VELUX Renovactive
User experience and post-occupancy evaluation

Final Report on the Sociological Monitoring
May 2017 – June 2019

03.03.2020

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Executive summary

In 2013, Velux announced the start of a climate renovation project in which efficiency of space and energy, affordability and an easily reproducible approach would be central. A house was selected in a Brussels neighbourhood, which was subsequently renovated. The renovation should lead to an optimal use of daylight and natural ventilation.

The house, called Renovactive, was opened to visitors in 2016. In May 2017 a family moved into the house. The house and the family were monitored by both sociologists and technical engineers. While the engineers undertook the task of checking all the physical/sensor data and the performances of the house, the sociologists were focused on the occupants’ perspective, their personal experiences and assessments with the house. With this crossbedding, VELUX wanted to evaluate whether the conceptual design of the house lives up to its promises. This report refers to the sociological perspective of the research program and tries to give an overview on how the family is perceiving the Renovactive house, being their new house. It attempts to find answers on the following questions:

1) How is the perception of the living comfort and the satisfaction of the occupants?

2) How do they deal with the technical infrastructure and adopt the operating system?

3) Is there a noticeable change in the health and the sleep quality?

4) How does the house affect the family’s behaviour?

The sociological monitoring took place between April 2017 and June 2019. During seven different measurement points, both the father and the mother were asked to complete both an online diary and a questionnaire, as well as to participate in an in-depth interview. The first measurement took place in the family’s former home. The remaining 6 measurement points took place in respectively Autumn 2017, Winter 2018, Summer 2018, Autumn 2018, Winter 2019 and Spring 2019. This approach attempted to gain an insight into the evaluation of the house by the family over the different seasons, and did also allow for a differing evaluation immediately after moving, and at later moments when the family had adapted to the new living environment.

When interpreting the results, it should be taken into account that the family has a very negative image of their former home. During the before interview, the family complained about several significant deficits they experienced, such as a lack of space, mould, bad insulation, insufficient heating, humidity, a lack of privacy, and poor noise insulation. Therefore, the level of comfort increased substantially when they moved into the Renovactive house.

The results show that the family is very satisfied with the level of indoor comfort. In both the questionnaire, the time diary as well as during the interviews, the family stated that they were very happy with the indoor temperature, the indoor air quality and the natural light. Especially in comparison with the evaluation of the indoor comfort in the former home, a big difference was noticed. Only the indoor air quality was assessed suboptimally during the Autumn 2018 and Winter 2019. During the interviews, the family clarified that this was due to a draught they experienced at night in the bedrooms. With regard to space and layout, the family indicated that they are very satisfied. There is generally enough room for the family and the layout ensures that the house can be used optimally. The house, according to the family, only lacks a storage for bicycles and a stroller.

To further improve the level of comfort, the family had various options to adjust appliances manually, such as opening windows, lowering sun blinds, adjusting heating and ventilation, ... Besides the daily adjustment of the heating in the bedrooms during winter, and the opening of windows during cooking and cleaning in order to let the bad air out, not many adjustments were made to improve the indoor climate. The sun blinds were
mainly used for privacy reasons (so that passers-by cannot look inside) and the ventilation system as well as the home automation system were mainly left untouched. Towards the end of the monitoring, it became clear that the family relied too much on experts to manage the system. If there were problems, it was always possible to call someone who solved it for them. They never went in search of solutions themselves, because they feared causing more problems. The family fears that they will be left on their own now that the monitoring has ended, whereby they themselves cannot anticipate in the event of problems. The comfort behaviour of the family cannot always be understood as instrumentally-rational behaviour in function of improving the indoor comfort. The family intentionally, and unintentionally behave sometimes differently. This can be to achieve other goals, such as protection of their privacy, or out of habit.

With regard to health, the family seems to have improved. The mother reports a positive development on her state of health. She reported to suffer from irritated airways in the former home because of high humidity during winter. This has disappeared. The perceived health condition of the father was already excellent in the former home. What is, however, really remarkable is the vanishing of sick-building-syndrom related symptoms since the family moved into the Renovactive house.

The quality of sleep has also been greatly improved since the family moved in. In the past, the family reported a lot of disturbing causes, such as a low indoor temperature, noise intrusion, the absence of ways to keep out the light, as well as having to share a bedroom with their daughter. The diaries made clear that since they moved, only the nocturnal hunger of their youngest daughter is getting in the way of a good night’s sleep. Temperature, light and sound intrusion are no longer obstacles that impede the sleep quality in the Renovactive house.

The move has thus had a major impact on the family. The mother noted that the children play much more with each other. The garden is also regularly mentioned as a reason for this. During the interviews, it also became clear that the family receives more often friends at home. Interviews were regularly interrupted because friends came by. This was not the case in the old home. The family indicates that this is mainly due to the fact that the Renovactive house is much larger, as well as, contrary to the former home, that one does not disturb the neighbours here.

In general, home satisfaction is therefore very high. Nevertheless, the family indicates that a number of things can be improved. For example, the windows should be equipped with mosquito nets, which prevent insects from entering while windows open automatically during the summer. The family also wishes that the windows would be equipped with a system that detects gusts of wind. In that case, the automatic windows should close, to prevent doors from slamming, especially at times when children are present.

All the results highlighted in this report indicate the positive effects of the Renovactive concept. The family indicated that they are very happy with the indoor climate, such as the indoor temperature, air quality and natural light. During the daily life, not many adjustments are needed to the automatic system. The family does indicate that they were sometimes dependent on others to solve technical problems. They fear that they will not be able to fall back on this after the monitoring. The health and sleep quality of the family have improved considerably since they moved in the Renovactive house. They also report that their family life as well as social contacts outside the family have greatly improved.
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1 Introduction

After completing the successful Model Home 2020 project the Renovactive project aimed to test the Active House principles in social housing and single-family homes where cost, comfort and energy efficiency have to go hand in hand. This involved the construction of a one-family house in Brussels, which was not only supposed to achieve high standards on energy consumption and an improvement of the occupant’s wellbeing, but also to fulfil the norms of Belgium’s social housing system. The idea was to combine aspects of sustainability and liveability in a low-cost version to build an affordable home that was good for the environment AND for the people who live in them and could be transferred to a larger scale. Seven elements for affordable climate renovation were tested and the goal is to take them from prototype to stereotype. Fresh air, a lot of daylight and open space were the main components of the architectural concept and were believed – along with others – to increase the occupants’ satisfaction with the buildings.

But the Renovactive project was more than just designing a social housing building of the future. It was conceptualised as a living-experiment where a test-family moved into the houses for a defined period of time and was monitored by scientists – both: engineers and sociologists. This way VELUX wanted to evaluate if the conceptual design of the house would live up to its promise. While the engineers undertook the task of checking all the physical data and the performances of the houses, the sociologists were supposed to take a look at the occupants’ perspective, their personal experiences and assessments and their interaction with the buildings. More precisely the monitoring of the Renovactive home wanted to find an answer to the question, if it is possible to build affordable sustainable houses that fulfil the growing demand on energy-saving technology and also create an increase on the living comfort?

In architecture it is common to use social performance standards to define comfortable living conditions. The achievement of pr-specified values for lighting, temperature, air-circulation and other parameters are supposed to evaluate a building on its liveability – regardless of the people’s actual perception inside these building. But to take the term ‘evaluation’ seriously, there is a need to measure the occupant’s reaction on the building – only this way you are able to draw conclusions on the effect sustainable housing has on the people’s well-being. Therefore, this report refers to the sociological perspective of the research program and tries to give an overview how the family is perceiving their home. It attempts to find answers on the following questions:

1) How is the perception of living comfort and the satisfaction of the occupants?
2) How do they deal with the technical infrastructure and adopt the operating system?
3) Is there a noticeable change in the health and the sleep quality?
4) How does the house affect the family’s behaviour?

