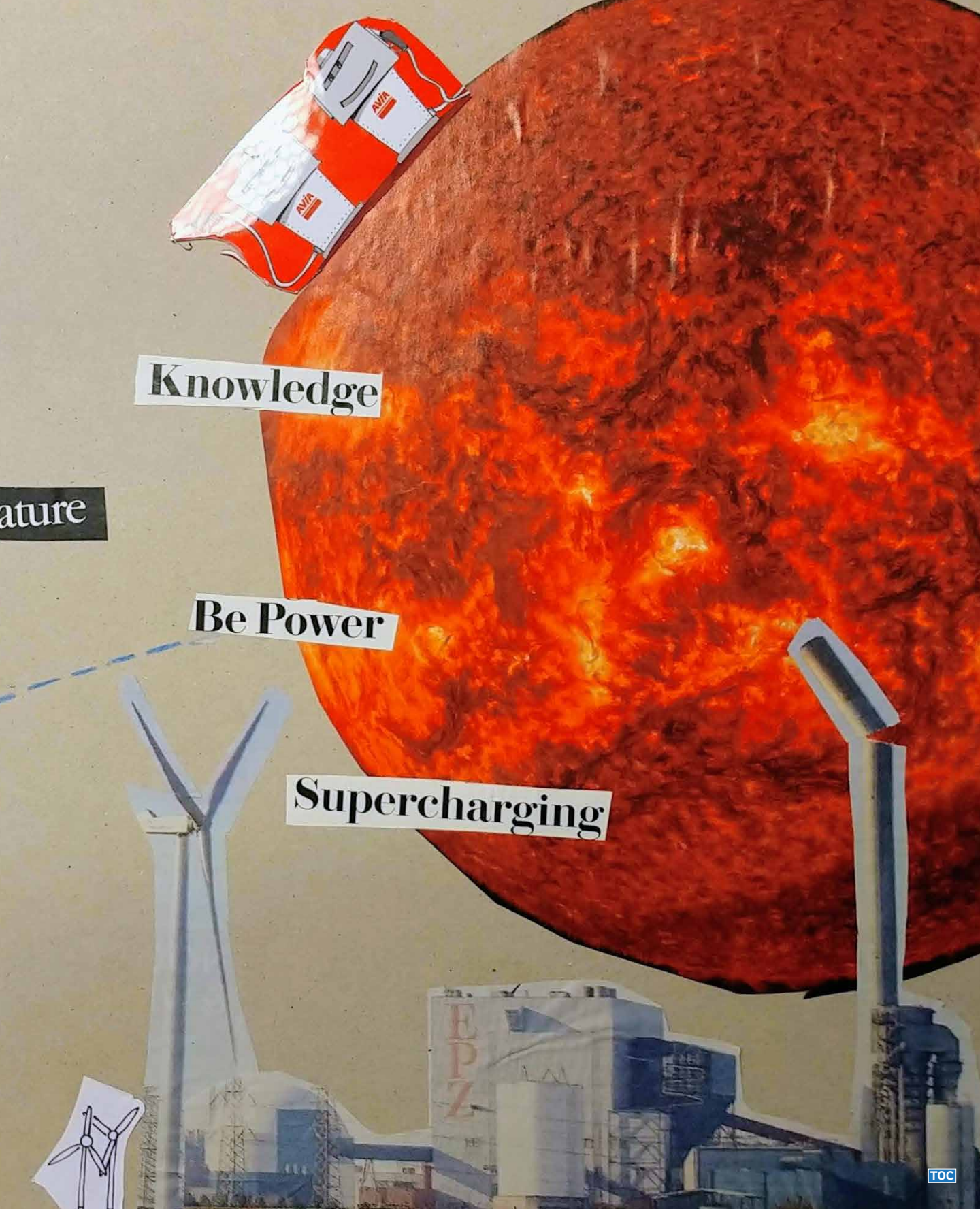
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6 Conclusion and recommendations

6.1 Introduction

This research provided insights into the comfort and energy-consuming behaviours of home occupants and into grouping these home occupants based on their individual differences. This was achieved by using a human-centered approach to an engineering challenge, by assuming comfort as a holistic experience of the home environment, and by treating the 'occupant-environment' interactions as a dynamic system.

