96% of respondents have a household income (before tax and social security) greater than € 30,000 (in Belgium the national average is € 27,761). 29% of respondents have a household income greater than € 90,000.
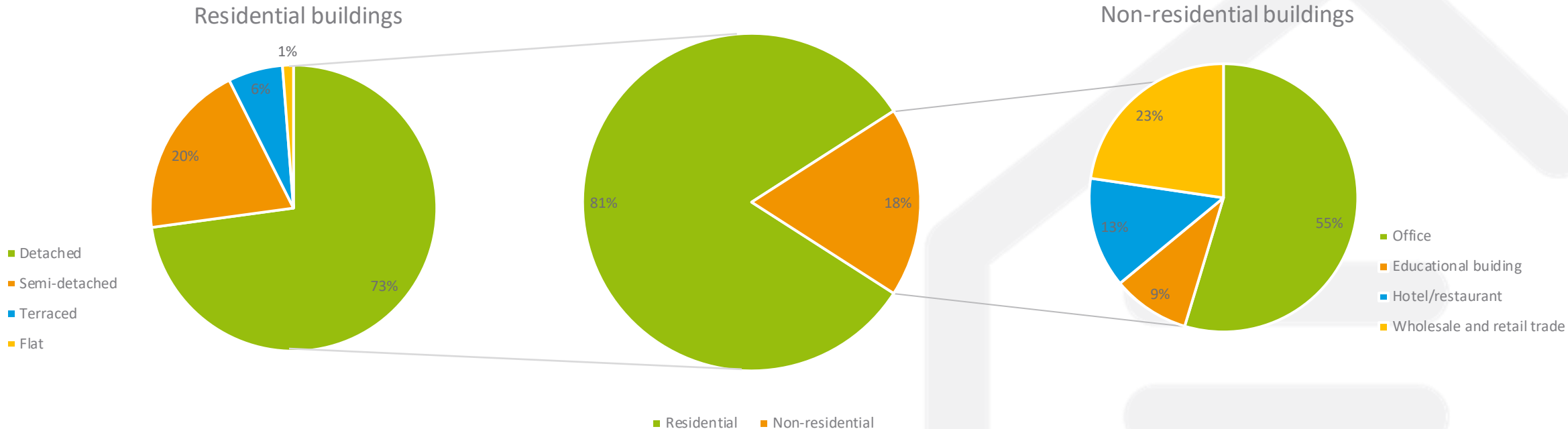
- The majority of customers are therefore likely to be couples and families with disposable income. Indeed, 66% of respondents in residential buildings had more than 2 people in their household.

- 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.

- This profile would be expected for a trial of this nature, with a new technology that is not yet widely used. The process of adoption over time of new technologies generally follows the rules of the technology adoption life cycle, in which the first group of people to use a new product are the "innovators", followed by "early adopters". In the early stages of a new technology such as FC mCHP it is therefore expected that the primary customers at this point will be affluent early adopters.

Building characteristics

FCmCHPs have in majority been installed in residential buildings (81%)

- Detached housing is the most common residential building type selected by respondents (73%)
- Office buildings are the most common non-residential building type selected by respondents (55%)

Residential buildings

- Detached
- Semi-detached
- Terraced
- Flat

1%
6%
20%
73%

81%   18%

- Residential   - Non-residential

Non-residential buildings

23%
13%
9%
55%

- Office
- Educational buiding
- Hotel/restaurant
- Wholesale and retail trade

Building Characteristics

Floor space of building (m²)
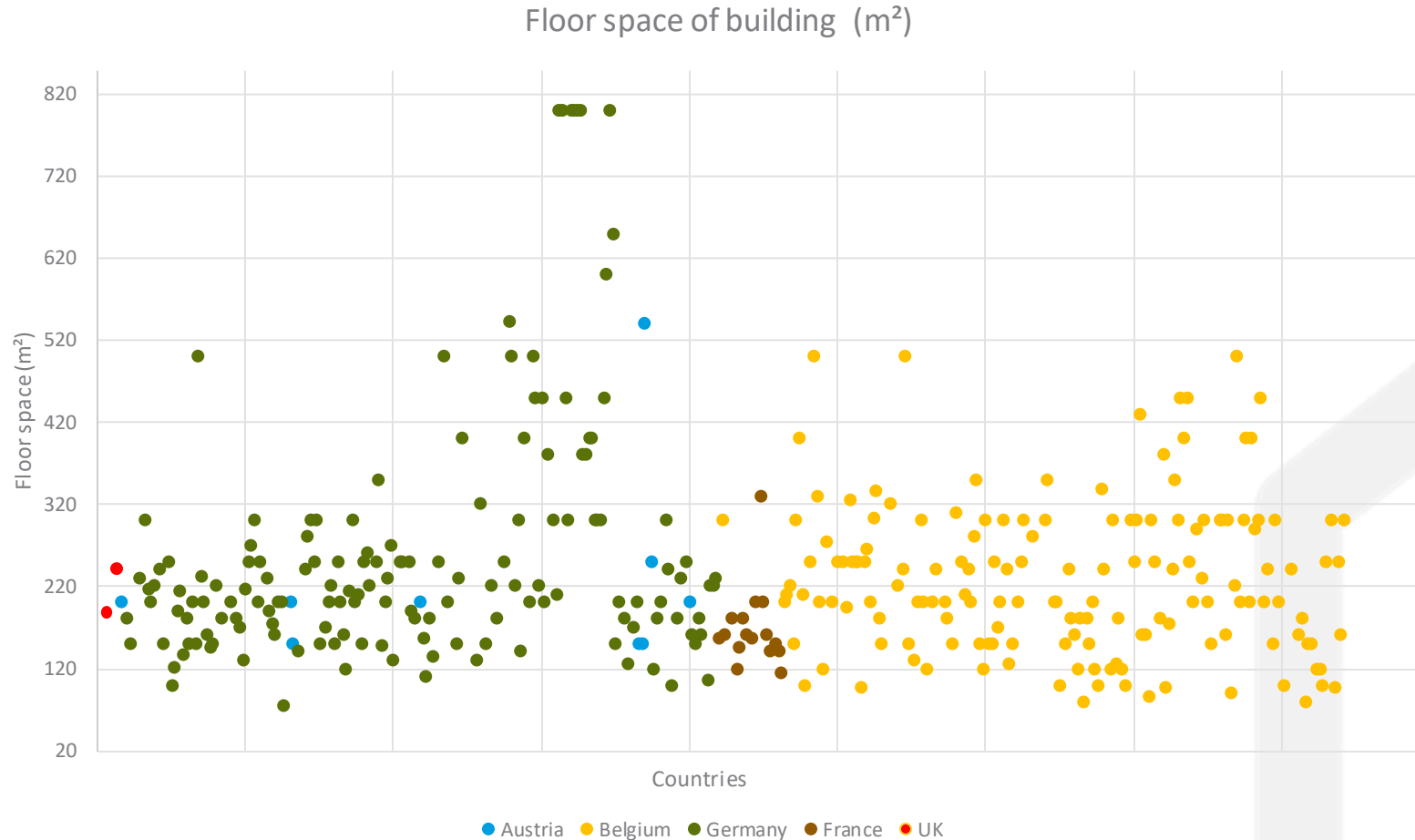
The average floor space supplied energy by respondents' FC mCHP is 257m².

The national average house size are:
- Austria: 91m²
- Belgium: 86m²
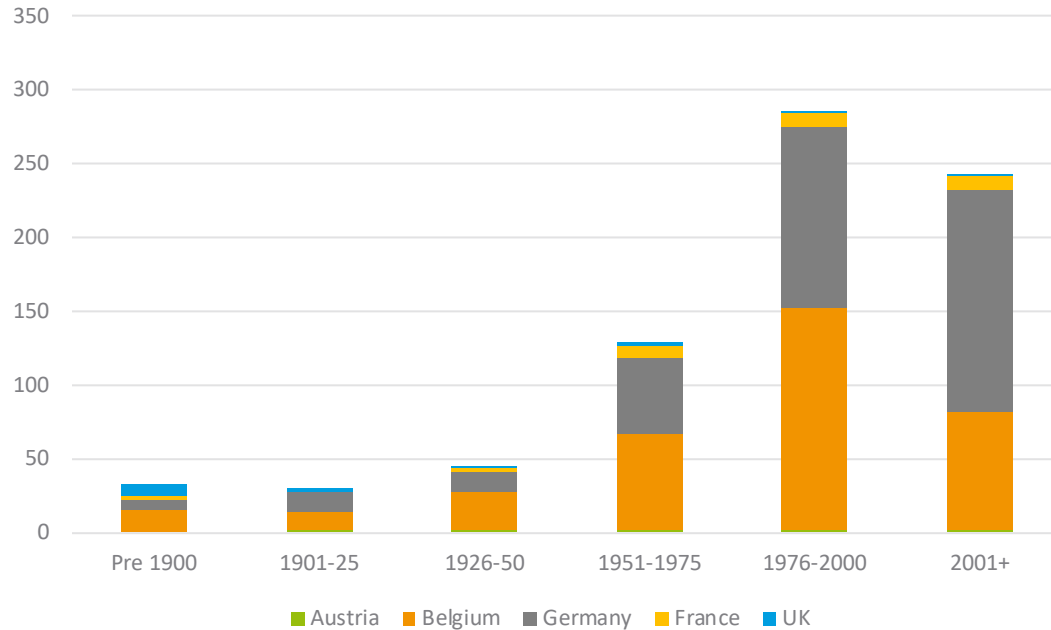- Germany: 87m²
- France: 88m²
- UK: 76m²

The larger areas outliers are expected to be from non-residential buildings.

Age of building

Energy Performance Certificate (EPC) rating of building
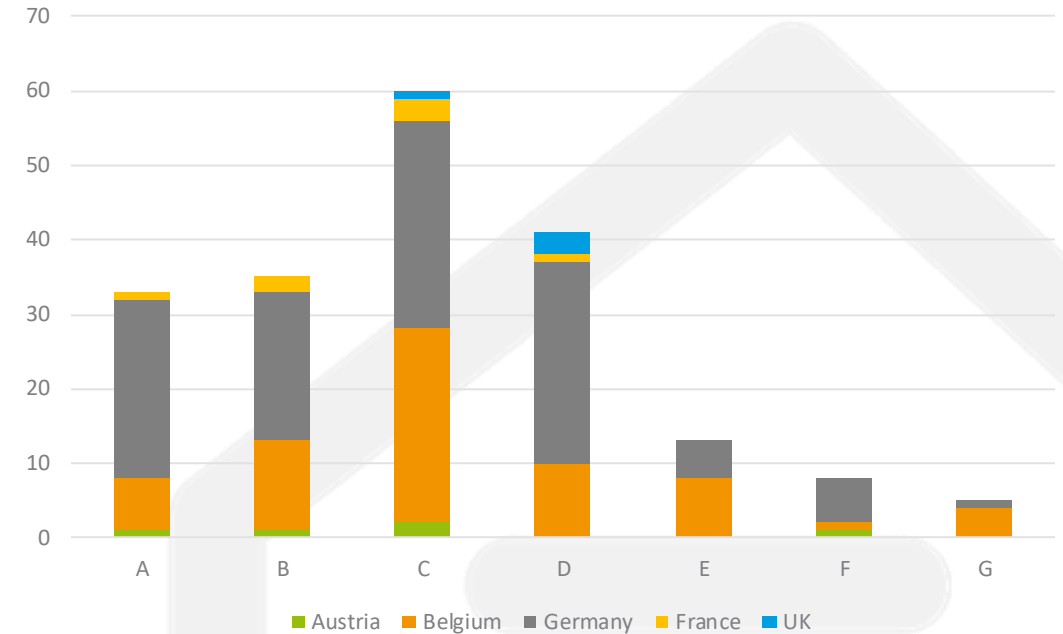
- Most FC mCHP units are being commissioned in relatively modern buildings built within the last 100 years. However, this varies with country – for example, the majority of units in the UK are in buildings built pre-1900.