2 Methods

The sociological monitoring was taking place for about 24 months and included three different instruments of data collection and several data collection points. There were face-to-face-interviews, online questionnaires and a time-diary-instrument. These three instruments were linked together and each is referring to the other. About two weeks after filling in each questionnaire the adults of the family were interviewed in a face-to-face-interview by one of the scientists, directly after the interview, both adults were asked to fill in a time diary for a one-week period. All three instruments serve other purposes.

The online questionnaire was used to quantify the opinions, level of satisfaction and comfort behaviour of the dwellers. These data can also eventually be used as a comparison with other families. The answers of the dwellers were also used as input for the face-to-face-interview. Especially complaints of the family were usually discussed more in-depth during the interviews. The interviews served furthermore the purpose of
clarification of various points, like comfort behaviour and the actual experiences of specific comfort related situations. The online time diary gave us a detailed view on how the house is used and where the family spends most of the time. Each activity that was registered was followed up by a supplementary short questionnaire. This questionnaire asked how the comfort is perceived during the activity, what they did in order to further improve their comfort during the activity, where they were during the activity and with whom. Sleeping activity was followed by a more specific questionnaire, asking the family how they rate their sleeping quality.

There are several data collecting points:

1. Before (in the family’s former home) – questionnaire and interview
2. Autumn 2017 – questionnaire, interview and time diary
3. Winter 2018 – questionnaire, interview and time diary
4. Summer 2018 – questionnaire, interview and time diary
5. Autumn 2018 – questionnaire, interview and time diary
6. Winter 2019 – questionnaire, interview and time diary
7. Spring 2019 – questionnaire, interview and time diary

For the before interview, we opted for a combined interview with both parents. This was done in order not to overload the family with questions and to get used to each other. We soon discovered that the father is very talkative, which meant that the mother did not have much opportunities to give her opinion. We also experienced that the mother has different opinions as the father. We therefore decided to do separate interviews with them starting from the autumn 2017 interview. For the winter 2018 interview we also conducted a separate interview with the oldest child of the family. This was done mainly because of the specific comfort situation of the attic, where the child sleeps.

This report covers the data of the whole monitoring period.

3 Results

When interpreting the results, we have to take into account that the family’s former home was in a really bad condition. In the before interview the family complained about several significant deficits they experienced in the old house, for instance bad insulation, insufficient heating, dampness and poor noise insulation. Therefore, the level of comfort increased substantial when they moved into the Renovactive building, leaving not much space for critical assessments of the house or its parameters. This is well illustrated by the father during the Spring 2019 interview, where he compares the old house with hell, whereas he describes the Renovactive house as the paradise: “Écoutez, c’est comme si, voilà, c’est comme si vous êtes au paradis et on vous dit “voilà, retournez à l’enfer”, c’est pas possible. […] Le paradis, vous avez tout, vous êtes libre, vous avez suffisamment de ce que vous voulez, tous vos besoins sont satisfaits, vous avez une vie normale, noble, tandis que de l’autre côté, c’est la souffrance.” This, of course strongly affects the results of the online questionnaire, where one can easily see that there are big differences between the before interview on the one hand and the other interviews on the other, whereas there is only minimal variance between the data collecting points in the new house.

3.1 Perceived level of comfort

In the online questionnaire both parents stated high satisfaction with the indoor temperature, the indoor air quality and the natural all through the year (Figure 1). Only the air quality during the second autumn and winter seemed to be suboptimal – a result, that needed to be clarified during the interviews.
They were also asked about possible discomfort and if they have been bothered by anything recently. Analysing the results in Figure 2 – Figure 4 there has been an improvement in many aspects due to the Renovactive building. While both parents complained a lot in the online questionnaire filled in while still in their old house, most of the bothering aspects disappeared after moving. Especially the room temperature and the air quality seemed to have improved. In detail:

1) While there had been little complaints in the first few questionnaires about the temperature being too high sometimes, this constraint disappeared in the second half of the monitoring.

2) Both parents were never bothered by cold temperatures in the house which indicates, that the heating was working properly.

3) After the first year none of the parents complained anymore about varying room temperatures, so this wasn’t a problem to them.

4) The mother and father sometimes perceived the amount of daylight in the house being insufficient. While, based on the questionnaire, there seem to be no relation to the season of the year, the family seems to relate this to the different seasons during the interviews.

5) Stiffiness, damp and draught were no longer a big problem in the Renovactive building. Only in the second winter both parents sometimes experienced draught in the building.
6) Sometimes both parents still seemed to suffer from dry air and dust.
7) There was no disturbing noise from the outside or the technical appliances.

It is already noted before, but in order to fully understand the views of the family, it is important to take into account that the family has very negative views of their former home. This, of course, affects their views as expressed during the interviews. During the before interview, both parents considered the indoor comfort as catastrophic: “Ici, franchement, c’est catastrophique [...] ça n’a pas été vraiment du tout agréable” (father, before interview). The family mainly referred to the indoor temperature as well as the humidity as the main problems in their former home.

It is also noteworthy that both the father and the mother said that a comfortable indoor temperature in winter is the most important aspect of housing. During the project, they did not alter their view and are still convinced that this is one of the most important factors that affects their perceived level of comfort. While the indoor temperature was very bad in their former apartment, they reported to be very happy with the temperature during winter, even during very cold days, in the Renovactive house: “même si il fait trop froid, nous, on ne le sent pas. Tu le sens ici, si il fait trop froid, tu ne le sens pas. Tu as vraiment une température qui est adaptée. Donc, voilà, regarde, ici, il fait vingt-trois, donc je crois, que voilà, vingt-trois, c’est normal, regarde déjà comment on s’habille, c’est rez-de-chaussée. Imaginez, je suis bien, moi, où on habitait avant, on ne pouvait pas s’habiller comme ça pendant l’hiver. Donc, c’est dire que voilà, la température est adaptée, il n’y a pas de problèmes” (father, winter 2018). As in the questionnaire, they never complained that it was too cold in the house during the interviews.

Besides a problematic indoor temperature in the old house, the comfort of the family was further limited by a lack of space and privacy. Their oldest daughter had to sleep in the sleeping room of the parent due to a lack of space and the neighbor was always complaining about the noise they were allegedly making. This combination led them to the conclusion that they couldn’t stay anymore in the former house: “Tout ça, c’est une maison qu’on savait qu’on ne pouvait pas y rester. Ce n’était pas vraiment une maison pour nous, donc il fallait partir” (father, before interview). After the family moved out, they report a much better indoor comfort: “Ici, il n’y a pas d’humidité ici [...], c’est nickel” (father, autumn 2017). The mother confirms this: “La qualité de l’air, c’est parfait, on est tranquille, il y a pas trop chaud, il y a pas trop froid, c’est normal. [...] Tout est, le confort est parfait pour moi” (autumn 2017).

The complaints about the high temperatures in the Renovactive building are about a period in July-August 2017 where the temperature in the house was too high, especially in the attic. According to the family the temperature did rise up to 30-32°C (later, especially during the spring 2019 interview, the temperature during that specific summer had risen to 60°C, according to the family) in the attic, whereas in other parts of the house it was up to 24°C. During later interviews, the family did not complain anymore about high room temperatures. The problem in the attic has been fixed by an external sunblind: “c’était plus de 60 degrés au grenier, il y avait un problème de fenêtre, de store. C’est pourquoi Velux, ils sont venus, ils ont renforcé la fenêtre en mettant des stores et tout ça. Sinon, [name oldest son, PtB], à un moment donné, il ne pouvait pas dormir donc je l’ai transféré au salon parce que là-bas c’était invivable” (father, spring 2019).