Such an approach drew methods typically used in design and ethnographic research, by gathering both qualitative and quantitative data from both the occupant and the building. The occupant data was collected quantitatively with the use of a questionnaire (self-reported) and qualitatively with interviews (procedural knowledge) and finally with generative techniques (interpretive knowledge). In such a way, different types of occupant knowledge were elicited and collected. The building data was gathered with checklists, monitoring, and energy readings.

With the questionnaire data and a clustering technique -the TwoStep cluster analysis- five distinct types of occupant, or archetypes, were discovered and they were progressively enhanced and substantiated with the interview and generative techniques data. Additionally, data of building characteristics, indoor environmental factors, and actual energy consumption completed the details of the archetypes.

The following paragraphs provide the conclusion and recommendations drawn from this research. First each of the key questions are answered followed by the answer to the main research question; in which the final description of the archetypes is presented. This is followed by the strengths and limitations of this work and

recommendations for the future process. Then for each archetype, environmental design parameters are presented. This finishes with recommendations for future research and the implications of this work.

6.2 Answers to the Research questions

6.2.1 Answers to key questions

Part 1 – (see Chapter 2)

- What lies behind behaviour?
- What characterizes habits?
- What is comfort?
- How do home occupants achieve comfort?
- How are comfort behaviours and energy use related in homes?

To answer these questions, an extensive and multidisciplinary literature review was performed, aiming at providing the main ground to identify new methods to study daily energy consumption and its relation to comfort.

Behaviours are actions that an individual exercises to achieve certain goals. These actions are motivated by several factors, ranging from the physical environment, to the social environment, and the psychology and culture of the person. For the study of comfort and energy use, a person-focused approach was explored, specifically with the Theory of Interpersonal Behavior (TIB). The TIB explains that behind any behavioural expression lie the intentions of the individual to perform the behaviour. These intentions are driven by four factors: emotions, attitudes, control, and needs. In simple words, emotions drive a person towards pleasantness and away from stress. Attitudes are appraisals of concepts that affect a person's thoughts and ultimately actions. Control is the degree to which a person believes they can influence their environment or vice versa. Needs are what an individual finds necessary to feel physiologically, socially, or psychologically satisfied. The combination of these constructs culminates in mental models that shape one's behaviours.

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Habits have to be treated independently from regular behaviours, as they are not influenced by the aforementioned constructs. This is because habits occur in a more primitive part of the brain, and as a result, they are semi-unconscious, automatic, repetitive, goal-oriented, and are triggered by stimuli. In this thesis, such habitual actions have been defined as interactions with the technical devices, and thus, that spend energy.

Comfort is described from different disciplines, showing how comfort is a dynamic and fuzzy concept, and it is more complex than the perception of thermal, acoustical, visual stimuli, or air quality environment. The chapter proposes a common definition of comfort: it is a state of homeostasis; a state in which the individual is physically, physiologically, psychologically, and socially neutral.

Humans achieve comfort by interacting and manipulating their environment, and many of such activities result in the consumption of energy (either with the use of electricity or gas). Homeostatic activities were summarized as: cleaning and ordering, warming up, cooling down, ventilating, using lights, cooking, controlling systems, relaxing activities, personalizing activities (décor, furniture), socializing or other freedom activities, control of privacy, changing the mood of spaces, and hobbies.

Part 2 – (see Chapter 3)

- How can home occupants be categorized into “clusters”?

A technique drawn from the user-centered design field was used to find personas or archetypes of occupants. Typically, an archetype is the synthesis of data collected from surveys or interviews with users, describing goals, patterns, skills, attitudes, etc. In this case, a specialized questionnaire to assess the motivations behind comfort and energy-consuming behaviours was developed. In the questionnaire, a total of fifteen items identified in the literature as ‘energy expending’ and ‘homeostasis attaining’ were selected, to assess their habit strength. Further habitual items that were deemed ‘necessary’ rather than homeostatic were included in the interviews for deeper analysis (i.e. showering and length).

The questionnaire assessed the variables related to the homeostatic activities that were identified in the previous chapter. The questionnaire was developed by adapting previously-validated questionnaires to the specific context of this project, namely, energy-consuming comfort-making activities in the home. The adaptation of previous questionnaires was done by adjusting the wording. The questionnaires that were adapted

were the locus of control questionnaire, the PrEmo2 for emotions, the self-report index of habit strength, in addition to using 5-point Likert scales with semantic differentials for the needs and attitudes, based on the theory of planned behaviour guidelines.