- Most FC mCHP units are being commissioned in buildings with a relatively high Energy Performance Certificate (EPC) ratings, and therefore likely in well-insulated buildings with high levels of energy efficiency. This fits with the profile of an affluent customer who considers themselves to care about "being green". For example, the average EPC rating for residential buildings in France and the UK is D.
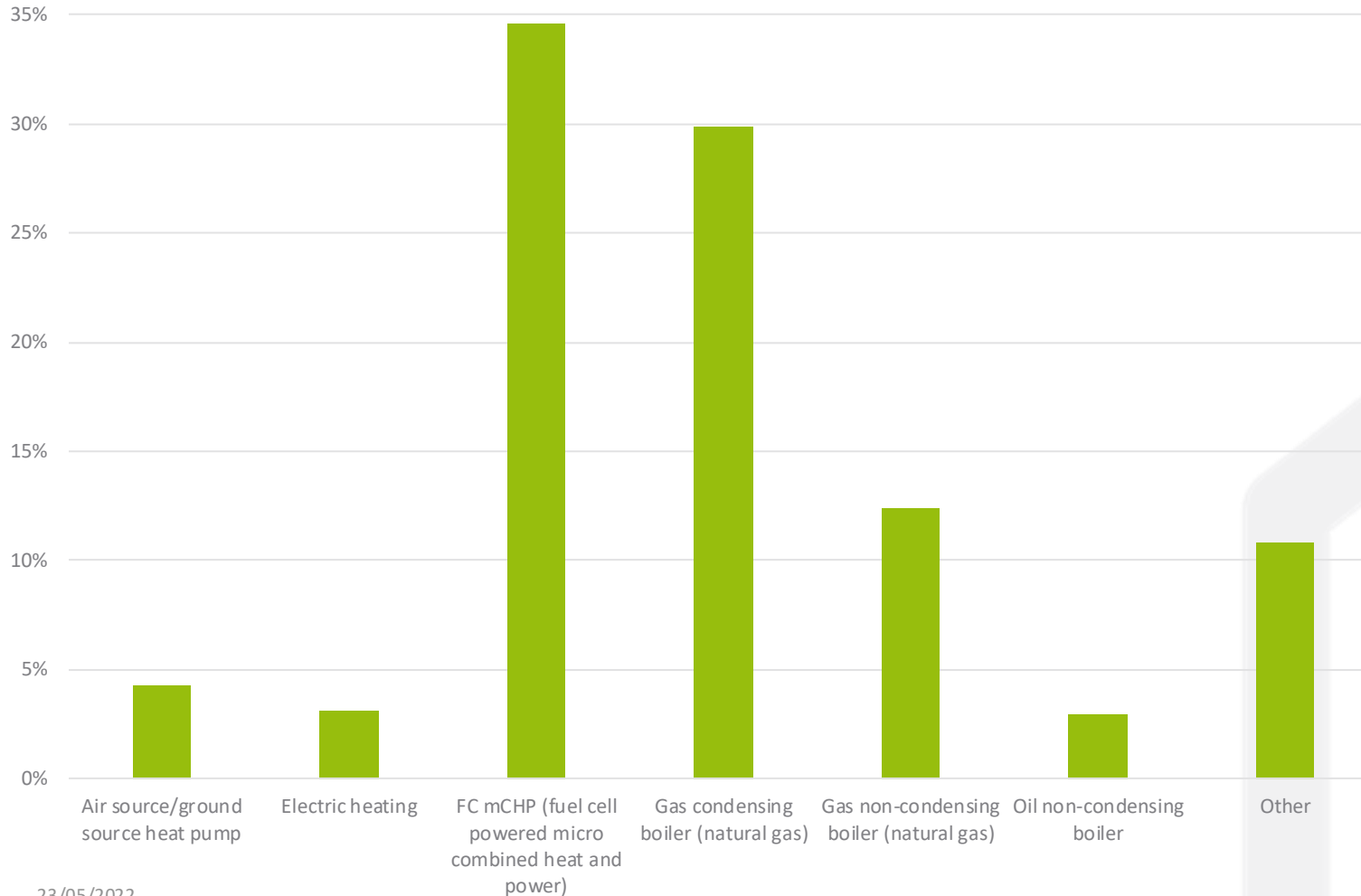
Building Characteristics

Primary Heating System

35% of all respondents use their FC mCHP as their primary heating system.

The second most used primary heating system from respondents is a gas condensing boiler (30%) and the least is biomass/wood burners (0%).

*Other includes gas boiler, oil condensing burner and biomass

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Summary

- 81% of the respondents have had their FC mCHP unit installed in a residential building. The 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. 73% 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. Of the 18% of respondents whose FC mCHP is located in a non-residential building, the most common building type was an office building (55%).

- The average size of the building (measured as the total floor space of the area the FC mCHP supplies energy to) is 257m². For context, the national average house size in Belgium is 86m². The large number of offices being supplied by the units is likely to have impacted this and increased the average area.

- 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.

- The EPC rating for customers is predominately C or above (60%), which is a relatively high rating and therefore reflects a well-insulated energy-efficient building. For context, the average EPC rating for residential buildings in France and the UK is D. This therefore fits the profile of a customer who considers themselves to be "green".

Motivations for purchasing FC mCHP

Who decided to purchase the FC mCHP?
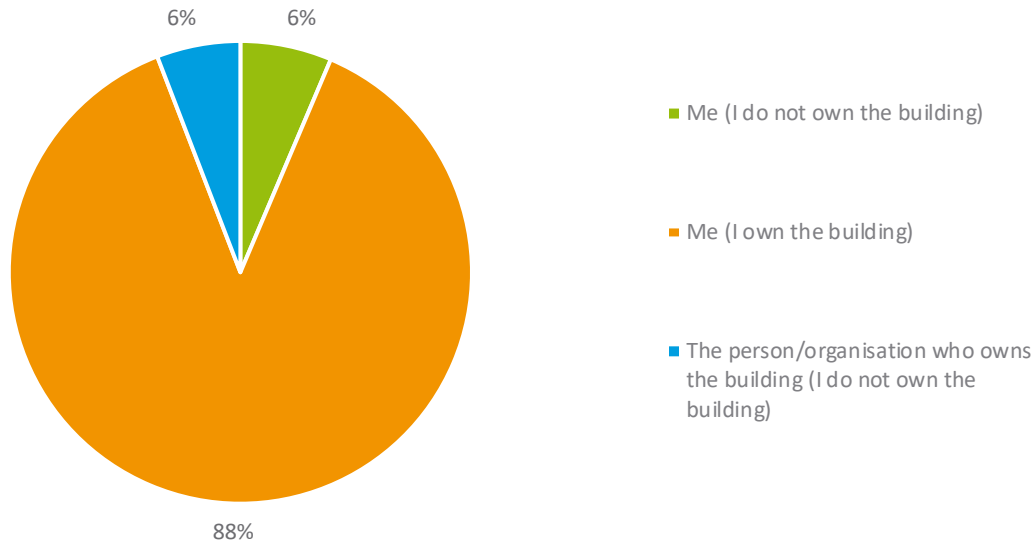
- 94% of all customers who responded chose to purchase the FC mCHP themselves.
- 6% of the respondents have had a FC mCHP installed following a decision from the building owner.
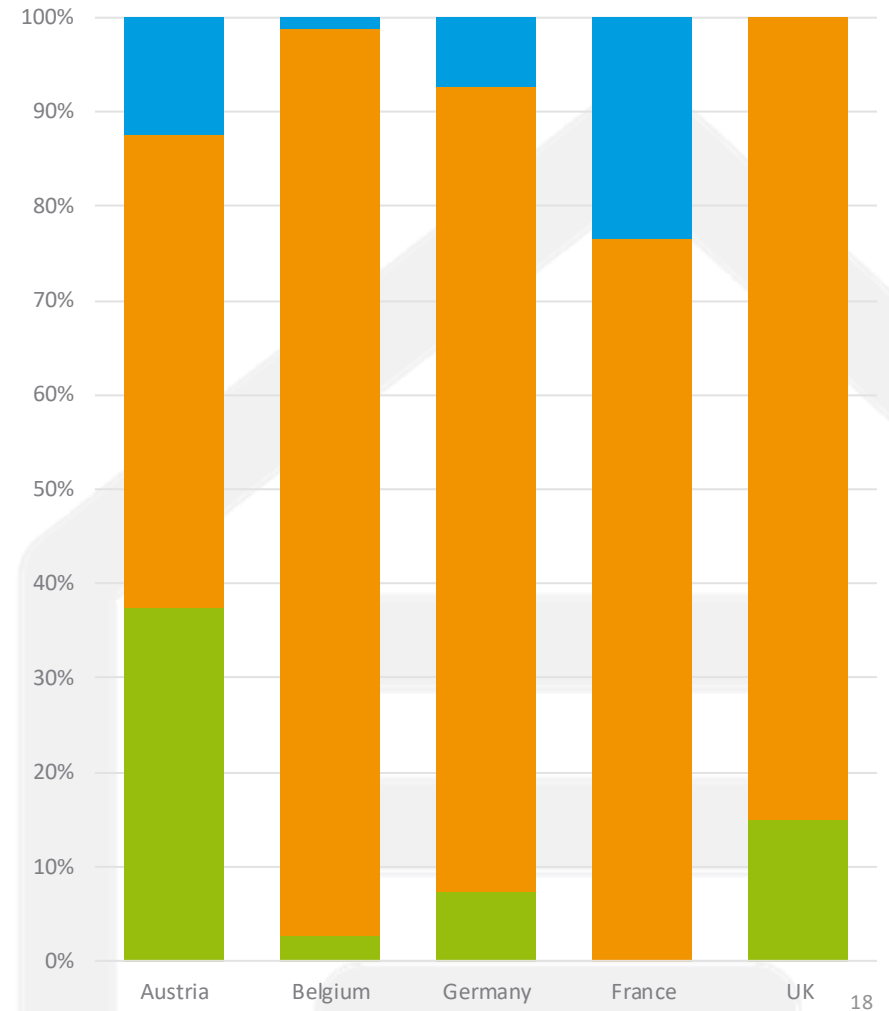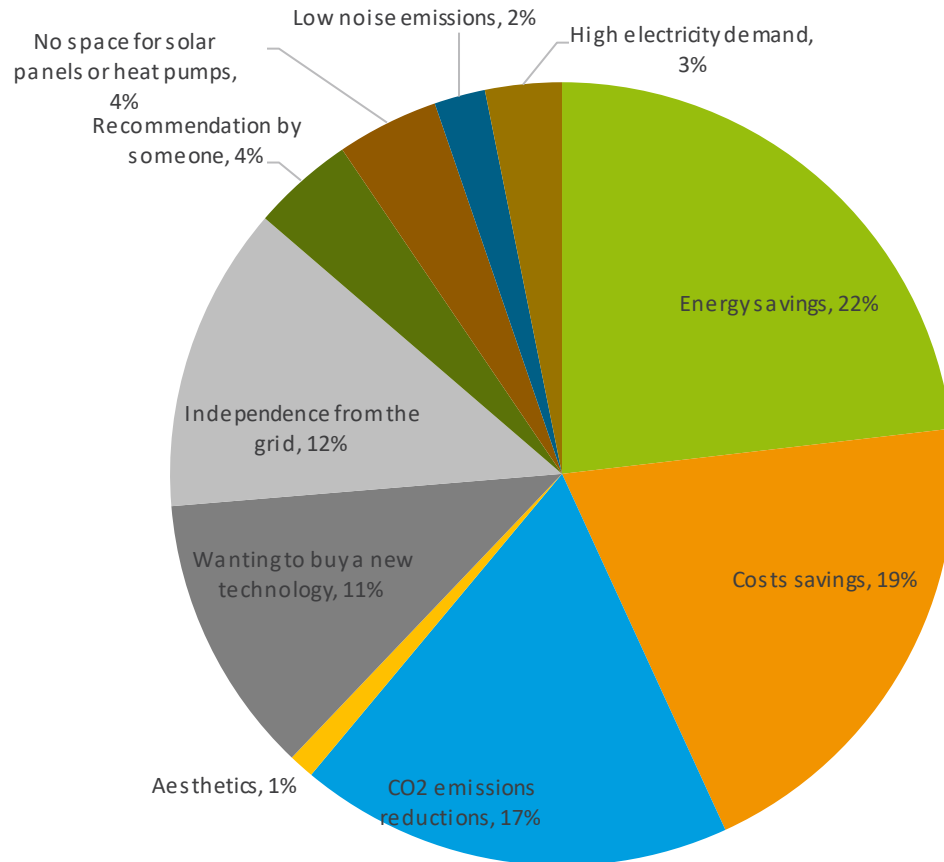
Legend:
- Me (I do not own the building)
- Me (I own the building)
- The person/organisation who owns the building (I do not own the building)