Except for this, no other big problems related to the indoor temperature were reported by the family. The mother reports the opposite: “le système de ventilation avec le chauffage, ça ne descend pas trop froid, trop chaud” (winter 2018). Concerning the varying room temperatures, she points out that the small sleeping room is heating up much faster as the other rooms. During later interviews, the family did not complain anymore about high or varying room temperatures.

Dust is also a frequent theme during the interviews. This was picked up after the family reported this problem in the online questionnaire: “l’air sec, c’est-à-dire, en fait, de temps en temps, il y a un tout petit peu de la poussière” (father, winter 2018). According to them, this problem is related to the ventilation system: “J’ai
compris que voilà, cela est dû à l'air qui peut-être se dégage au niveau des systèmes d'aération, qui, des fois, est un peu sec. [...] Je crois que c'est ça parce que le système de ventilation, il essaie de dégager l'air. Donc c'est tout à fait normal qu'on le ressente un peu parce que ça permet de dégager un peu l'air.” (father, winter 2018). According to the father, the sun blinds also help preventing dust: “quand on baisse le store un peu, ça permet d'éviter la poussière qui vient de l'extérieur” (winter, 2018). In the summer of 2018, in absence of the family, the whole house, including different aspects of the ventilation system, was cleaned. Ever since, the family does not report any problems with dust anymore. They, themselves, relate the absence of this problem to the cleaning during the summer: “Depuis qu'ils ont nettoyé la ventilation, à l'été, donc on était en vacances, il y a moins de poussière. Je crois qu'ils ont un peu renforcé la qualité du truc, la qualité de la ventilation qui peut-être permet d'aérer beaucoup, de souffler beaucoup afin de ne pas retenir la poussière dans la maison, il y a moins de poussière” (father, autumn 2018).

The remark about insufficient daylight during winter was also discussed during the winter 2018 interview. During this interview, the father explicitly states that this is not related to the house: “Pendant l’hiver, quand le soleil par exemple se couche à seize heures trente ou seize heures quarante-cinq comme ça, vous voyez, nous vivons dans l’obscurité de façon générale, je ne parle pas de la maison. [...] Donc, c’est de ce côté que s’il n’y a pas de soleil, c’est vrai qu’il y a une obscurité, donc qui empêche des fois d’avoir une lumière naturelle. » In the next quote from the same interview with the father, he states that, indeed, the house is not the problem: “Il y a suffisamment de fenêtres, il y a une, il y a deux, il y a trois, il y a quatre. Donc essaie d’enlever tous le rideaux de ces quatre fenêtres, directement tu vas avoir suffisamment de lumière et tu n’as pas besoin d’utiliser la lumière artificielle.”

We also asked the oldest child of the family about his opinion about the comfort in his home. First, we wanted to know what is really important to him when he had to build a home himself. These things were natural light, good indoor temperatures and enough available space. As a follow up question, we asked how he would rate the house on the level of comfort that it offers. This is, in his opinion, very good. When asked what he likes most about the house, he comes back to the same points: “C’est la lumière, j’aime la lumière, la temperature, elle est confortable pour... Et il y a aussi, il y a de l’espace pour jouer, pour... oui” (winter 2018).

The last point that was found in the online questionnaire, the absence of noise was confirmed by both parents during various interviews. During the first interview in the Renovactive house, they reported some noise from some alarm system. This went on for three days. The family did not understand why the alarm went off, neither did they know how to fix this. Fortunately for them, it stopped without any intervention: “vous voyez la semaine passée, il y a une machine-là et je crois que c’est l’alarme, c’est le boitier qui fait souvent le système d’alarme zéro, un système zéro, système zéro, quelque chose comme ça. Ça fait comme ça, mais ça résonne en, je dis c’est un peu bizarre. Et un peu après, je suis venu, j’ai trouvé que c’est le boitier de l’alarme. Et après trois jours, ça s’est arrêté. Et je sais pas pourquoi ça fait ça, je sais pas” (father, autumn 2017). During all other interviews, the family denied that they heard any noise, neither from technical appliances, nor from outside factors: “il n’y a pas de bruit à l’extérieur, donc tu entends rien, il n’y a pas de bruit” (mother, autumn 2018). We then asked very specifically per technical equipment if this caused noise. This was always denied: “Il n’y a plus de bruit, il n’y a pas de bruit” (mother, autumn 2018). Also note that the family did not look for a solution themselves in order to fix the noise. We saw this behavior more often. The family often relies on others to operate the technical appliances because they think they can break something and the system is still being operated by others. We will come back to this later.
People sometimes experience discomfort in their homes. Considering the following aspects, have you been bothered by one or more of them during the past four weeks?

a) Room temperature too high

b) Room temperature too low

c) Varying room temperatures

d) Insufficient daylight
People sometimes experience discomfort in their homes. Considering the following aspects, have you been bothered by one or more of them during the past four weeks?

- **e) Glare**
- **f) Stuffy "bad" air**
- **g) Draught**
- **h) Unpleasant odour**
People sometimes experience discomfort in their homes. Considering the following aspects, have you been bothered by one or more of them during the past four weeks?

j) Dry air

k) Dust and/or dirt

l) Noise from the outside (traffic, playground, industrial sites, bars)

m) Noise from technical appliances of the dwelling
3.2 Comfort behaviour

The behaviour of the family in order to improve the comfort at home was discussed in the interviews and the online questionnaire. To prepare the interviews and in order to fully understand the behaviour of the family, we applied the Talcott Parsons framework for action (1967). Every action, which he calls an unit act (A), consists of the following characteristics: a situation (S) in which we behave based on a goal that we want to achieve (E), based on conditions (C), means (M), normative or ideal elements (i) and symbolic expressions of normative or ideal elements (i_\text{e}). Adriaansens (1976) then schematically depicts the Parsons unit act as:

![Parsons unit act diagram]

A typical goal to achieve in the Renovactive house can be to achieve a good air quality (E), while cooking and unpleasant odours are released (S). One can opt to use a kitchenhood (provided that you have one)(M) or to open a window. The decision to opt for either option is dependent on the external conditions (is it raining?) (C) and to someone’s normative orientation, say, energy saving (i). The theoretical scheme was used in order to formulate the questions: When did you act like this, under which conditions, based on what norms and what did you want to achieve? The framework for action, however, suggests a rational consideration of someone’s behaviour. Very often, the family, however, could not provide logical explanations for their behaviour. Their behaviour could only be understood as behaviour out of habit. It is, according to Max Weber (1922), one of four types of social action. He makes a distinction between 1) instrumentally-rational, 2) value-rational, 3) emotional and 4) traditional behaviour. In their comfort behaviour, the family showed all four kinds of behaviour. Very often, discussions with the family started with findings from the technical monitoring, which found that the family showed other behaviour than the behaviour the technical monitoring deemed instrumentally-rational in order to improve the indoor comfort. We will discuss this in detail in this paragraph.

When asked about their behavioural routines to improve the comfort at home, the mother and father sometimes gave varying answers (Figure 5 and Figure 6). Mother and father seem to interact differently with the house and its technical infrastructure. There is also a change from autumn to winter. In detail:

1) While the mother was adjusting the heating system daily during the cold season, the father did so less often.
2) Both parents normally didn’t adjust the ventilation system but reported in the questionnaire that they did so in the second autumn of the monitoring. Later, during the interviews, they will nuance that.
3) The home automation system was mostly left on its own, only the father stated that he was changing the setting nearly daily during the second autumn of the monitoring. This was also nuanced during the interviews.
4) Cleaning seems to be part of the families daily routine.
5) The sun/view-protection (indoor and outdoor) was used daily, in autumn as well as in winter.