The method of analysis is highly dependent on the type of questions or the variables that are asked in the questionnaire. Literature suggests that questionnaire data can be categorized by using a wide range of techniques, such as principal component analysis, discriminant analysis, cluster analysis, correlation analysis, exploratory factor analysis, or factor analysis.

Due to the type of variables making up this questionnaire, the cluster analysis was used, and more specifically the TwoStep cluster analysis. This method allows for the clustering of both categorical and continuous variables.

With the method, six archetypes were found in the proof-of-concept were found. The final model of clusters comprised of variables pertaining to emotions, control, and affordances.

Part 3 – (see Chapter 4)

- How does the indoor environment of different home occupants differ?
- How do the characteristics of their buildings differ?
- How do the different types of occupants differ in their use of energy?
- How do the different types of occupants express themselves about comfort habits, energy, and affordances in their homes?

Once it was determined that the questionnaire and the analysis type worked in a stable way to classify home occupants, the questionnaire was administered to a full sample. With the full sample and the TwoStep cluster analysis, a final model of five distinct archetypes was produced.

However, the clusters from the questionnaire are limited to self-reported data. Additionally, since this thesis follows a user-centered design method in which not only self-reported data is used but also qualitative data, a field study was designed to interview participants and to use that data to complete the clusters. The interviews were analysed with sentiment analysis. Sentiment analysis is a process from the field of computational linguistics that enables identifying and categorizing opinions expressed qualitatively to find if the person expressing such opinions has positive, negative, or neutral attitudes towards a certain topic, in this case, comfort and its context, as defined in this thesis.

For the environmental monitoring, due to the small number of field study participants, it was not possible to determine whether statistically significant differences exist among archetypes, however, by treating the archetypes as case studies, the following results are drawn: for temperature, carbon dioxide, and relative humidity of their preferred location indoors, there are no major differences among archetypes. Specifically, for temperature, a 4-degree difference exists between the coolest and the warmest location, with archetype 2 having the hottest location and archetype 1, the coolest. For CO2 and relative humidity, archetype 2 has also highest readings. Archetype 1 has the lowest CO2 readings, and for RH, archetype 4 has the "driest" environment. These results, because of coming from fifteen dwellings, are not definitive to propose that differences of indoor environment exist amongst archetypes. The same applies for the results of the building features.

For the actual energy consumption, the readings varied greatly among archetypes. From a lowest reading of 81 kWh a month, up to 617 kWh and gas varied from 9 m3 to 624 m3 per month per person. By treating the archetypes as case studies, from least wasting to most wasting, the archetypes can be ranked as 3; 1; 5; 2; and 4.

The sentiment analysis should also be assumed as individual case studies. For the psychobehavioral topics, in general, which include energy awareness, general home comfort, and control, all archetypes had relatively positive attitudes and opinions, except for archetype 3, which had negative ones. For the topics regarding different elements of their home (freedom at home, lights, temperature, smells, cleanliness, noises, privacy, and security), both archetypes 2 and 3 expressed positive attitudes and opinions. However, 1, 4, and 5 were either neutral or ambivalent.

Part 4 - (see Chapter 5)

- How do the occupant profiles differ in their "home comfort experience"?
- How do occupant profiles perceive their own "experience of using energy in their homes"?

A focus group with generative techniques was conducted to answer these questions. Seventeen participants, who had also responded to the questionnaire before, were recruited to take part in the focus group sessions. The focus groups had two generative activities, one for the meaning of energy use at home, and the second for expressing their ideal home experience. The generative techniques were designed with the creation of collages: participants were given materials with visual stimuli to express their feelings about the topics.

The analysis was done by transcribing their explanations and analysing the collages with content and thematic analysis, and eventually by creating affinity diagrams showing the relationships of the data found.

The affinity diagram generated two main categories: building themes and human themes, containing five sub-themes (home, financial, energy, psychological, and behavioural aspects). The analysis shows that per archetype, each one expressed different needs in terms of an ideal home experience as well as different meaningful aspects of experiences of using energy in their homes.