Pie chart: 6%, 6%, 88%

Bar chart countries: Austria, Belgium, Germany, France, UK

Motivations for purchasing FC mCHP

Pie chart: "Motivations for purchasing FC mCHP"
- Energy savings, 22%
- Costs savings, 19%
- CO2 emissions reductions, 17%
- Aesthetics, 1%
- Wanting to buy a new technology, 11%
- Independence from the grid, 12%
- No space for solar panels or heat pumps, 4%
- Recommendation by someone, 4%
- Low noise emissions, 2%
- High electricity demand, 3%

- Overall energy savings is the main motivation for buying of FC mCHP (23%), followed by cost savings (20%) and CO_2 emissions reduction (18%).

- Motivation varies slightly depending on the application:
  - Customers in both residential and non-residential applications are mostly concerned by energy savings.
  - Customers in residential applications are more concerned with the aesthetics of their FC mCHP than non-residential.

Customer attitudes

Legend: Strongly agree | Agree | Neutral | Disagree | Strongly disagree
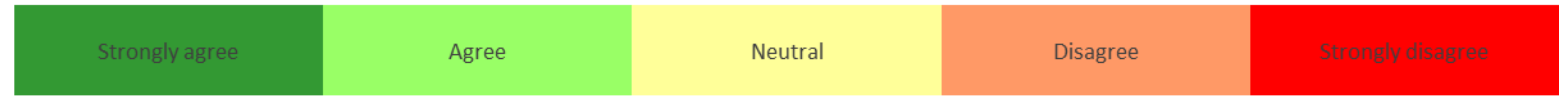
I am the type of person to worry about being 'green'

62% agree with this statement

I am the type of person who likes to try new products

89% agree with this statement

I feel a moral obligation to reduce my emission of greenhouse gases

77% agree with this statement

I am the type of person who needs a reputable brand to be willing to invest in a new product
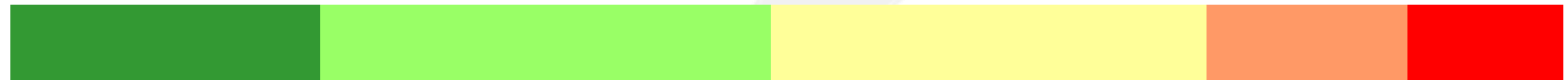
49% agree with this statement

I would be willing to pay a little more for an energy system if I knew it was less harmful to the environment

81% agree with this statement

I would be willing to pay significantly more for an energy system if I knew it was less harmful to the environment

42% agree with this statement

Motivations for purchasing FC mCHP

- The motivations for purchasing FC mCHP are similar for both residential and non-residential customers, with energy savings, cost savings and CO_2 emissions reductions the most-cited reasons for purchasing FC mCHP.

- Energy and 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.

- Most 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. The generally high income of respondents also reduces the consequences of financial and operational risks.

Benefits of FC mCHP

Operational Performance
How satisfied are you with the following?

| Very satisfied | Satisfied | Neutral | Dissatisfied | Very dissatisfied |

Generation of electricity
75% are satisfied with this feature

Cost of repair
37% are satisfied with this feature

Environmental impact
77% are satisfied with this feature

Ability to heat a building quickly
61% are satisfied with this feature

Ease of operation
71% are satisfied with this feature

Reliability
67% are satisfied with this feature

Noise
67% are satisfied with this feature

Size
67% are satisfied with this feature

Design
78% are satisfied with this feature

Comfort and warmth
81% are satisfied with this feature

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What do you most like and dislike about your FC mCHP with regards to the following aspects?

Favourite feature

- Ability to heat to temperature quickly 2%
- Ease of operation/control 7%
- Reliability 17%
- Noise 3%
- Size 4%
- Design/Aesthetics 6%
- Comfort and warmth 61%

Least favourite feature

- Ease of operation/control 9%
- Comfort and warmth 9%
- Design/Aesthetics 14%
- Reliability 22%
- Size 26%
- Noise 20%

- The most liked feature of respondents' FC mCHP unit was the comfort and warmth it provides, which has the vast majority of responses. This aligns with the improved performance vs. expectations for heating performance shown on Slide 24.

- The responses for least favourite features were more evenly split, with the least liked feature being the size of the unit, followed by the reliability. However, when asked if these features needed improvement, just 21% selected that the size could be improved upon and 26% reported that reliability could be improved. Therefore, although these features were selected as a least favourite, respondents were overall happy with them. This question did not provide an option to select "no least favourite" so we can conclude that respondents are generally happy with all features.

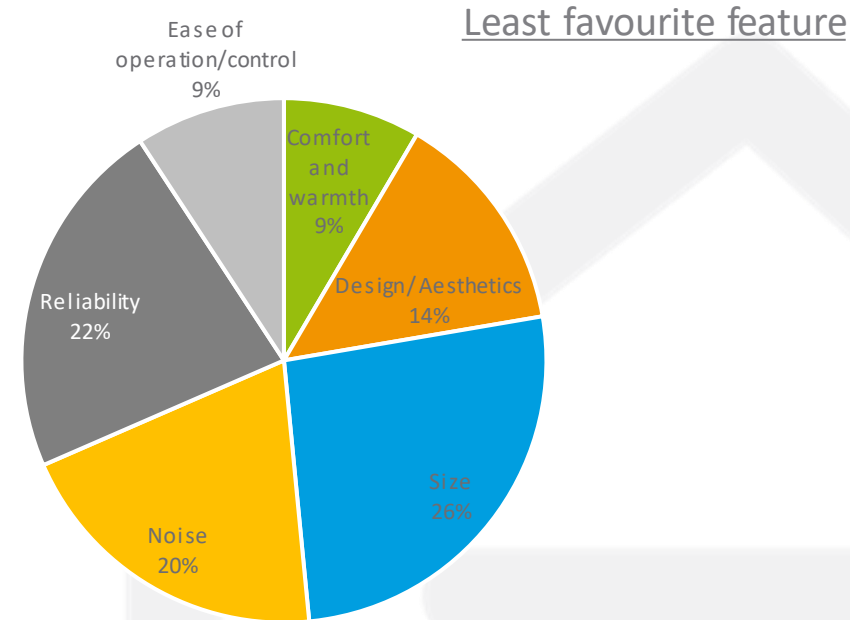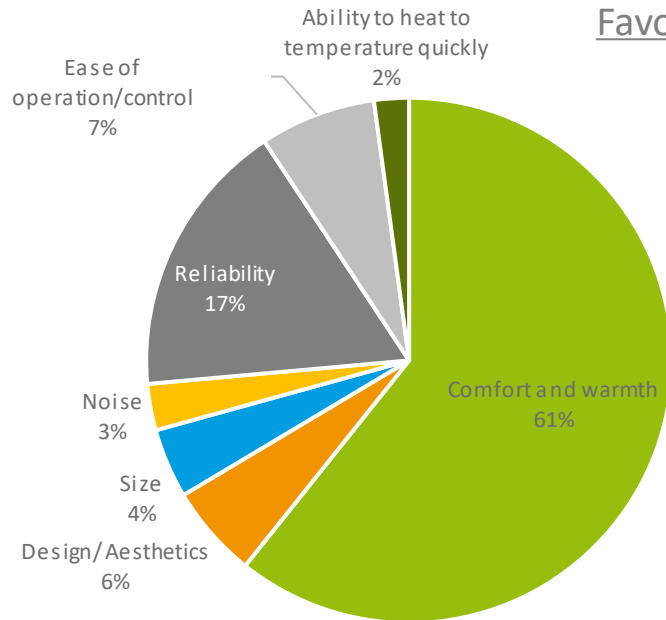23/05/2022   25

Based on your experience with a FC mCHP, which of the following do you think have to be improved?

- Respondents were generally positive regarding the improvements needed to FC mCHP units.

- Most parameters were consistently found to be "already sufficient" by the majority of respondents

- The following three parameters were considered most in need of improvements:
  - Cost of repair and maintenance
  - Effort of the installation process
  - Public visibility of FC mCHP

- These parameters are all common problems related to new and emerging technologies, as OEMs and installers develop the technical competencies to install and maintain FC mCHP. As a new technology, FC mCHP has additional requirements for specialised training (e.g. electrician know-how, IT skills), and as such only trained and qualified installers can sell and install the technology.

- The PACE D1.11 Report on Regulatory Barriers Working Group also identified that the lack of public visibility of FC mCHP is one of the key regulatory barriers preventing the technology from widespread uptake.