Figure 5: Actions to improve comfort at home I (red=father; blue=mother)
In the before interview, the family stated that there is no possibility to control the indoor comfort at all in the old house: “le contrôle, non, y a pas de contrôle. Le chauffage est allumé et laissé. On sait pas à quelle temperature on est, au niveau des CO2 on ne sait pas” (father). They also showed that there was too much natural light in the sleeping room in order to sleep well. To cope with this, the house did not have the right equipment. Therefore, the family decided to put up a blanket in order to block the natural light. When we asked them about their expectations about the new house, they were especially eager with the opportunities to take control over the indoor comfort: “La temperature est maîtrisé, tout est calculé, tout est réglé, vous pouvez régler votre temperature de la façon don’t vous voulez, c’est-à-dire pour notre bien-être” (father, before interview).

The house seems to meet up to the expectations of the family. They say that they are very happy with the indoor temperature and air quality. Concerning the temperature, the family stated in the interview that they do not feel the need to control the temperature on the ground floor. This heating system is always set on 23 °C. The father noted during the winter 2018 interview that there is sometimes a malfunction of this system, but he cannot exactly explain when this happens. If he notices a malfunction, he just presses one time with his finger on the screen in order to solve it. He never came back to this issue during later interviews.
When the mother states in the questionnaire that she is adjusting the temperature on a daily basis, she means the temperature in the sleeping rooms. The temperatures in the sleeping rooms are adjusted using the thermostat knob on each radiator. Interestingly, according to the father, the heating is only put up for 2 hours a day, whereas the mother says that she uses it for 4 hours a day. The technical monitoring confirms the duration that the mother states, confirming that, indeed, mainly she seems to adjust the heating system on a daily basis. According to the questionnaire and interviews, she only adapts the thermostat knobs during autumn and winter. In other seasons, she does not use any heating.

The ventilation system was almost never adjusted by the family during the project. There is no need to, as the mother states: “En fait, il n’y a pas beaucoup de choses à faire pour améliorer le confort parce que le système fait le travail. Les fenêtres s’ouvrent automatiquement” (winter 2018). Both the mother and father are very happy with the air quality. During autumn 2018, they reported to do some adjustments to the ventilation system as well as the home automation system, whereas they did not report any adjustments in other seasons. This gave rise to discussion during the interviews. This was also the time that the family for the first time noticed a cold draught in the sleeping rooms. Possibly they tried to make adjustments in order to fix this draught. During the interviews, both parents however declined doing much adjustments of the ventilation system or the home automation system. The father says that there was someone who came to install an application on his smartphone in order to adjust both systems. He only used this a few times, before he decided to delete it from his phone. He did not do this because he was unhappy with it, but the more because he felt that putting personal apps on his work cell phone was not really appropriate: “La ventilation, oui, avant au début, il y a un qui est venu ici et je sais pas si c’est [name technician, PtB], ou comment il m’avait montré, on avait même installé, on fait l’application sur mon téléphone de travail mais il est déjà désinstallé parce que c’est un téléphone de travail. Et mon téléphone privé n’était pas adapté à cette nouvelle application. Donc il m’avait montré comment il fallait régler, c’était simple, magnifique, cool, c’est facile à faire, il suffit juste d’envoyer à un niveau qui te permet d’avoir une situation normale de chauffage. Mais j’ai plus l’application quoi parce que c’était le téléphone du travail” (father, autumn 2018). Note however that he learned to appreciate the application during the short time that he used it. He describes it as cool, simple, and easy to use. To get some more concrete information about the usage of the ventilation system, we went more into detail about this. He describes his adjustments and control over the ventilation system as something that works automatically. It is controlled by a company: “Au niveau des ventilations, pourquoi je dis qu’on a la maîtrise, on a le contrôle ? C’est parce que, c’est-à-dire, c’est fait de façon automatisée, c’est contrôlé par une société. C’est de ce côté que je me base pour dire qu’il y a le contrôle, parce que si tu vois sur le questionnaire, tu ne peux pas dire qu’il n’y a pas, soit tu dis tu contrôles ou tu contrôles pas. Ce sont les deux réponses qui sont là quoi. Il n’y a pas de justification tu ne peux pas justifier. S’il y avait une partie où tu peux justifier, pourquoi vous contrôlez, comment vous contrôlez ? J’aurais préféré cette question. Vous contrôlez ? Oui. Comment ? À travers une société qui gère le système de ventilation” (father, autumn 2018).

Cleaning is something that the family reports to do daily. With cleaning they mean that the rearrange stuff in the house, and that the mother scrubs the floor on a daily basis. However, there seems to be a discrepancy between what the family does in order to clean the house, and what some experts affiliated to this project seem to expect from the family. Daidalos reported that for example the solar panels are almost never cleaned. This leads to a lower performance. Indeed, while asking the family what they did while cleaning the house, they never reported to clean the solar panels. Also, the ventilation portholes do not seem to be cleaned very often according to Daidalos. This was discussed various times with the family. During the spring 2019 interview, the mother reported to clean the portholes sometimes, but could not say exactly how she does this. When asked about the frequency of her cleaning the portholes, she says that it happens once every month or every two months, but only when necessary:

Interviewer: “Est-ce que vous nettoyez souvent le système ?”
MOTHER: “Pas souvent, on nettoie quand c'est nécessaire.”
Interviewer: “Ok. Et combien de fois est-ce nécessaire par an par exemple?”

Mother: “Par an peut-être une fois par deux mois, ou une fois par mois.”

Interviewer: “Une fois par deux mois. Et le nettoyage des bouches d'aération au-dessus des fenêtres ?”

Mother: “C’est [name father, PtB] qui fait ça donc. Moi je nettoie le sol, tout.” (Spring 2019)

This quote makes clear that cleaning, according to the family, mainly means that they are mobbing the floor, and that they do not really think about cleaning the technical equipment.

The sun protection is used very often. At first, this system worked completely automatic, but this was manually changed by the family in order to cope with their privacy concerns. Figure 7 gives an overview on the reasons, why sun protection was used. To increase the level of privacy seems to be most importantly, followed by the wish to prevent glare and to keep the house cool. The wish to keep the light out is normally no reason for using the sun protection.

Indeed, when the theme of the sun protection comes up in the interviews both state that the main reason for using is their privacy concerns. These concerns are related to the work experience of the father. He sees a lot of theft during his work for a social housing company and therefore feels the need to use the sun protection so that strangers cannot see his possessions in the house: “Pourquoi, je baisse un peu, je baisse le store? C’est pour une mesure de sécurité. Faut pas qu’il voit, que c’est un jeune mal intentionné voit ça, il pense que y a pas ce qu’il y a pas à la maison, un jour il vient, il essaie de casser. C’est pour ne pas les inciter à vraiment, parce que moi je travaille, je suis [job title of the father, PtB]. Je vois de temps en temps le vandalisme ou vraiment le cambriolage qui se fait dans le quartier” (autumn 2017). During our visits at the house, we noticed that it is mainly the sun protection in the eating room that is down due to privacy reasons. The sun protection in the living room was never down during our visits. The usage of the sun protection gave a lot of discussion, as the behaviour of the family was, according to the technical monitoring team not instrumentally-rational when one would achieve a better indoor comfort. The family, however, makes a different priority setting. For them, safety in this case is a rational motive (although based on emotions) and they consider this more important than keeping the sun out.

Besides these privacy reasons, the family also said that they lower the sun protection to keep the sun out. When the family states that they use the sun protection in order to keep the house cool, they mainly mean that they use the sun protection in the attic. This is related to the earlier comments that especially the attic becomes too warm according to the family: “On baisse le store, pour calmer le soleil un peu […] Ça fonctionne bien. Déjà pendant tout l’été, pendant tous les mois d’août, ou juillet, août, on baissait presque le store, pour vraiment, pour avoir vraiment une température normale dans la maison. Parce que les vitre, ça projette de la chaleur encore, oui (father, autumn 2017).
Regardless the automated ventilation system, airing out by the windows is still part of the daily routine of the family (Figure 8).