The findings of this study specifically show that for energy aspects, Archetype 4 is concerned about wasting energy, Archetype 5 about the technologies surrounding energy, while Archetypes 2 and 1 are neutral, and archetype 3 is focused on renewable sources. For behavioural aspects, freedom of action is important for Archetype 2, while Archetype 4 values social interaction and the rest of the archetypes put importance on the activities carried out at home. Psychological aspects, Archetype 5 values their lifestyle principles, Archetype 4 and 3 having sense of control, Archetype 2 finds feeling safe important, and Archetype 1 needs personal space. In the home aspects category, Archetype 1 needs a view to the outside; Archetype 2 needs the right size and layout, Archetype 3 values cleanliness, Archetype 4 values softness of materials, and 5 values aesthetics décor. Finally, only Archetypes 1 and 2 find finances important. Understanding this information is a first step to implement lines of action at home or to design interventions tailored to the archetypes understanding of energy and needs of comfort.

6.2.2 Answer to the main question

How can energy behaviours be studied from a comfort-driven perspective in order to facilitate the development of technologies that support more efficient occupant behaviours and that provide the comfort needs of the person?

The methodology used in this thesis was a mixed-methods approach, in which first, the quantitiave data was collected and subsequently the qualitative one was gathered. This sequence tends to be done in fields relatively new to qualitative approaches. The quantitative part of the research involved the administration of the questionnaire, which was developed from the extensive literature review. The results of the questionnaire were the basis for the qualitative part. The overall intent of this design was to have the qualitative data from the interviews and the focus groups explain and complete in better detail the quantitative cluster results by exploring the participants' views and mental models in depth.

The reasoning behind both kinds of data is because neither quantitiave nor qualitative data are enough to explain the trends and specificities of the challenge of comfort and energy behaviours (Ivankova et al. 2006). Yet, when integrating them to complement each other, a richer and stronger outcome can be reached. This project strived for such complementation of quantitative and qualitative strengths. For the qualitative part, it was decided to use interviews first and focus groups second. The reason for this is that each method elicits different types of knowledge: procedural and interpretive.

As this research is based on a human-centered design approach, talking directly with those that are being investigated is important to hear from them their opinions on the topic (IDEO.org, 2015). The interviews were conducted in the participants' own homes to learn about their mind-sets, lifestyle, and behaviours related to energy use and comfort-making. With the interviews, different insights are gained, and with the type analysis, it was learned about their opinions on comfort and comfort behaviours, their homes affordances, and their views on energy use.

The next method involved the focus groups, and specifically asking participants to produce collages. Making collages enables participants to think in other ways about the topic, and especially to express their feelings, values, and thought processes in relation to the use of energy, comfort, and what makes an ideal home (Sanders & Williams, 2002).

Five distinct archetypes were found: the Restrained Conventionals, the Incautious realists, the Positive savers, the Sensitive wasters, and the Vulnerable pessimists.

The Restrained Conventionals are the youngest group (mean age: 25.4 years). They reported to generally have higher-than-average negative emotions, and low positive emotions, while having high external and low internal control. They expressed positive opinions for energy motivations, comfort, and sense of control, but a general ambivalence of opinions about affordances during the interviews. They are the second lowest energy consumer with 366 kwh and 189 m^3 of energy monthly.

The Incautious Realists are the second largest and have a mean age of 27.3 years (SD: 9.3). They have the highest rating of negative emotions, while having low positive emotions. They score lowest in internal locus of control, and higher-than-average external control. Interviewees expressed relative positive opinions about their general affordance and psycho-behavioural topics. They are the second largest waster with 394 kWh and 419 m^3.

The Positive Savers are the oldest cluster (33.9 years). They show the second highest ratings in positive emotions, and lowest for negative emotions. They have the lowest scores in external control, and second highest scores in internal control. In interviews, they expressed very highly positive opinions about affordances and slightly negative ones about comfort and energy. They are the biggest savers with only 81 kWh per month per person on average and 9 m^3 of gas.

The Sensitive Wasters scored the highest in positive emotions, and the second lowest in negative emotions. They have the highest internal control scores and second lowest external control. Interviewees expressed positive opinions about comfort and control of the environment topics but negative ones about energy awareness, while half of their opinions about affordances were positive. They are the highest consumers with 644 kwh of electricity and 557 m^3 of gas.