Operational Performance – Expectation vs Experience

Responses to the question "My FC mCHP has…" from during-operation surveys, compared to customer expectations of what their FC mCHP would provide from the pre-operation survey.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
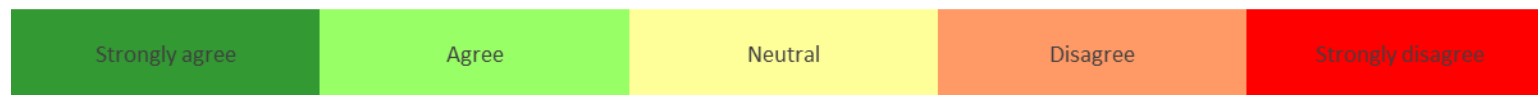
Produced all the electricity we use

31% agree with this statement (27% decrease compared to pre-operation expectation)

Produced all the heat we need

58% agree with this statement (20% increase compared to pre-operation expectation)

Provided hot water when we need it

80% agree with this statement (5% increase compared to pre-operation expectation)

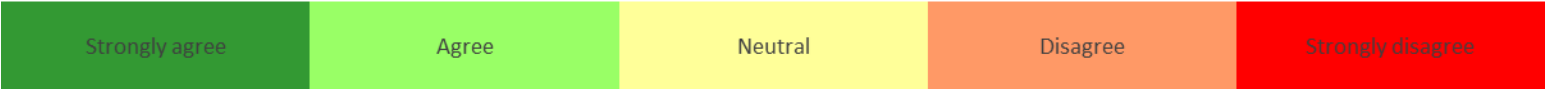**Kept us warmer than our previous heating system**

46% agree with this statement (2% increase compared to pre-operation expectation)

Decreased our total energy consumption

61% agree with this statement (29% decrease compared to pre-operation expectation)

Operational Performance - Expectation vs Experience

| Strongly agree | Agree | Neutral | Disagree | Strongly disagree |

Decreased our total energy cost

69% agree with this statement (22% decrease compared to pre-operation expectation)

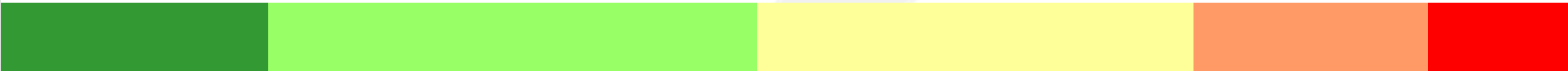**Had fewer malfunctions than our previous heating system**

33% agree with this statement (5% decrease compared to pre-operation expectation)

Decreased the frequency of power outages

13% agree with this statement (16% decrease compared to pre-operation expectation)

Helped protect us against rising energy costs

45% agree with this statement (37% decrease compared to pre-operation expectation)

Reduced our building's CO2 emissions

54% agree with this statement (38% decrease compared to pre-operation expectation)

Given us greater independence from the grid

39% agree with this statement

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Operational Performance – Expectations vs Experience

Percentage of respondents that agree or strongly agree with the following: "my FC mCHP has / will..."
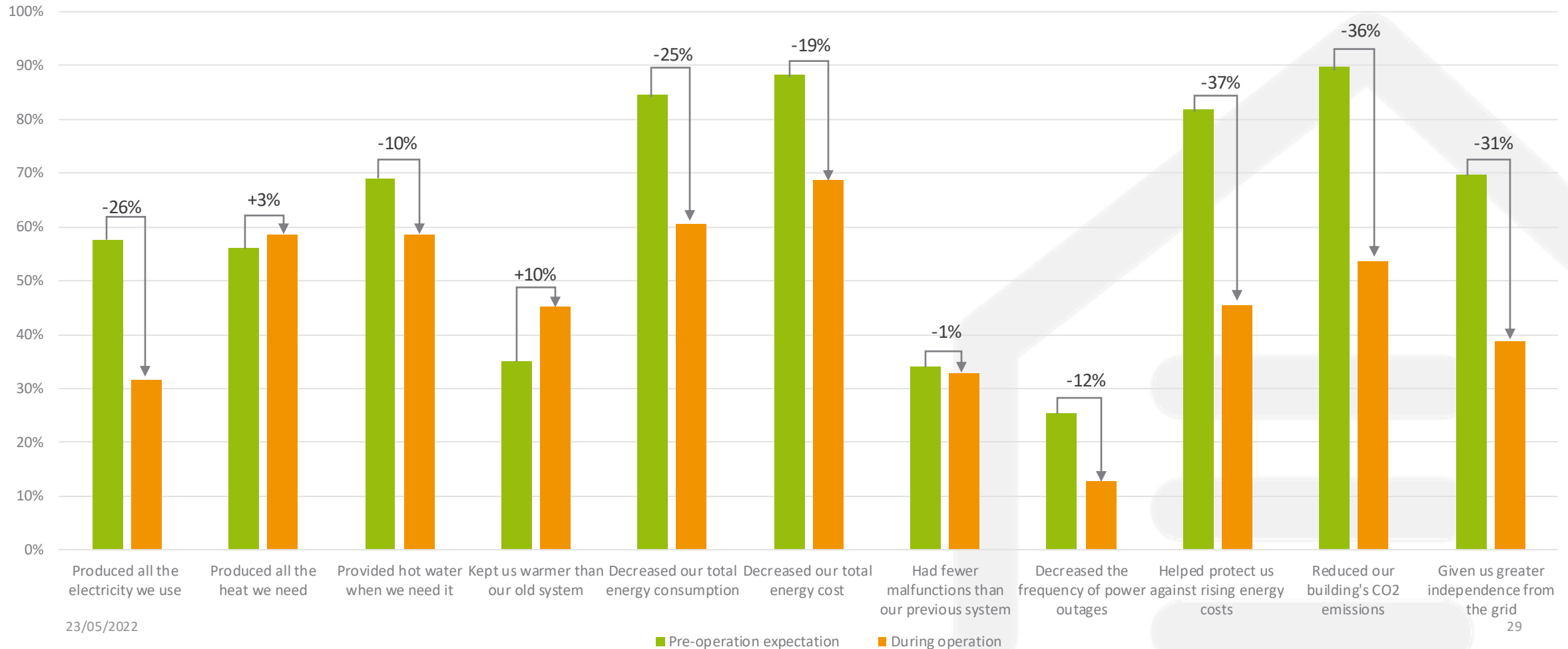
23/05/2022

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- Expectations of FC mCHP were generally high, particularly regarding the reduction of CO_2 emissions, energy consumption and energy cost.

- In all but two cases, the expectations of FC mCHP were higher than the reality recorded in the during operation surveys.

- For parameters related to heating performance ("produced all the heat we need" and "kept us warmer than our old system"), the actual experiences scored higher than customer expectations.

- Many parameters are likely interlinked. For example, with fewer respondents than expected having their FC mCHP decrease their total energy consumption, this may also affect the expectation vs experience of energy costs, CO_2 emissions and independence from the grid.

- The greatest % divergence between expectation and actual experience was seen for "helped protect us against rising energy costs", where a large proportion of respondents (82%) had agreed with the statement prior to operation, whereas less than half agreed with the statement after their experience with using FC mCHP. However, this may reflect wider energy market issues over the trial period (for example the emergence of the COVID-19 pandemic and the rise in natural gas prices).
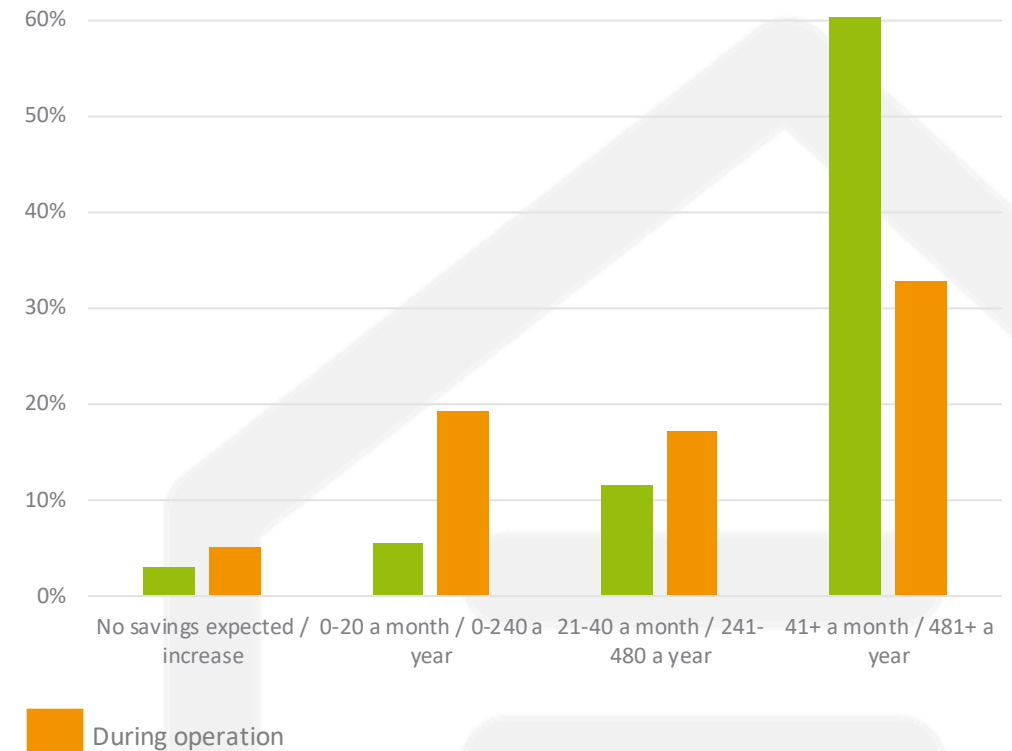
It is clear that the expectations that end users had for their FC mCHP units were very high and that, despite the divergence between these expectations and their experiences, overall appraisal of the system remains very high.

Expected financial benefits of FC mCHP compared to actual benefits

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Decrease in gas and oil bills
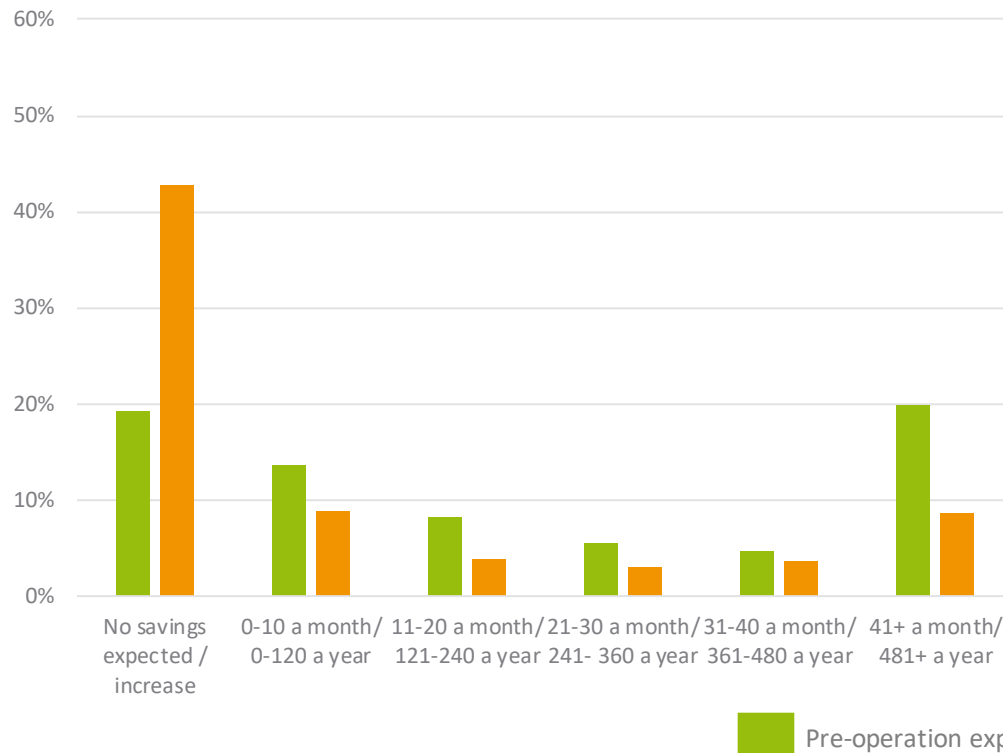
Decrease in electricity bills

Legend: ■ Pre-operation expectations   ■ During operation

- 81% of respondents anticipated a decrease in their gas and oil bills after installation, whereas only 57% actually experienced a decrease. This may reflect wider energy market issues over the trial period (for example the emergence of the COVID-19 pandemic and the rise in natural gas prices).