The before interview made clear that the family was airing out every day in the old house in order to cope with the humidity. This was done by opening the windows for two hours every day. They did this during the whole year, even in winter when it meant that it became colder. The pattern has somewhat changed after they moved out. It seems that it is not as necessary to do so as before.
As asked about the reasons why airing out, there doesn’t seem to be a hierarchy of motives for none of the parents. Cooling down the house is just as relevant as letting out smelly or unhealthy air (Figure 9). Only dampness is less often a reason to air out. It seems like the need to air out decreased since they moved into the Renovactive house.

During the interview, we talked in detail about their habits and motives to air out. We had a strong impression that the family at first could not give a proper explanation for their habits:

Mother: “En fait, on ouvre un peu les portes chaque jour pour les, comment on dit ça, le vent rentre un peu dans la maison.”

Interviewer: “Est-ce que c’est nécessaire?”

Mother: “Non, en fait, moi, j’aime faire ça donc je ne sais pas.”

Only after specifically asking her whether or not she opens the windows to let out the smelly or unhealthy air, she confirms that she airs out during cooking and cleaning for these reasons. We suspect that the family indeed airs out when necessary, but besides this, still have the feeling that opening doors and windows gives them some “extras”. The family cannot motivate this in more detail. The mother explicitly states that opening the windows does not further increase the indoor comfort: “En fait, c’est la même chose, c’est juste pour ouvrir un peu pour sortir les, si j’utilise la cuisine, les fumées, c’est juste pour ça” (winter 2018). Here, too, the family behaves differently than the technical monitoring team would like to improve indoor comfort. That is why certain actions regarding the opening of the windows and doors (that was often unnecessary due to automatic opening of windows) were discussed into detail. Here, the family just seems to act out of habit for which they cannot provide a reason at the point of acting.

Figure 10 give information on the situations, when the family was airing out through the windows. It affirms the assumption that the need to air our decreased in the new home. In detail:

1) Both parents usually open the windows when cooking or cleaning. Airing out seems to be closely linked to these two housekeeping actions.

2) While in the old house the mother was airing out before sleeping and when waking up, she was only doing so rarely in the Renovactive building.

3) It seems like there was less need to air out during spring in the second year of monitoring.
Figure 9: Reasons to air out (red=father; blue=mother)

How often did you air out to...

a) cool down the home?

b) let out smelly air?

c) let out damp?

d) let out unhealthy air?
Figure 10: When to air out (red=father; blue=mother)

How often did you air out...

a) before sleeping?

b) when waking up?

c) when cooking?

d) when cleaning?

Kadiatou Oumar

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When evaluating a building it is always very relevant, how much dwellers have a feeling of being able to adjust their indoor housing conditions according to their needs. They should feel that they have control instead of being controlled. The following Figures (11-13) give a good overview on several actions and their assessment by the family. The results show very clearly the positive effect of the Renovactive house. Both parents feel very able to adjust all four parameters of the indoor housing conditions (heating, cooling, ventilation and lighting) according to their needs. They think the handling is easy, they mostly have control and their actions result in better indoor conditions. Only the ventilation systems sometimes is perceived difficult to control. Comparing these results with the data from their former home we see a big improvement which is caused by the Renovactive house.

This is mainly confirmed during the interviews. If the technical appliances are configured, the father thinks that the handling is easy: “Il suffit que le système soit configuré. Ça ne prendra pas assez de temps pour maîtriser, pour comprendre le système comment ça fonctionne. [...] Ce n’est pas tellement compliqué, c’est vraiment facile, il suffit juste de cliquer sur l’endroit que tu as besoin” (winter 2018).

The family also says that they have the feeling that they are in control of the heating system. It reacts in the way that they want it to: “Le système est fait comme ça, si il fait trop trop froid, j’essaie de monter un peu pour vraiment chauffer la pièce, et puis après ça garde la température, et c’est comme ça” (father, winter 2018). They do not feel controlled by the system. For example when talking about the automatic opening and closing of the windows, the mother says that she likes to hear the sound of the automatic opening of the windows: “J’aime bien. [...] Quand j’entends les fenêtres s’ouvrir, je regarde juste, c’est ici, aussi ici. [...] Ça ne me dérange pas” (winter 2018). The father says that the windows sometimes open at the exact moment when he feels that something should happen: “De temps en temps, je sais pas si c’est par coïncidence ou, quand je pense qu’il fait un peu sombre, quelque chose comme ça, je sens quelque chose qui ne va pas directement, j’entends le déclenchement des fenêtres. Je sais pas, je sais pas si c’est par coïncidence ou pas. [...] C’est géré par Velux. Le système est bien mis, à chaque fois qu’il y a une nécessité, ça se déclenche. C’est comme ça.”

The best way to describe the family’s view on the debate between controlling and being controlled, is that they feel that they are in control of the indoor climate, because they are being controlled. During the project, it became very clear that the family does not adapt the heating system downstairs or the ventilation system. This is not really needed, according to them. They like the fact that the indoor climate is good, without doing a lot of interventions. The father describes this well during the autumn 2018 interview: “Au niveau des ventilations, pourquoi je dis qu’on a la maîtrise, on a le contrôle ? C’est parce que, c’est-à-dire, c’est fait de façon automatisée, c’est contrôlé par une société. C’est de ce côté que je me base pour dire qu’il y a le contrôle, parce que si tu vois sur le questionnaire, tu ne peux pas dire qu’il n’y a pas, soit tu dis tu contrôles ou tu contrôles pas. Ce sont les deux réponses qui sont là quoi. Il n’y a pas de justification tu ne peux pas justifier. S’il y avait une partie où tu peux justifier, pourquoi vous contrôlez, comment vous contrôlez ? J’aurais préféré cette question. Vous contrôlez ? Oui. Comment ? À travers une société qui gère le système de ventilation.” The whole debate about being in control versus being controlled is something that does not make sense to him.

During summer and autumn 2018, especially the mother reported in the questionnaire to have the feeling that she did not fully control the ventilation system. This was discussed during the interview:

**Interviewer:** “Dans le questionnaire, vous avez indiqué que vous n’avez pas de contrôle du système de ventilation et que ce n’est pas assez facile de le manipuler. Pourriez-vous m’en dire plus ?”

**Mother:** “Donc, on n’a pas de contrôle du système de ventilation, c’est contrôlé à distance.”

**Interviewer:** “Et est-ce que vous aimeriez avoir le contrôle ?”

**Mother:** “En fait, non ça m’intéresse pas de contrôler.” (Summer 2018)
The mother thus reported to have less control over the ventilation system, but this doesn’t necessarily mean that this is negative. She reports that the system is controlled at distance, and this is perfectly fine for her.

During the last interview, spring 2019, it became clear that this can also lead to insecurities. The father made it clear that he hopes that the technical monitoring will continue after the project is finished. He fears that the house will deteriorate quickly and that this will lead to lower indoor comfort: “depuis qu’on est rentrés ici, on est contents. Et c’est ce qui continue. Il n’y a pas, même si des fois il y a quelques problèmes, si vous voulez, techniques, mais c’est normal que ça arrive dans un endroit où il y a des appareils techniques qui sont installés, donc ça arrive. Mais voilà à chaque fois qu’il y a un souci au niveau du monitoring, Velux est là pour pouvoir intervenir. [...] On souhaite que ça continue comme ça, que ça arrive, que la maison soit toujours contrôlée parce qu’on sait, voilà, au fur à mesure que ça avance, peut-être bon je sais pas, peut-être au fur et à mesure ça commence à se lasser même si dans cette maison ça ne sera pas le cas, ces années, mais ensuite que vraiment que ça continue comme ça.” The family’s trust in Velux controlling the different technical appliances, and their satisfaction with it, possibly led to a situation in which the family seemed to prefer to call the responsible persons instead of finding out themselves how they could adapt the technical appliances in order to cope with problems. It seems that the father feels that he shouldn’t try too much, that he is sometimes scared to break things. For example, during the winter 2018/2019, he was unhappy with the ventilation in the sleeping rooms, that was causing a draught and leading to a lower indoor temperature. Did he try to adapt the ventilation? His answer was negative, because he feared that he would cause extra problems. Instead, he decided to call a responsible person. On the question if he tried to customise the system in order to deal with the draught in the sleeping room, he answered: “Non, je n’ai pas, c’est parce que je n’ai pas eu la pièce qu’elle m’avait demandée, c’était avec des tournevis qu’il faut dévisser un peu, mais voilà je n’avais pas, j’ai pas voulu rentrer dans ça pour ne pas créer trop de problèmes” (spring, 2019).
Figure 11: Adjusting indoor housing conditions (difficult vs. easy to handle) (red=father; blue=mother)