The Vulnerable Pessimists scored the lowest in positive emotions and second highest in negative emotions, while having the highest external control scores, and second lowest in internal control. They expressed ambivalence on energy awareness, control of environment, and affordances, but positive sentiments with general comfort. They are the third largest waster with 324 kWh and 288 m3 according to energy readings.

To show a ranking of the archetypes in terms of actual energy use and of comfort needs, Figure 6.1 depicts such variables drawn from the results of the questionnaire.

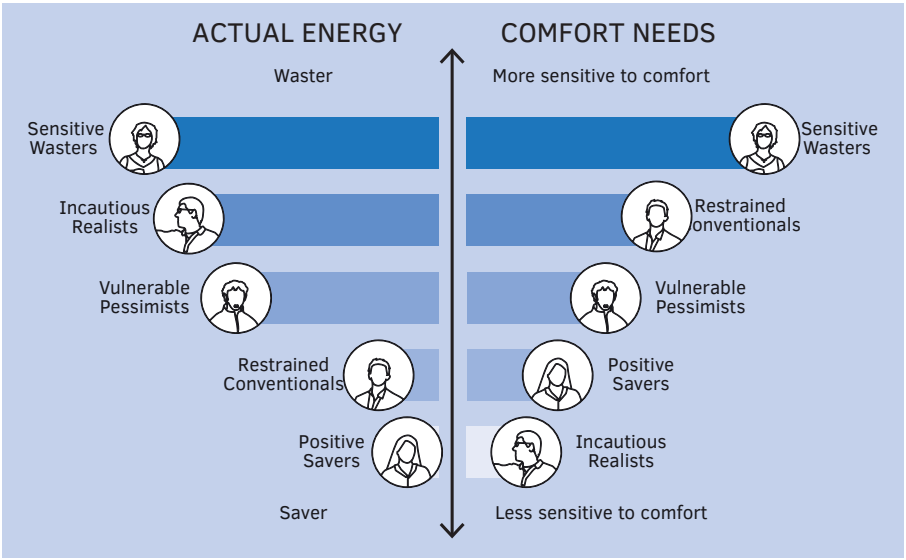

FIG. 6.1 Ranking of Archetypes for energy use and comfort affordance needs.

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The diagram shows the biggest energy waster and the biggest saver, juxtaposed with the archetype that needs more home features to feel comfortable. The diagram proposes that there seems to be a negative relationship between comfort and energy use, which is supported by the idea that, to be comfortable, energy has to be spent.

Finally, the results of the thesis suggest that the mixed-methods approach is a suitable approach to study energy and comfort, as these are fields that normally do not use qualitative data. Clustering the respondents of the questionnaire is a strong basis to build upon to create archetypes. Basing the qualitative methods on human-centered design techniques, with interviews and focus groups, is also an adequate method to study energy and comfort behaviours, because this allows getting to know the lifestyles, opinions, values, and processes in more depth of each of the archetypes and the differences among each other.

The archetypes produced in this work are not only supported by other studies of occupant profiles as shown in chapter 4, but they also show that each of them has different needs to feel comfortable, different behaviours to attain comfort, different attitudes towards energy use, and different ways of spending energy.

Finally, all results of the quantitiave phase –the statistical clusters- were integrated to the results of the subsequent phases, to create the final archetypes as shown in Table 6.1.