- Conversely, of the 97% of respondents who expected to see a decrease in their electricity bills, 95% did.

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How much more would you be willing to pay for a FC mCHP, assuming you made a saving of €30/month and reduced your carbon emissions by 20%.
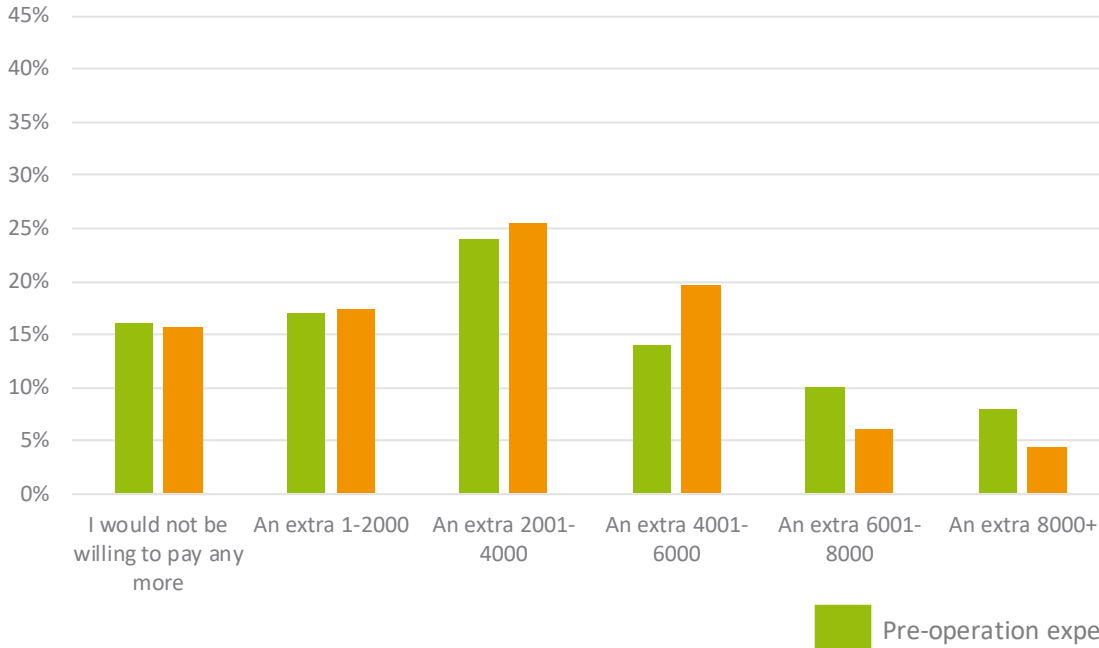
How much more would you be willing to pay for a FC mCHP that reduced your household carbon emissions by 40% rather than 20%?

Legend: ■ Pre-operation expectations ■ During operation
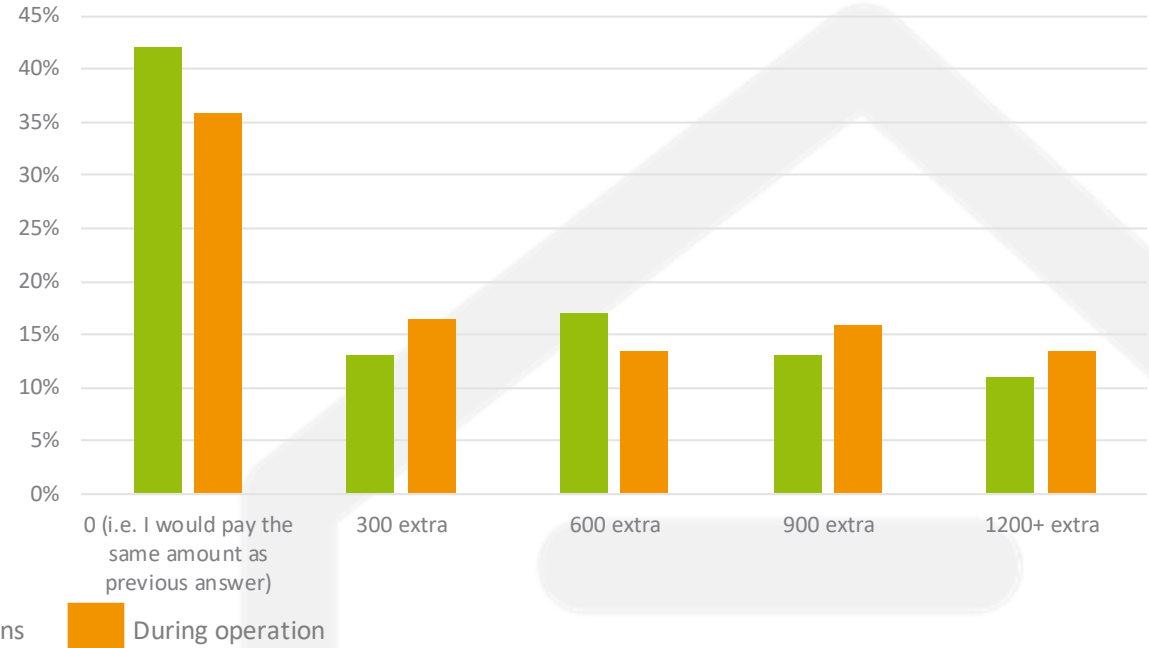
- Over 80% of respondents would be willing to spend more money on a FC mCHP compared to a conventional boiler, assuming cost savings of €30 per month and carbon emissions reductions of 20%. A further >50% of customers would be willing to pay an additional amount to reduce household carbon emissions by 40% rather than 20%.

- 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 in the buying decision.

- Customer attitudes remained fairly constant between the pre-operation and during-operation surveys. There has been a slight increase from the pre-operation survey in the amount customers would be willing to pay if their household carbon emissions were reduced by 40%, while a small decrease in the amount for a reduction of 20%.

Payback on investment compared to building EPC rating and country
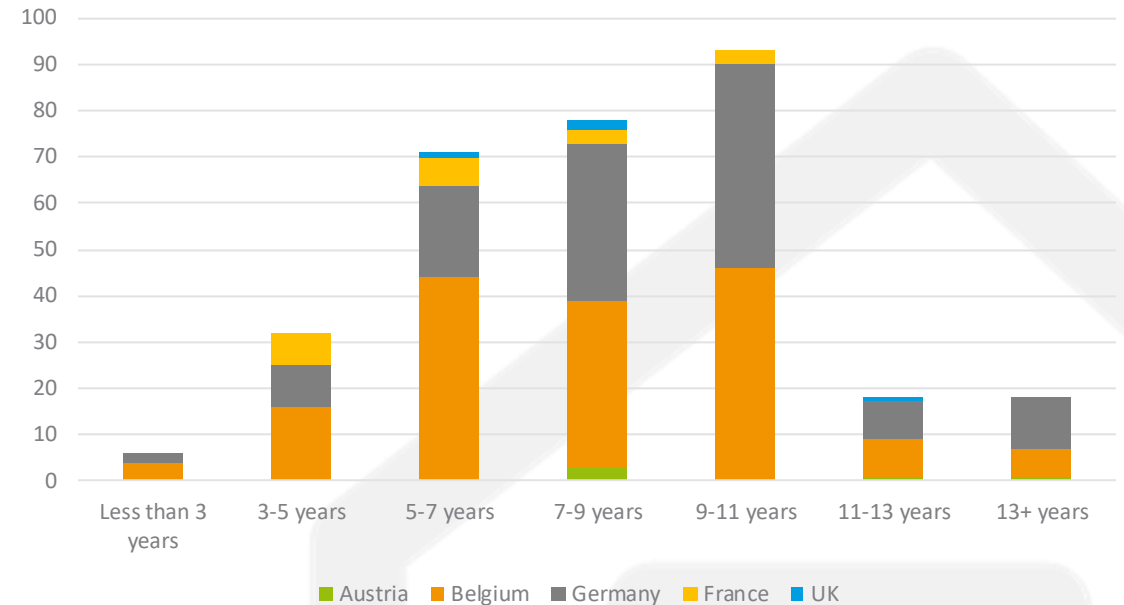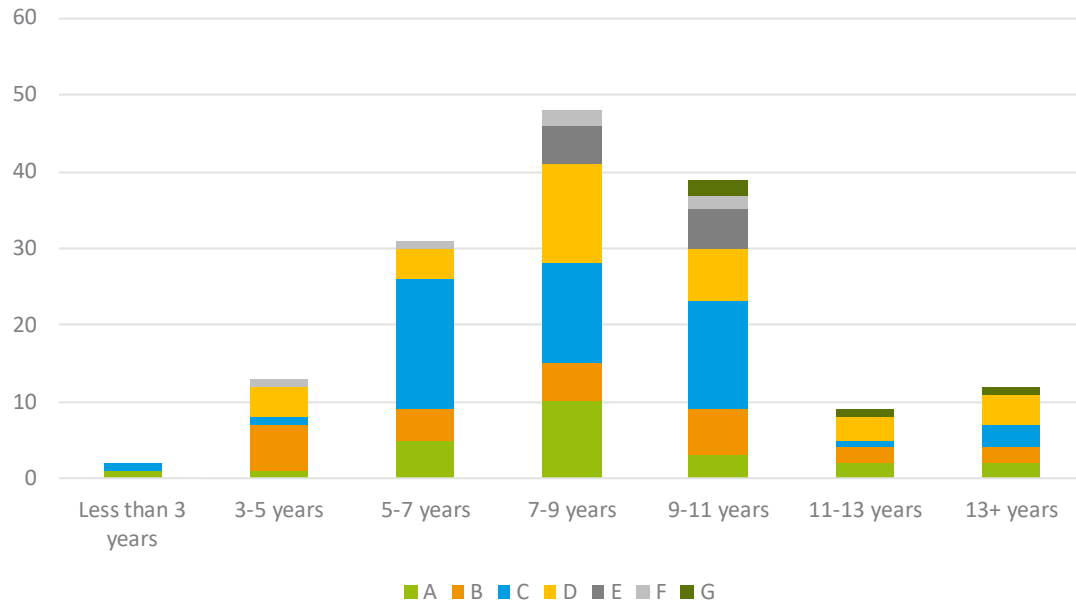
- 65% of all respondents in the pre-operation and during operation surveys would be willing to wait for more than 7 years for payback on the money spent on a FC mCHP through energy savings.

- Only 8% of respondents would only be willing to wait up to 5 years.

- Respondents from Germany would be prepared to wait slightly longer for payback than those from other countries.

- Respondents with a lower EPC rating would be prepared to wait slightly longer than those with a higher rating.

Benefits of FC mCHP – Expectations vs experience

- Expectations of FC mCHP were generally high, particularly regarding the reduction of CO_2 emissions, energy consumption and energy cost. In all but two cases ("produced all the heat we need" and "kept us warmer than our old system"), the expectations of FC mCHP were higher than the reality recorded in the during operation surveys.

- The most liked feature of respondents' FC mCHP unit was the comfort and warmth it provides. The least liked feature was the size of the unit, followed by the reliability, although the spread of responses were significantly more distributed and there was no one, clear least liked feature. The warmth and comfort of the unit is consistently cited as good by respondents throughout the survey.