How do you feel about the possibilities to adjust the indicated parameters in your home according to your needs? Adjusting the... (difficult vs. easy to handle)

a) heating

b) cooling

c) ventilation

d) lighting (daylight)
How do you feel about the possibilities to adjust the indicated parameters in your home according to your needs? Adjusting the... (no vs. full control)

a) heating

b) cooling

c) ventilation

d) lighting (daylight)
How do you feel about the possibilities to adjust the indicated parameters in your home according to your needs? Adjusting the...

a) heating

b) cooling

c) ventilation

d) lighting (daylight)
3.3 Technical behaviour

As the Renovactive building is using a home automation system it is interesting to check, if the information provided by the in-home display is affecting the dwellers behaviour (Figure 14, Figure 15). There seem to be a difference between the mother and the father. While the mother in the first year wasn’t really interested in the data provided, her interest increased during the time of the monitoring. In the last questionnaire she also stated that she is taking daily actions according to the information provided. The father always has been interested in the in-home display, was checking its data daily, and act according to the information provided.

Figure 14: Information through the in-home display (red=father; blue=mother)

How often during the past four weeks did you take information through the in-home display?

![Graph showing frequency of information use by the mother and father over time.]

Figure 15: Actions due to information from in-home display (red=father; blue=mother)

How often during the past four weeks did you take actions regarding the indoor climate because of the information on the in-home display?

![Graph showing frequency of action-taking by the mother and father over time.]

During the winter 2018 interview, the father said that he is somewhat obsessed with the temperature. He watches weather forecasts several times a day, as well as checking the indoor and outdoor temperature on the in-home display. Other information seems to interest him less. He, indeed, adjusts primarily the heating system based on the information he sees on the screen.

The mother said during the winter 2018 interview that she also likes to watch on the in-home display. She is also mainly interested in the temperature and says that she sometimes makes adjustments. More often than not, however, this is not necessary. Therefore, it is less than weekly: “Je regarde souvent la température de la météo, après j’essaie d’utiliser les fenêtres donc. […] Je regarde souvent parce que j’aime bien regarder la
météo, même à la télé, je regarde. [...] Il n’y a pas beaucoup de choses à faire pour améliorer le confort parce que le système fait le travail. Les fenêtres s’ouvrent automatiquement.”

3.4 Space and Layout

Asked about the layout of the Renovactive house, both parents agree that there is enough space to welcome visitors, have an undisturbed rest during the day, a customised private area and pursue hobbies (Figure 16). Compared to their former home this is an improvement, as there was not enough space to undertake these activities before. Therefore they don’t feel restricted by the space or layout of their new home while they did by their old one (Figure 17).

During the interview in the former house, it became very clear that the lack of space was a major problem for the family. They focused mainly on the fact that they didn’t have an extra bedroom for their second child with a third child on the way, as well as that they saw that the space in the former home was not sufficient to properly invite guests. About the lack of sleeping rooms, the father told us that they used to sleep in the attic whereas their oldest child slept in the sleeping room. They changed this, because going to the attic was too dangerous with a young child, mainly because of the unstable stairs. Their second child already fell of the stairs once. From then on, both parents slept with their second child in the same sleeping room, a highly uncomfortable situation according to the father: “Mais nous trois, on reste ici et sur le même lit. C’est pas confortable, quoi, vraiment, c’est trop gênant, c’est trop serré, ce qui fait qu’il fallait s’adapter pour y rester. Donc la chambre vraiment, c’est pas le top” (before interview).

About the lack of space to receive guests, the father talks about his voluntary work for an organisation and how much he likes to invite friends from this organisation at his place. This was according to him impossible in his former house. During the before interview he expressed his wish to finally be able to receive guests: “Donc on sait jamais, je peux dire que voilà, j’ai trouvé un nouveau logement, à mes amis. Est-ce qu’il y aurait certains qui auraient souhaité se rendre chez moi pour vraiment prendre du café ensemble une heure, ou deux heures de temps, quelque chose comme ça. Donc c’est dans ce cadre je dis que peut-être un jour j’aurai des visiteurs pour vraiment, où je pourrai les loger, tranquillement, là, je suis pas... Je sais que vraiment y a un espace suffisant pour des personnes qui auront besoin de me visiter. [...] Ça va être une grande différence, oui. Et on sait jamais, j’ai un ami, je sais pas, qui vient de, je sais pas, n’importe où, je peux l’inviter chez moi, si il veut, il passe. Vous-même, si vous voulez, je peux vous inviter, vous passez, vous prenez un thé” (before interview).

A last point that was very unsatisfactorily for the family was the layout of the bathroom, that also included a toilet, which meant that they didn’t have a separate toilet. This meant that the family never had privacy and that there were always other family members coming in the bathroom and sometimes had to wait because the bathroom was already in use by others. This frequently led to embarrassing situations. In the before interview, the father expressed the wish to finally have some privacy due to a separate toilet.

The space-theme is still often discussed during the interviews. When we asked the father about his first impressions in his new home, he referred directly to the garden and how this space is useful for the children to play in and for himself to enjoy his coffee. It is also one of the most important points (together with the “quality” and isolation) when he compares his former house with the Renovactive house. When comparing he also came back to the situation with the separate toilet. When we asked the mother about what had changed in her daily life since they moved she directly points out the extra space: Ici, le quotidien, je me sens bien, parce que... Je me sens bien, les enfants jouent, je joue avec les enfants, il y a l’espace, par rapport à l’autre maison, il n’y a pas beaucoup d’espace, il y a pas il y a rien dans l’autre maison” (autumn 2017). For the mother it is very important to see that the children now play more together, whereas they did not do that in the former home. She also notices the importance of having an own bed: “Tout est parfait, le chambres, il
y a des grandes chambres, grandes toilettes, tout est parfait. Chacun dort dans son lit, donc il n’y a rien à dire” (autumn 2017).

The oldest son also points out the available space as one of the most important aspects of the house. When we asked him what he would take in mind when he had to build a house himself, he also said that he would think about enough space, especially for playing.

**Figure 16: Amount of space (red=father; blue=mother)**

Is there enough space in your dwelling to...

- **a)** welcome visitors?

- **b)** have an undisturbed rest during the day?

- **c)** pursue your hobbies?

- **d)** have your customized private area?
3.5 Health

The mother reports a positive development on her state of health and their energy level since she moved into the Renovactive home (Figures 18-20). The perceived health condition of the father was already excellent when he filled in the questionnaire in their former home. What is really remarkable is the vanishing of sick-building-syndrom related symptoms and allergies since the family moved into the Renovactive building (Figures 21-24). To complete this positive picture we also observed a positive development in indicators of mental health for both parents (Figure 25).

During the interview in the former house, when talking about health, it soon became clear that mainly the irritated airways of the mother were a problem. She said during the before interview that this was primarily due to, what she describes as hay fever. According to the mother, this is caused by the house, because she only noticed it since they moved to their former home. Besides the hay fever, she also reports having ear problems, but those problems cannot possibly be related to the house, because she already suffers from this since she was young. The expectations of the family about the development of these health issues after moving were rather high: “Ça va être beaucoup mieux, ça, déjà on le sent, on sent que ça va mieux” (father, before interview).