TABLE 6.1 Final characteristics of the archetypes

Archetype		Psychobehavioral factor	Description
Archetype 1	Restrained conventionals	Emotions	Low positive emotions, high negative emotions
		Locus of control	High external control, and low internal control
		Affordance sensitivity	Medium sensitivity
		Energy readings	Second highest saver
		Sentiments	Positive sentiments of energy, control, comfort, but neutral about affordance needs
		Experience highlights	Importance of outside view, personal space, social interaction
Archetype 2	Incautious realists	Emotions	Low positive emotions and highest negative ones
		Locus of control	High external control and lowest internal control
		Affordance sensitivity	Doesn't care about affordances
		Energy readings	Second highest waster
		Sentiments	Negative sentiments about comfort, positive about energy, affordances, and control
		Experience highlights	Importance of freedom of action, appropriate size and layout of home, but awareness of energy use
Archetype 3	Positive savers	Emotions	Second Highest positive emotions and lowest negative emotions
		Locus of control	Lowest external control, and high internal control
		Affordance sensitivity	Slight affordance indifference
		Energy readings	Highest energy saver
		Sentiments	Positive sentiments about affordances and comfort, negative about energy and control
		Experience highlights	Importance of cleanliness, feeling of control, cares about finances of energy
Archetype 4	Sensitive wasters	Emotions	Highest positive emotions, second lowest negative emotions
		Locus of control	Low external control, and highest internal control
		Affordance sensitivity	Affordances are very important
		Energy readings	Highest waster of all
		Sentiments	Negative about energy, ambivalent about affordances, and positive about control and general comfort
		Experience highlights	Need for feeling in control, furniture and décor, awareness of drawbacks of wasting energy
Archetype 5	Vulnerable pessimists	Emotions	Lowest positive emotions, high negative emotions
		Locus of control	Highest external control, low internal control
		Affordance sensitivity	Affordances are not important
		Energy readings	Third highest waster
		Sentiments	Positive about comfort and control, ambivalent of energy and affordances
		Experience highlights	Needs aesthetics of home, technology is important, perform habitual activities

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Details of the potential translations into design parameters of their specific comfort needs and energy attitudes are laid out in section 6.2.3.

6.2.3 Archetypal design parameters

This section presents a few preliminary concepts as to what environmental features are needed in the homes of each of the archetypes to save energy and to maintain their comfort. These design parameters are translated from the results of all the data gathered throughout this project; they are therefore conceptual.

The Restrained Conventional needs large windows allowing a visual connection with the outside. Because they value personal space and their own time but simultaneously they need social interaction at home, they need a home whose plan allows for a transition from private to more public. However, due to their low external control, this transition shall not be modular; the floorplan needs to be that way. Although they are not particularly aware of using energy, they are still conservative in their consumption, likely because their finances concern them. To boost their energy savings, this archetype can be given real-time monetary readings of their expenditure.

The Incautious Realist emphasizes the importance of size and layout: they need order and special places for particular things; therefore, a home whose layout is modular and can convert the function of a space into another one. The occupant should be able to modulate this on their own, as they have a high need to control. They also emphasize that they need safety: in design terms, this can be translated to haptic locks in the doors and windows or modular window frostings, which also will satisfy their need for control or as an app showing which doors and windows are open. As this is the archetype with the highest financial concern and second highest wasting patterns (yet well aware of it) but with high need for control, their homes can be equipped with a 'control station' where they can see the financial savings they make when they perform different actions, such as turning lights off, heating one room only, etc.

The Positive Saver feels comfortable with cleanliness and orderliness. As a result, their homes need materials and surfaces that are easy to clean and reach, and places for orderly storage. In addition, they emphasize a need for their activities at home, from hobbies to relaxing, reading, or dining: they need a home that allows this in an orderly way and without feeling constrained. They are the highest energy savers, however, financial aspects are not important, rather, they have green attitudes and

save energy for its own sake: this is a reason why they mention to wish to have a home powered by renewable energy. Because they also need control, care about the environment, and need cleanliness, their homes can have a smart system (similar to Keyson and Herrera, 2017), reminding them of cleaning schedules, and how their energy actions influence the environment.

The Sensitive Waster shares several similarities with Archetype 3 (the positive saver). They emphasize a need for soft tactile sensations, thus soft upholstery in their living rooms, studios, and bedrooms. They need appropriate spaces in the house for their personal activities from playing instruments to inviting friends; however, they can perform this in a single multifunctional space but with the adequate affordances depending on their activities. Similar to Archetype 3, they have a high need to control their environment and green attitudes; yet, they are the biggest energy consumers of all. Because for them finances are not a priority but saving the environment is, a feedback device can be designed for them to see a balance between their energy use, their actions, and the repercussions they have on the planet.

The Vulnerable Pessimist values the aesthetics of the house, and is a technology savvy homeowner that wants gadgets in their homes. This archetype places the emphasis on the community, rather than the house itself, and hence seems to prefer interconnected compounds that allow interaction among homeowners. Finances and energy are not their concern, and are midway between savers and wasters. Although they feel they cannot control their environment, they see control as something they could have, and as result need empowering tools. One of these can be small communal living, in which they can compare consumption amongst the different occupants, which could encourage energy savings.