- Respondents were generally positive regarding the improvements needed to FC mCHP units. Most parameters (with the exclusion of the cost of repair and maintenance, effort of the installation process and public visibility of FC mCHP) were consistently found to be "already sufficient" by the majority of respondents. It is clear that cost remains a particularly important limiting factor, in addition to installation and maintenance requirements. This could also reflect some difficulties encountered over the last few years related to the COVID-19 pandemic and energy price rises.

- The actual financial benefits of FC mCHP were lower than the expected, particularly regarding gas and oil bills. 81% of respondents anticipated a decrease in their gas and oil bills after the installation of their FC mCHP, whereas only 57% actually experienced a decrease. Conversely, of the 97% of respondents who expected to see a decrease in their electricity bills, 95% did.

- The responses regarding overall experiences with FC mCHP units have highlighted some concerns, despite the customers being generally supportive of the technology and being 'early adopters'. These concerns could therefore be exacerbated in a wider market where customers may be less accepting of issues with the technology. It is also worth noting, however, that as these respondents are largely 'early adopters' trying out new technologies, this may have led to inflated initial expectations.

Problems and Breakdowns

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In the past year, have you experienced any problems or breakdowns with your mCHP?

If your problem required non-emergency repair, how long did it take between reporting the issue and someone coming to visit?
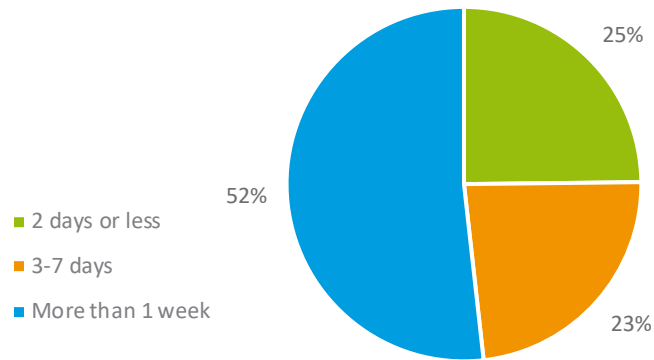
If your problem required emergency repair, how long did it take between reporting the issue and it being resolved?

- 25%
- 52%
- 23%

- 2 days or less
- 3-7 days
- More than 1 week

- 46%
- 30%
- 24%

- Yes, non-emergency repair
- No
- Yes, emergency repair

- 10%
- 10%
- 62%
- 18%

- A few hours
- Less than 1 day
- 1-2 days
- More than 2 days
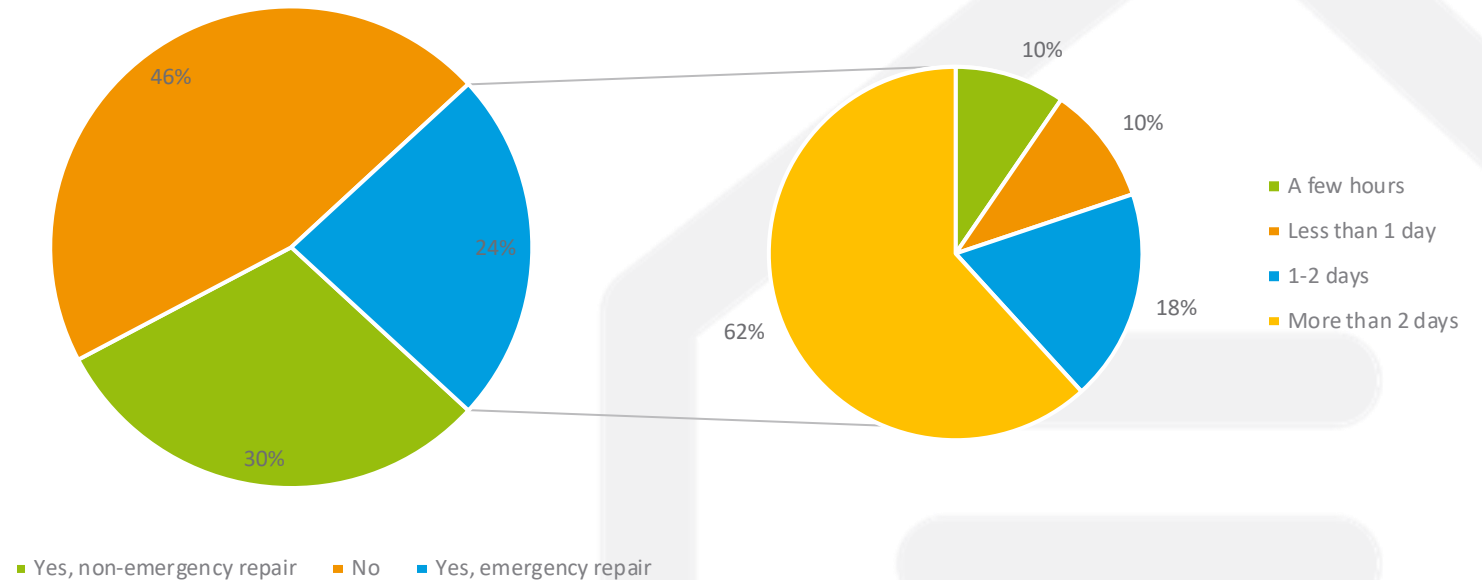
- The majority of respondents required repairs during operation of their FC mCHP.

- This high rate of problems reflects the nature of new technologies, and it would be expected that this will decrease over time.

Problems and breakdowns

The most common problem or breakdown experienced by respondents has been "no electricity". This problem has also been reported to be the slowest to be repaired, whether in an emergency or not.
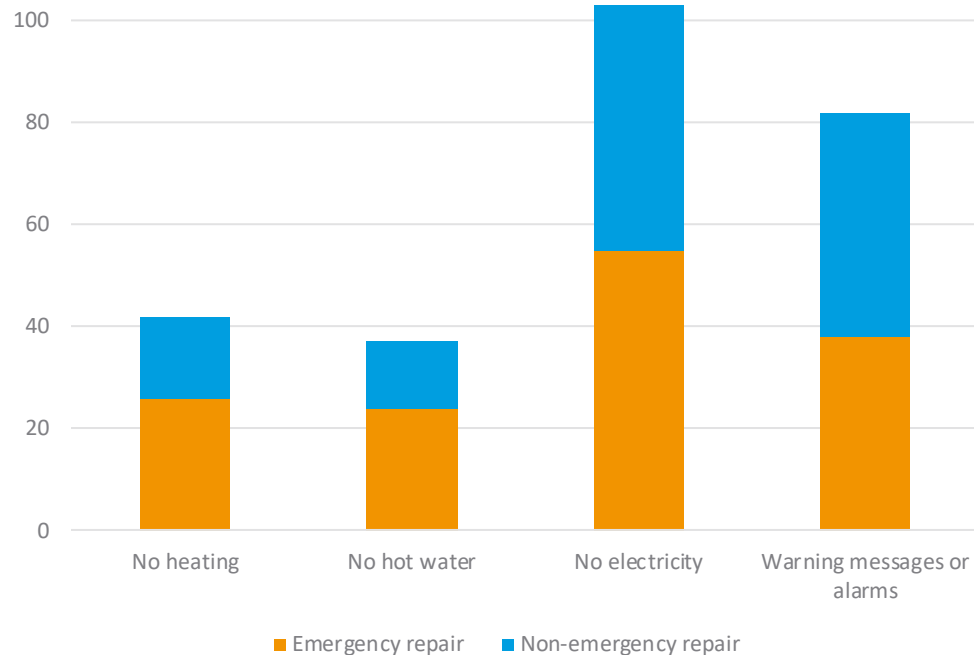
How long did it take between reporting the issue and someone coming to visit?

Length of Installation
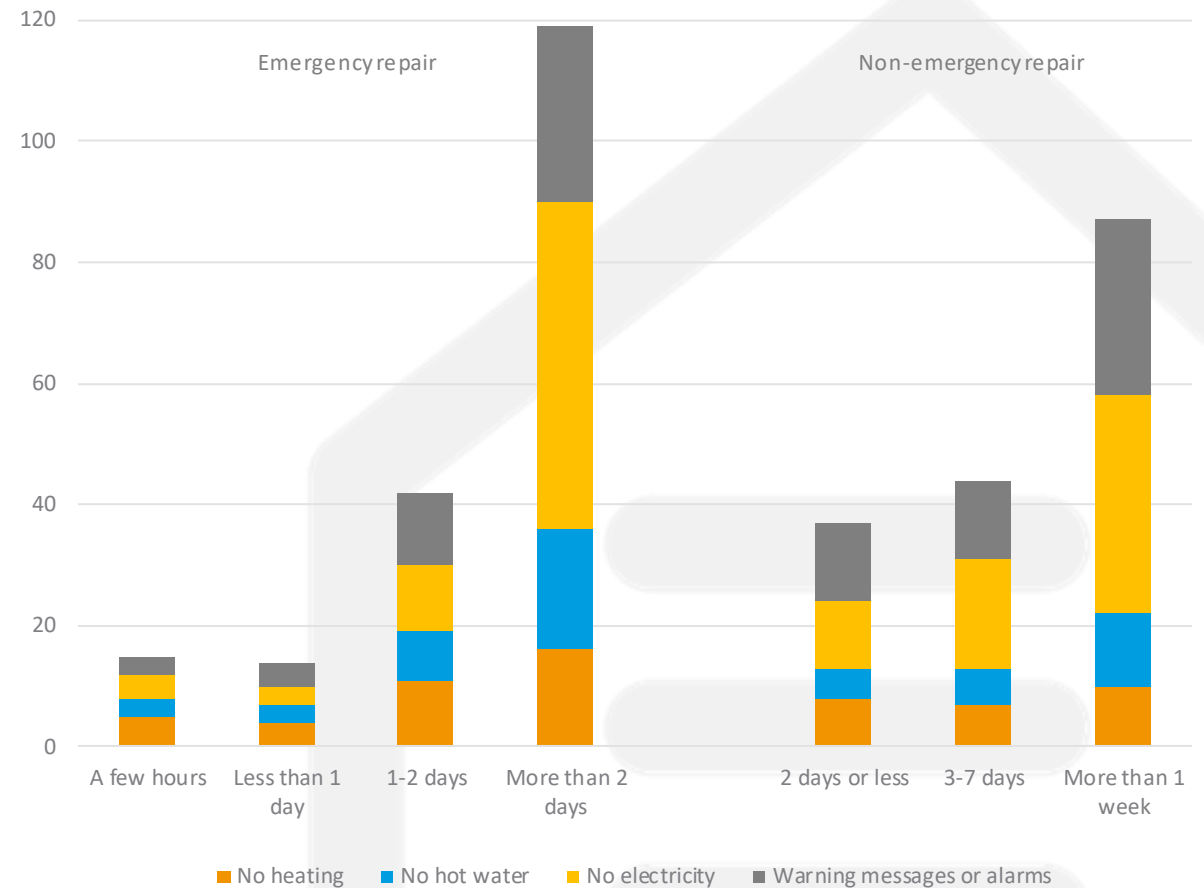
69% of respondents reported that the installation of their mCHP unit took longer than their previous heating system*. The length and effort of the installation process was also identified as being a key area of improvement for the technology.