The first interview after moving (autumn 2017) already made clear that the health situation of the mother had improved. She says that she does not suffer from hay fever anymore. She furthermore adds that she doesn’t have to cough and doesn’t suffer from a running nose anymore. According to the mother, this is essentially caused by the absence of humidity: “En tout cas, je souffre plus ici, je me sens bien ici, par rapport à l’autre maison, il y avait beaucoup d’humidité” (autumn 2017).
The father did not report any health issues in the questionnaire, except for having a headache sometimes when he gets up. He reported this for the first time in the before interview and, when we asked him about this, he went in more detail and said that this was due to the heating system and the lack of ventilation in the sleeping room: “C’est vrai que j’avais une tête lourde, ça fait partie encore du chauffage, vu que la chambre n’était pas aérée. Mais madame, par exemple elle avait du sang qui coulait sur son nez, donc c’était dû au système de chauffage. Et... mais ici, c’est le contraire, ce n’est pas le cas, il y a le chauffage mais je vous ai dit, le chauffage ça chauffe en fonction du besoin, donc pas trop trop trop chaud, pas trop trop froid, donc c’est en fonction du besoin pour vraiment la nécessité de l’être humain, afin qu’il soit vraiment dans le confort” (winter 2018). According to him, in the new house he suffers less from this, mainly because of a heating system that heats in function of what is necessary. The father also notices the positive effects of the ventilation system on the health of his wife. He refers to the situation with his wife who suffers from coughing because of the combination of a heating system with no ventilation: “Le système de ventilation, il a vraiment, il fonctionne très bien et il a vraiment un effet positif pour la santé parce que ça te permet d’éviter d’étouffer. Il y en a qui ne supportent pas le chauffage dans une pièce et directement ils étouffent. Mais avec le système de ventilation, ça permet vraiment de dégager le CO2 pour tu aies vraiment suffisamment de l’air” (winter 2018).

He also describes during the winter 2018 interview how he suffered from psychological fatigue caused by the state of the former house and the housing situation the children had to grow up in: “Ça vous fait créer des stress inutiles qui vous fatiguent, vous aurez une fatigue psychologique, donc c’est pourquoi je me réveille vraiment fatigué, vue que la maison ne peut pas... l’appartement n’était pas bien fait. Il y a des problèmes de fenêtres, il y a des problèmes d’infiltrations d’eau, il y a l’air qui pénètre de gauche à droite, il y a de l’humidité, tout ça, ça vous crée des soucis, vu que vous avez des enfants et ils vivent là. Voilà vous avez essayé tout pour que ça soit résolu de la part du propriétaire qui doit faire des travaux et que ça n’a pas été fait. Donc, c’est ce qui crée vraiment des soucis et puis des frustrations qui des fois amènent vraiment une fatigue psychologique.”

Figure 18: General health (red=father; blue=mother)
Compared to one year ago, how would you rate your health in general now?

During the last four weeks, how much time did you have lots of energy?

Does anybody else in your household suffer from allergies? (eg. asthma, hayfever, eczema)
During the last 3 months have you had any of the following symptoms?

a) Fatigue

- yes, often (every week)
- yes, sometimes
- no, never

b) Feeling heavy-headed

- yes, often (every week)
- yes, sometimes
- no, never

c) Headache

- yes, often (every week)
- yes, sometimes
- no, never

d) Nausea/dizziness

- yes, often (every week)
- yes, sometimes
- no, never
Figure 23: Symptoms of sick-building-syndrom II (red=father; blue=mother)

During the last 3 months have you had any of the following symptoms?

- e) Difficulties concentrating
  - yes, often (every week)
  - yes, sometimes
  - no, never

- f) Itching, burning or irritation of the eyes
  - yes, often (every week)
  - yes, sometimes
  - no, never

- g) Irritated, stuffy or runny nose
  - yes, often (every week)
  - yes, sometimes
  - no, never

- h) Hoarse, dry throat
  - yes, often (every week)
  - yes, sometimes
  - no, never
Figure 24: Symptoms of sick-building-syndrom III (red=father; blue=mother)

During the last 3 months have you had any of the following symptoms?

- **i)** Cough
- **j)** Dry or flushed facial skin
- **k)** Scaling/itching scalp or ears
- **l)** Hands dry, itching, red skin
Figure 25: Mental health indicators (red=father; blue=mother)

Please indicate for each of the statements which is closest to how you have been feeling over the past two weeks. Over the past two weeks...

a) I have felt cheerful and in good spirits

b) I have felt calm and relaxed

c) I have felt active and vigorous

d) I woke up feeling fresh and rested

3.6 Social life

The family reports that their social life has been greatly improved. In their former home, they never invited friends over. They experienced problems with their neighbours who often complained that they were too loud: « nous avons un grand espace et nous n’avons pas des voisins qui nous reprochent qu’on fait beaucoup... »
de bruit par rapport à l’ancienne maison. L’ancienne maison, même les enfants ne bougent pas beaucoup. C’est pour ça qu’on a décidé de venir” (mother, winter 2019). Also, according to them, they did not have enough space to invite friends over. Now, in the Renovactive house, they indicate that they invite a lot of friends: “il y a un ami qui doit venir tantôt, on va regarder un foot à seize heures, ici, je les invite, on mange, on fait du thé, parce que voilà, j’ai le temps, j’ai suffisamment d’espace pour accueillir mes amis quoi. Si c’est pendant l’été, on reste dehors, voilà, on fait un petit barbecue, et voilà, c’est comme ça » (father, winter 2018). They appreciate the house, for the space, the garden and the sound insulation: “c’est bien adapté, elle est grande, il y a beaucoup d’espace, la maison elle est bien isolée donc personne ne nous entend. Elle est bien adaptée” (mother, winter 2019).

In addition to social contact with friends, the social life within the family also appears to have improved. When this point is discussed, the children are often directly referred to. Where they almost never played together (also because of the neighbors who complained about noise from playing children) the social contact between the children has improved considerably: “Par exemple, par rapport à l’autre maison, [name oldest daughter, PtB] et [name oldest son, PtB], ils ne jouaient pas ensemble parce que même si ils voulaient jouer ensemble, on disait "ils ne peuvent pas jouer parce que on va déranger les voisins". C’était pour faire attention, mais ici, ils jouent ensemble, je trouve ça très important de jouer entre frère et sœur, de parler, de communiquer” (mother, winter 2019).

3.7 Satisfaction with life

Having a look at the results from the satisfaction with life scale we can see a clear improvement for both parents (Figure 26 and Figure 27). While their satisfaction with life in the former home was only on a medium level, in the last questionnaire after living almost two years in the Renovactive building it has increased for both up to the highest satisfaction. This is a remarkable result and indicates the positive impact the building has on fundamental aspects of life.
Below are five statements that you may agree or disagree with. Please be open and honest in your responding.

a) In most ways my life is close to my ideal.

b) The conditions of my life are excellent.

c) I am satisfied with my life.

d) So far I have gotten the important things I want in life.
Figure 27: Satisfaction With Life Scale II (red=father; blue=mother)

Below are five statements that you may agree or disagree with. Please be open and honest in your responding.

e) If I could live my life over, I would change almost nothing.

3.8 Sleeping

For both parents sleep disturbing causes decreased since they moved into the Renovactive building as shown in Figure 28 and Figure 29. Therefore it is not surprising that their overall sleep quality was rated very good in the new home and better compared to the time before (Figure 30). In their old house for example both parents had trouble sleeping because of cold temperatures and the mother also suffered frequently at night from light and noise and because she couldn’t breathe comfortably. All these constraints where reduced when interviewed in the Renovactive house.