6.3 Limitations

The basis of the thesis was on the respondents to the questionnaire. It was administered to a sample of 761 respondents, including bachelor and master students, and staff members from Saint Gobain Recherhe and from the Applied Sciences faculty of the TU Delft.

This makes the sample population non-representative, as it is too young, it has a proportionally too high an education, and the average housing type is

not represented, and is culturally heterogeneous. Therefore, in the future it is recommended to administer the questionnaire to a wider audience in terms of demographics (education, age, background) and also in terms of sample size. Widening the target group could result in different archetypes, however, large differences should not be expected as the number of archetypes, and their characteristics are comparable to what can be found in the current literature (chapter 4).

A larger sample in the field study is especially important to be able to make statistical relationships between the occupants and their building features in the current context. Similarly, the main improvement for the interviews themselves is to have a larger sample (Mason, 2010). For the analysis type, in this work the sentiment analysis was performed. However, several other methods exist to analyse interview transcriptions, and they should be experimented with. Some examples of other analysis techniques that could be used would be affinity diagramming, other types of text mining or computational linguistic techniques, or recursive abstraction. The choice depends on the data to be extracted and whether the analysis is qualitative or quantitative (Leech & Onwuegbuzi, 2008). In this study the choice of this method was to bring objectivity to the analysis, knowing that upcoming studies (Chapter 5) would be purely qualitative.

For the IEQ monitoring, it is recommended to take the measurements for longer periods -from two weeks to a month- as is typically seen in the field, although no standard protocol exists for this. Additionally, the readings were made during the summer. The reason for doing this was to avoid the typical results with thermal comfort and heating energy consumption; and to limit the energy use variables to only what the person consumes in the summer excluding heat. However, it could be beneficial to perform the field study and the readings in different seasons, not only to include heating factors, but also to find out potential behavioural changes related to the seasons.

For the focus group, more participants are needed, as it would lead to more data that would be easier to relate to the archetypes, and more data would enable generating stronger design concepts during the ideation phase in the future. The right amount of participants can only be determined until data saturation is achieved (Guest et al. 2006; Mason, 2010).

The final limitation is with the assessment of habits. It was explained that habits are responses that are semi-automatic and highly unconscious, frequent, and contextual. The questionnaire assessed habit strengths with the Self-Report Index of Habit Strength, which gives an ideas as to what may be habits exercised by the

respondents, but it is not known whether these are real habits, as they are difficult to self-report, due to their unconscious and automatic nature. Similarly, in the interviews and the generative sessions, habits were assessed by asking questions and by requesting to fill out the diary in the sensitizing booklet. Yet, none of these ways are completely successful to capture the habits themselves. Literature suggests that for daily habits, self-report can capture habit strength, but direct assessment of the context and response, are the most valid ways to capture. This can be done by in-situ observations or video recording, which brings ethical questions for the study of habits in homes.

6.4 Future process recommendations

The research resulted in five occupant archetypes. For each one of them, there are large amounts of data that can be translated into design parameters, and eventually into concepts, and future customized products, services, or systems that will support the archetype's behaviours, save energy, while satisfying their comfort needs and expectations.

In the human-centered design process, what has been done in this work can be viewed as the first phase of the process, where empathy with the occupants is gained by learning about them, and where points of views based on their needs are constructed. The typical stages following those steps are to ideate, prototype, and test (IDEO.org, 2015, Brown, 2009).

In ideation, what has been learned from the archetypes in the questionnaire, interviews, and focus groups has to be shared with a multidisciplinary design team comprising different stakeholders (occupants, designers, contractors, architects, etc), to make sense of all the data to identify design opportunities, by brainstorming an coming up with creative solutions (IDEO.org, 2015, Brown, 2009).

Next, the best solutions should be further developed into design concepts, and eventually into prototypes. In the prototyping phase, the main components of the design concept are built, by always keeping in mind that such components need to satisfy the behavioural and comfort needs of the archetype. It is at this stage that further physical and technical characteristics are developed, as to how the idea works (IDEO.org, 2015, Brown, 2009).

In the testing stage, the built prototypes are tested with participants from the archetype that the solution is designed for. During the testing, the response of the user has to be monitored to assess if the solution responds to the initial problem found for the particular archetype. Testing can take time, especially if it is a system or service that is being assessed (IDEO.org, 2015, Brown, 2009).