Pie chart legend:
- 19% — The installation of my mCHP took much longer
- 50% — The installation of my mCHP took slightly longer
- 26% — The installation of my mCHP took approximately the same amount of time
- 3% — The installation of my mCHP was slightly shorter
- 2% — The installation of my mCHP was much shorter

Bar chart legend: Austria, Belgium, Germany, France, UK

Bar chart categories: The installation of my mCHP took much longer; The installation of my mCHP took slightly longer; The installation of my mCHP took approximately the same amount of time; The installation of my mCHP was slightly shorter; The installation of my mCHP was much shorter

*30% conventional gas boiler

23/05/2022

38
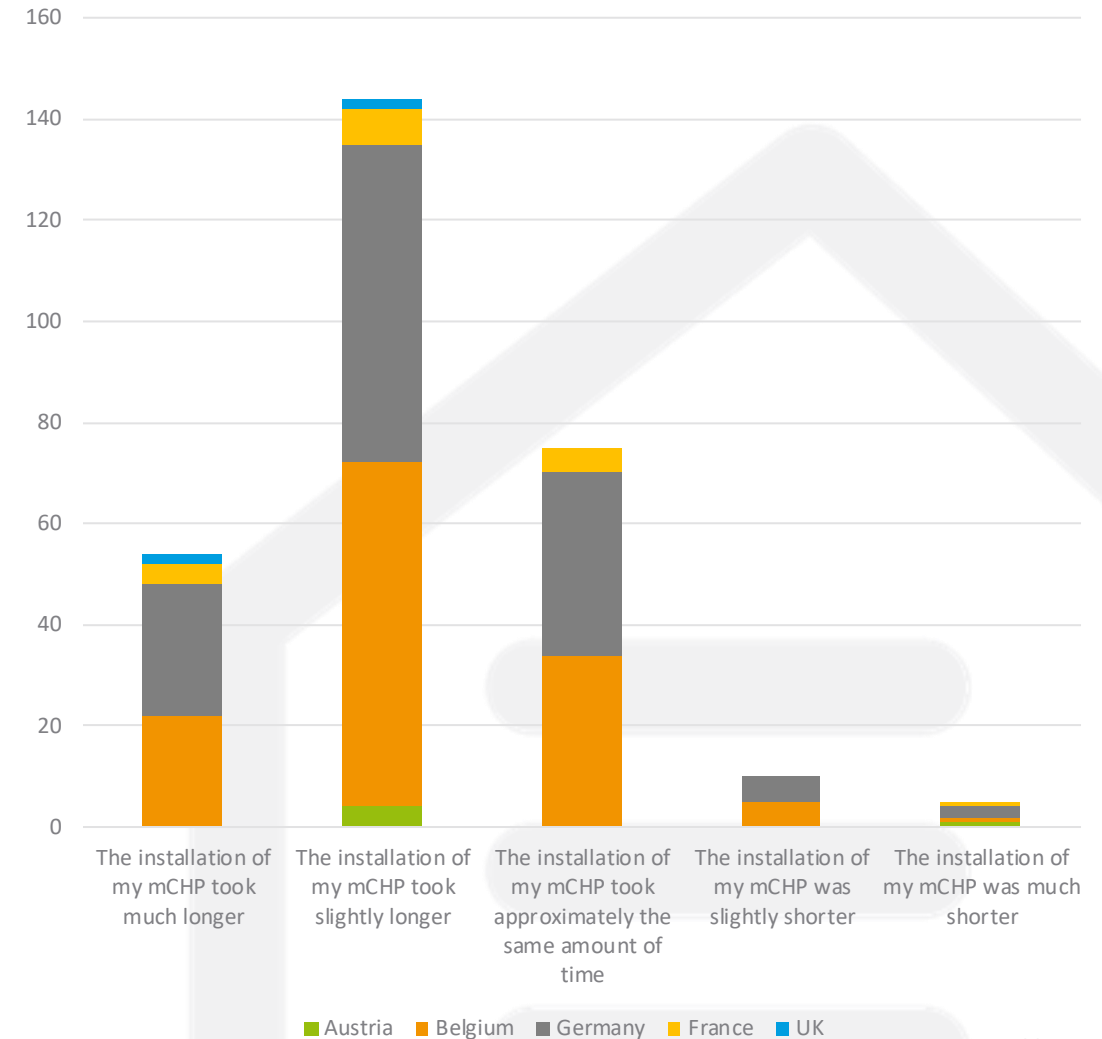
Problems and breakdowns

- 54% of respondents experienced a problem or breakdown in the past year. 30% of these were non-emergency problems and 24% were emergencies. This high rate of problems reflects the nature of new technologies, and it would be expected that this will decrease over time.

- The most commonly reported problem was no electricity (103 responses), followed by warning messages or alarms (82 responses).

- The most common length of time between reporting an issue and someone coming to visit was more than 2 days for emergency problems, and more than 1 week for non-emergency issues. The relatively long time taken to repair these issues may reflect the lack of installers who are able to carry out maintenance on this new technology (See D1.2 report for further information).

- 69% of respondents also found the installation time of their FC mCHP to be longer than that of their previous systems. This aligns with the effort of installation being identified as a key area of improvement for the technology.

- The average consumer for this technology is currently still an early-adopter, and there is therefore a strong need to improve on these areas when scaling up the technology to larger markets.

Conclusions and next steps

Overall how would you describe your experience with your mCHP?

Nearly 80% of respondents reported having a positive overall experience with their FC mCHP unit and just 8% described their experience as negative or very negative.
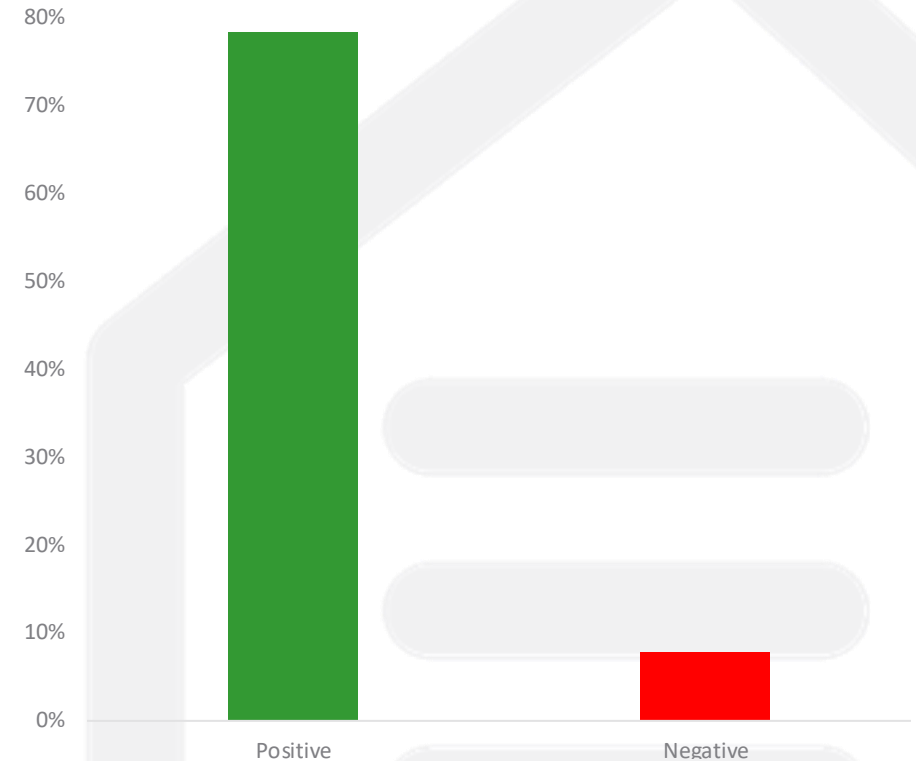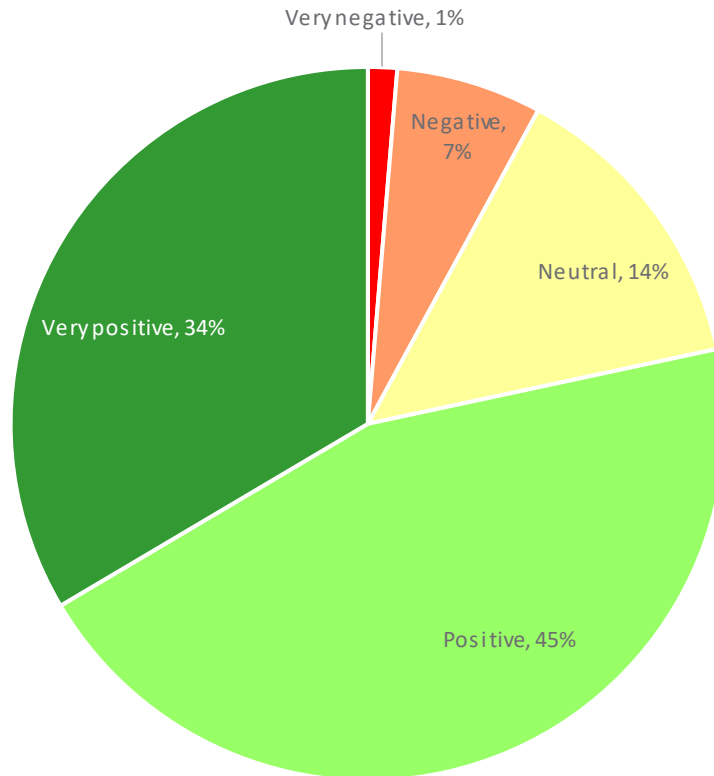
Overall how would you describe your experience with your mCHP?

No negative responses were reported by any non-residential respondents.

Austria reported the highest number of "very positive" responses, and only Belgium and Germany were the only two countries to report any "very negative" experiences.

As the two countries with the most installations, it would be expected that Germany and Belgium would have a broader range of responses.

■ Very negative ■ Negative ■ Neutral ■ Positive ■ Very positive

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| Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
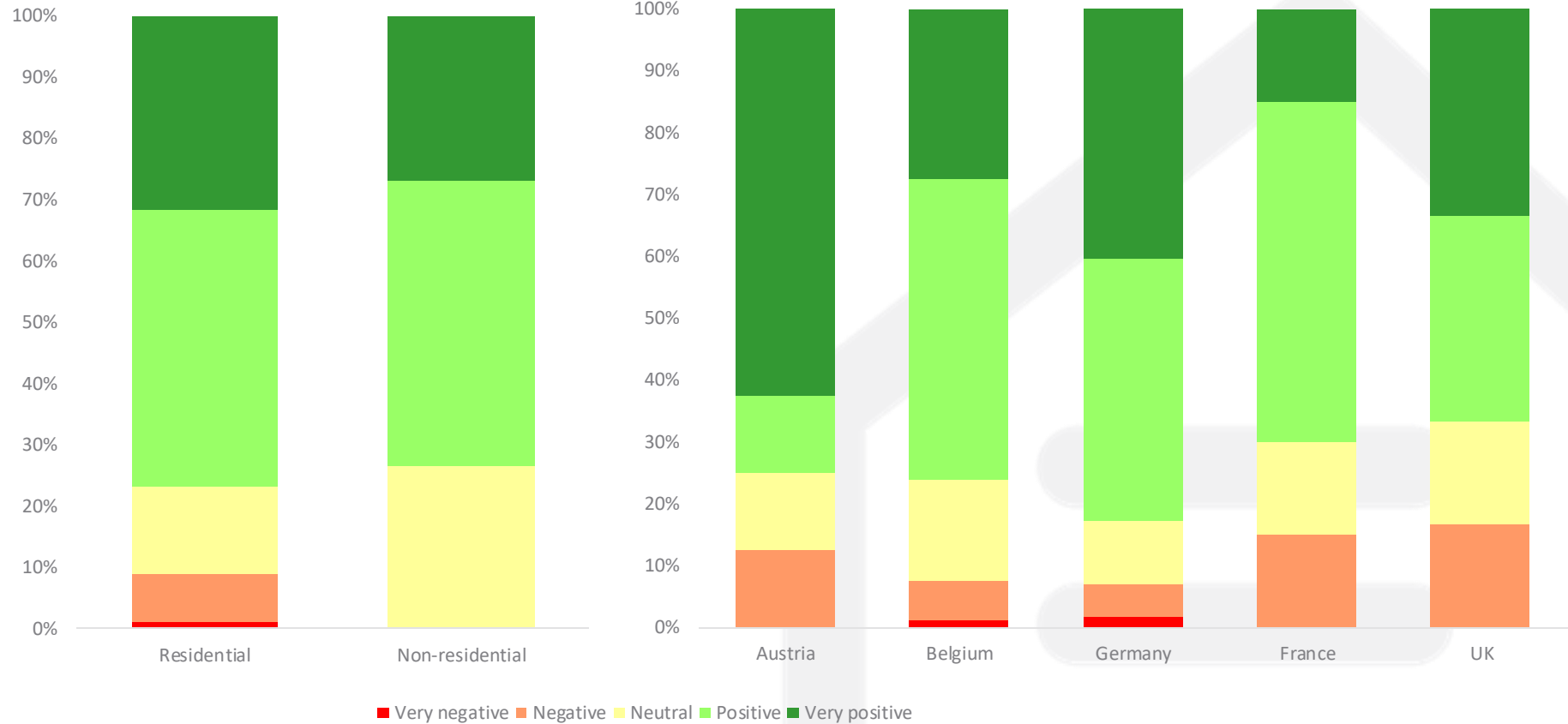
I am the type of person to worry about being 'green'

I am the type of person who likes to try new products

I feel a moral obligation to reduce my emission of greenhouse gases

- 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 were 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. These expectations were not always met in the responses to the during operation surveys. It is clear that cost remains a particularly important limiting factor, in addition to installation and maintenance requirements. This could also reflect some difficulties encountered over the last few years related to the COVID-19 pandemic and energy price rises.

- Customers were, on the whole, very satisfied with the performance and features of their FC mCHP unit. The environmental impact, comfort and warmth, design and generation of electricity were considered the most liked features, while the cost of repair and maintenance, effort of the installation process and public visibility of FC mCHP could all use improvements. These parameters are all common problems related to new and emerging technologies, as OEMs and installers develop the technical competencies to install and maintain FC mCHP. As a new technology, FC mCHP has additional requirements for specialised training (e.g. electrician know-how, IT skills), and as such only trained and qualified installers can sell and install the technology.

- The responses regarding overall experiences with FC mCHP units have highlighted some concerns, despite the customers being generally supportive of the technology and being 'early adopters'. These concerns could therefore be exacerbated in a wider market where customers may be less accepting of issues with the technology. It is also worth noting, however, that as these respondents are largely 'early adopters' trying out new technologies, this may have led to inflated initial expectations.

In the past year, have you experienced any problems or breakdowns?
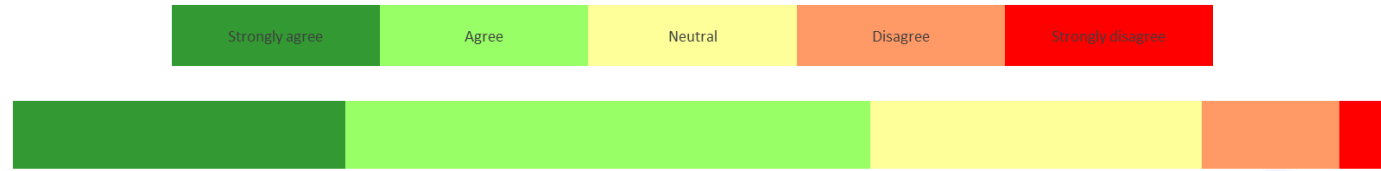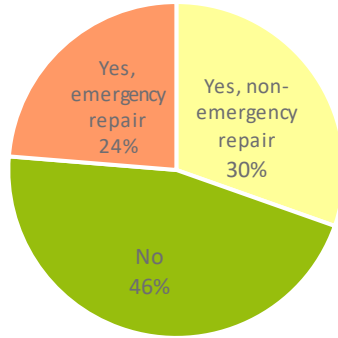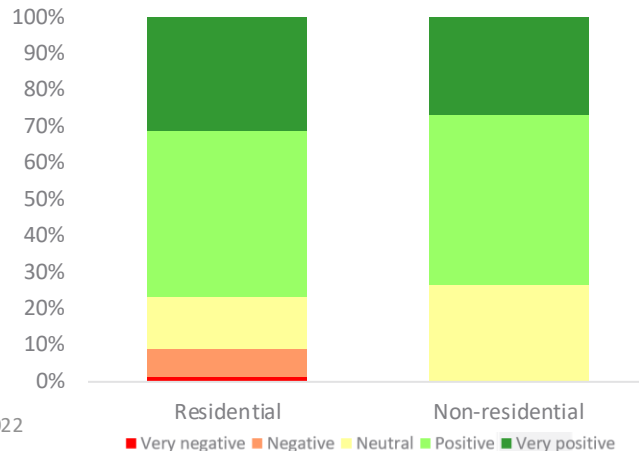
Yes, emergency repair 24%

Yes, non-emergency repair 30%

No 46%

Overall how would you describe your experience with your mCHP?

Residential   Non-residential

Very negative Negative Neutral Positive Very positive

- The actual financial benefits of FC mCHP were lower than the expected, particularly regarding gas and oil bills. 81% of respondents anticipated a decrease in their gas and oil bills after the installation of their FC mCHP, whereas only 57% actually experienced a decrease.

- Over 50% of respondents experienced problems or breakdowns in the first two years of their FC mCHP, with electricity loss being the most common problem. The most common length of time between reporting an issue and someone coming to visit was more than 2 days for emergency problems, and more than 1 week for non-emergency issues. The relatively long time taken to repair these issues may reflect the lack of installers who are able to carry out maintenance on this new technology (See D1.2 report for further information). The average consumer for this technology is currently still an early-adopter, and there is therefore a strong need to improve on these areas when scaling up the technology to larger markets.

- With regards to their overall experience with the unit, non-residential respondents were reportedly more neutral. There were no negative experiences reported from non-residential respondents, but there were also fewer positive and very positive responses. Customers are perhaps more inclined to feel strongly about technology being used for their own use in a private, home setting.

- As found in Report 1, financial considerations are still a major part of customer motivations and expectations. This is likely to be exacerbated through wider industry developments in the energy market.

- The final iteration of this report will be prepared in 2023, including additional responses to be collected from customers. In particular, a higher completion rate of 12 and 24-month surveys is expected, which will allow for a stronger longitudinal analysis of participants' experiences with their units.

- With a larger dataset from more responses, more detailed and diverse customer 'profiles' can be created, expanding upon the generalised profile in this report.

- In-depth case studies of some participants can be created, following their responses over the course of the three surveys, and comparing the differences between expectations prior to installation with experiences of using FC mCHP for 12 and 24 months.

- More qualitative data will be explored and analysed, including testimonials provided regarding participants' experiences, providing diverse personal stories from users of the technology, both positive and negative.

- The impact of the COVID-19 pandemic on participants' experiences, particularly with maintenance and repairs of their FC mCHP units, will be explored, as well as wider market trends.

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D2.15 will include testimonials provided regarding participants' experiences, providing diverse personal stories from users of the technology, both positive and negative. Examples of these can be seen below, which will be analysed in detail.

In depth case studies of some participants will be explored to analyse their experience from pre-installation through to present day.

Please provide a short testimonial regarding your experience with your FC mCHP:

„Fazit: komplett Paket, welches sehr zu empfehlen ist."

"In conclusion: a complete package, which is highly recommended."

"In principle, the concept of generating our own electricity while having a highly efficient gas boiler was exciting Unfortunately, the reality has been disappointing"

« Une solution d'avenir à mettre absolument en avant auprès du grand public.. «

"A solution for the future that absolutely needs to be promoted to the general public."

"Let wel niet goedkoopste oplossing, wel duurzame oplossing met comfort."

"Not the cheapest solution, but a sustainable solution with comfort"

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Callux

The Callux project, a predecessor to Ene.field and PACE, ran from 2008 – 2015 and installed 500 FC mCHP systems in Germany. This was a large scale practical test for FC mCHP systems for domestic use in Germany.

- 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

The heating system...	agree completely	agree	tend to agree	tend to disagree	disagree completely	Top 2 box values	Low 2 box values
... has an attractive design	37	56		6	2	92%	2%
... takes up a reasonable amount of space	41	37	15	6		78%	7%
... was installed by the technicians quickly and with no hassle	55	21	21		3	76%	3%
... runs quietly	44	31	21		4	74%	5%
... runs reliably without interruptions	34	34	21	9	2	68%	11%
... is easy to operate	30	35	20	9	8	64%	16%

Survey of Callux field test customers in June 2013

Results of the accompanying activities: AP2 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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Ene.field

The Ene.field project, a predecessor to PACE, ran from 2012 – 2017 and installed >1,000 FC mCHP systems in 11 European countries. PACE has continued to build on the work of this project to continue large scale demonstration of the technology and contribute to early market uptake.

- 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.
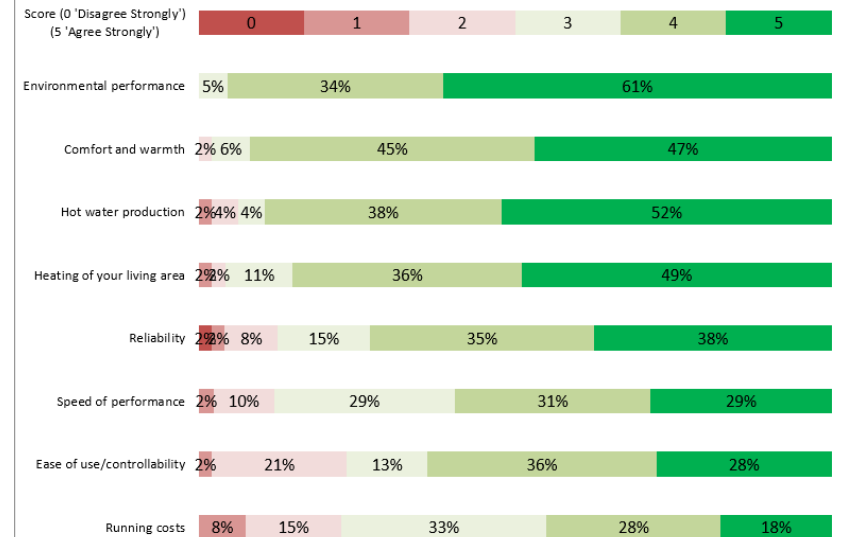
Table 2: Property types

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%

Satisfaction with heat and hot water

Score (0 'Disagree Strongly') (5 'Agree Strongly')	0	1	2	3	4	5
Environmental performance			5%	34%		61%
Comfort and warmth		2%	6%	45%		47%
Hot water production	2%	4%	4%	38%		52%
Heating of your living area	2%	2%	11%	36%		49%
Reliability	2%	2%	8%	15%	35%	38%
Speed of performance	2%		10%	29%	31%	29%
Ease of use/controllability	2%		21%	13%	36%	28%
Running costs	8%		15%	33%	28%	18%

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Fuel Cell micro–CHP Market

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