Once these new products, services or systems are in the market, and an "archetype-environment" model exists, architects, engineers, or contractors can administer the questionnaire to the future occupant, so they know which archetype the future occupant belongs to, and then they can implement those products in the homes were the occupants will live.

6.5 Future research recommendations

As previously laid out, this work acts as a pathfinder for future research in the field of IEQ, and therefore this work can be used as a guiding framework for future research of comfort and energy behaviours.

The recommendations are listed below in chronological order:

1. Be presented with instant result after taking questionnaire
2. Increase number of respondents
3. Increase number of field study dwellings
4. Increase number of interviewees and focus group participants
5. Carry out ideation, prototyping, and testing phases
6. Develop an 'archetype-environment' match matrix.

For the last point, developing the archetype-environment needs the following approach. Archetypes may be dynamic over time, and as a result, longitudinal studies should be performed, thus studying the same group of people over a longer period. The objective of this is to observe not only how the archetypes change behaviourally but also in terms of their responses to other environmental stressors. Therefore, their environment has also to be monitored parallelly in the long term. Such study should, similar to the present work, be a mixed-methods triangulation, in which both qualitative and quantitiave data are gathered in a parallel fashion, to validate and confirm each other. As a result, during a long period, at different points,

environmental data has to be monitored (beyond the IEQ factors) while also taking into account what the archetypes say in interviews at different points in time.

The value of a longitudinal triangulation is that it can enable to better develop an archetype-environment system, in which archetypes are the conglomeration of qualitative and quantitative studies (behavioural, self-reported, and physiological) and the environment are also patterns of environmental stimuli (both negative and positive) varying from chemical to physical.

This archetype-environment system would therefore allow knowing what different types of persons need to thrive and be healthy and comfortable. It would also allow what they do not need and what may affect their health negatively, and how to change the environment accordingly over time, as the archetype evolves (Bluyssen, 2019).

6.6 Implications

This work shows that by stepping back from the traditional ways in which the topic is studied opens up the space for new techniques and results, and hence different views and knowledge of home occupants, their energy-consumption patterns, and comfort behaviours. By drawing inspiration from a human-centered perspective, this work shows the first phase before ideating better-performing energy-saving technologies, because in this way, we learn how to better understand home occupants, their lives, hopes, desires, which teach us how to tackle the energy challenge.

As a result, with the methodology of this work along with its individual results, it is shown that:

- Qualitative methods can be used to study comfort-making energy-consuming behaviours,
- Home occupants can be grouped into types of differing psychobehavioral characteristics.
- The methods used in this work are reliable to find archetypes.
- The archetypes generated match profiles performed in other studies (chapter 4) albeit; the ones in this work are more comprehensive.

This work is a first attempt in the IEQ field and the energy engineering field to develop archetypes in this comprehensive way. This was done by taking into account the factors used in this study and to use further qualitative data to strengthen the clusters, the work acts as a pathfinder to improve the study of comfort, energy, and technology development with an innovative technique.

Practical implications of this work are the following: for the design of buildings, for the existing stock, and for simulation and predictions. The archetypes can be used in prediction making models, in order to enter different behavioural variables, to make more accurate simulations. For architects, it can make the design process more inclusive a participatory. By knowing what archetype their clients belong to, architects may be able to make better decisions based on real needs, eliminating desirability bias. In the existing housing stock, especially for housing corporations (i.e. containers, old office buildings) knowing what the archetype of the future occupant can help to customize the spaces with specific appliances, interfaces, or feedback information that will help save energy while improving comfort. Furthermore, knowing the archetype of a future occupant can also help allocate or select different types of future occupants into the existing housing, depending on the characteristics of the current location.

As far as policy is concerned, the results of this study suggest that energy efficiency policies and programs should provide the option for stakeholders involved in supply, feedback, and interfaces of technical devices to better adapt to the archetypes' needs and requirements. Policies and programmes to reduce energy consumption in residences should also encourage the research and design of the technologies to accommodate the needs of the different archetypes, so as to give final occupants more 'flexible' technologies fitting their comfort and energy behaviours. Having the archetypes, can therefore allow for closing the gap between occupants and energy.

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