In the before interview, the family stated that the main problem with sleeping was that they had to sleep with three people in the same bed. With every movement, everyone would wake up. Movements happened very often, especially because their second child, who slept in the same room, was afraid of spiders and other insects. She saw them very often in the sleeping room also causing nightmares. For both parents, this meant that they lie awake for longer periods every night: “Moi, je dors pas beaucoup parce que c’est très serré, en ce moment, je dors pas beaucoup, y a beaucoup de mouvements” (mother, before interview). Besides this main problem, the family also complained about light intrusion in the sleeping room. In order to cope with that, they hung a makeshift cloth in front of the window. This worked well according to the family. The father also told us that it was frequently too cold in the sleeping room during winter. As a reaction, he used extra blankets in order to get it more or less warm so that he could sleep.

In the first interview after they moved, the autumn 2017 interview, the mother describes that she sleeps much better, primarily because her daughter has her own bed. In the past, her daughter did not want to sleep alone in a room, and always needed someone with her. This is over now, also because the daughter doesn’t see any insects and doesn’t suffer from nightmares anymore: Avant, dans l’autre maison, elle ne voulait pas dormir toute seule. Maintenant elle va dormir toute seule dans cette maison. […] C’est bien pour moi qu’elle dorme, qu’elle accepte de dormir toute seule. Il n’y a personne qui la colle, elle ne voit rien ici donc c’est bien” (mother, autumn 2017). For herself, it means that she can now sleep better. Besides this, she also says that, during the night, they do not experience any light intrusion anymore, as they did in the former apartment.

Also the father noticed that he now sleeps better. When asked about his own opinion why he sleeps better, he comes back to the psychological fatigue that kept him awake: “Losqu’on a déménagé, mois je fais un sommeil vraiment extraordinaire. J’ai très très très bien dormi et sans problems, sans soucis, parce que des fois, les soucis, ça te bloque de dormir. Si tu ne te sens pas bien, tu dors pas” (autumn 2017).
Despite that they seem to sleep better now, the family still wakes up several times during the night. This became apparent while analysing the time use diaries. The main reason for this are the children. The mother had to feed her youngest daughter and also their second daughter sometimes wakes up at night. This is the only reason why they wake up during the night. Both father and mother confirmed this during the interview and say that this is unrelated to the house. Later during the project, the occurrence was much lower, presumably because their youngest child didn’t need to be fed that often anymore.
During the past four weeks how often have you had trouble sleeping because...

a) you couldn’t get to sleep within 30 minutes?

b) you woke up in the middle of the night or early morning?

c) you were worrying about things?

d) you couldn’t breathe comfortably?
During the past four weeks how often have you had trouble sleeping because...

e) it was too cold?

f) it was too hot?

g) it was too light?

h) there was disturbing noise?
3.9 Home satisfaction

Checking the overall evaluation of the Renovactive building by its tenants we get a very clearly picture. The family is very satisfied with their new home (Figure 31, Figure 32). While both the father and mother rated their former home unsatisfactory, they are satisfied with the Renovactive house. Their new home meets their needs much better. And even when the family was asked more in detail about their assessment of the Renovactive building, they reported full satisfaction with all parameters of comfort and a significant improvement from their former home (Figures 33-36). They either see much need to improve the building, only the relationship of space respectively the amount of storage could be improved (Figures 37-38). On the other hand, their former home was really in need for improvement. Due to all this positive ratings it is not surprising that would easily recommend Renovactive to their friends (Figure 39).

This is very often discussed during the interviews. We asked the family in every interview how they would rate their actual dwelling overall. During the before interview, terms as “catastrophic” and “not adapted for our family” came up very often. We also asked them to describe their home in maximum three words. For the father, these words that described best their former home were “humidity” and “non-conformity”. He describes the new house as “environment”, “conformity” and “well-being”. For the mother, the words to describe the former home were “humidity”, “environment” and “lack of space”. She describes the Renovactive house as “environment” and “enough space”. Later, during the winter interview, she describes the house as “I am happy”, “well made” and “it’s beautiful”.

It is striking how often the family still refers to the former house during later interviews (see also quotes earlier in this report). The former dwelling is always seen as the worst example for what a house should be. This becomes very clear when we asked the family what, according to them, is the most negative aspect of the Renovactive house. The mother says that there is nothing negative about the new dwelling: the only negative thing is the old dwelling: “Il n’y a rien ici qui est pire. Ce qui est pire, c’est l’autre maison. Ici, tout est bien fait” (autumn 2017).

Asking them about the most negative as well as the most positive aspects, give a good idea about why they rate the house so positively. The father says that he house offers him “freedom” and, when talking about negative points of the house, he makes clear what he means with this, when talking about having no problems with neighbors anymore as well as finally having enough space: “Bon, on n’a pas de choses negatives ici, parce qu’on n’a pas un problème de voisins, on n’a pas un problème d’espace. Bon, on est libres et voilà. Franchement, ça va” (winter 2018). Note that he is here also referring to the situation in this former dwelling.
When asking him if there is really nothing that can be improved, he comes back to his two points of critique: 1) having not enough space for his bicycle and stroller and 2) the water in the bathroom that is running wrongly, what means that they always have to clean the bathroom. These themes also come back frequently during the talks with the mother when we ask her what should be improved. Especially the lack of space comes back often during the interviews. During the last interview, during spring 2019, the father said that at the end of the monitoring, he is going to buy a small shack where he can leave the stroller. He did not want to do this before, because he thought it would intervene with the monitoring: “Après le monitoring avec Velux, je crois que je serais heureux de mettre, je vais chercher une petite cabane pour mettre dans le jardin. Mais pour le moment, j’attends d’abord parce que Velux est en train de travailler. Je laisse comme ça ce que Velux a fait et puis voilà. C’est normal je crois encore pour faciliter leur travail” (father, spring 2019).

Figure 31: Overall home satisfaction (red=father; blue=mother)

<table>
<thead>
<tr>
<th>All things considered, how do you rate your dwelling overall?</th>
</tr>
</thead>
<tbody>
<tr>
<td>satisfactory 5</td>
</tr>
<tr>
<td>satisfactory 4</td>
</tr>
<tr>
<td>satisfactory 3</td>
</tr>
<tr>
<td>satisfactory 2</td>
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<tr>
<td>satisfactory 1</td>
</tr>
<tr>
<td>unsatisfactory 1</td>
</tr>
</tbody>
</table>

Figure 32: Overall need satisfaction

<table>
<thead>
<tr>
<th>Overall, how much does your dwelling meet your needs?</th>
</tr>
</thead>
<tbody>
<tr>
<td>satisfactory 5</td>
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<tr>
<td>satisfactory 4</td>
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<tr>
<td>satisfactory 3</td>
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<tr>
<td>satisfactory 2</td>
</tr>
<tr>
<td>satisfactory 1</td>
</tr>
<tr>
<td>unsatisfactory 1</td>
</tr>
</tbody>
</table>
In general: How do you rate the...

a) indoor temperature during summer?

b) indoor temperature during transition season?

c) indoor temperature during winter?

d) indoor air quality during summer?
In general: How do you rate the...

e) Indoor air quality during transition season?

f) Indoor air quality during winter?

g) Amount of natural lighting that you get through the windows?

h) View or outlook through the windows?
Figure 35: General assessment of comfort parameters III (red=father; blue=mother)

In general: How do you rate the...

b) sound insulation?

c) amount of space?

d) layout of the building?

e) aesthetic quality of exterior?
In general: How do you rate the...

f) aesthetic quality of interior?

- Unsatisfactory 1
- Satisfactory 5

Kadiatou Oumar

<table>
<thead>
<tr>
<th>Former Home</th>
<th>Aut'17</th>
<th>Win'18</th>
<th>Sum'18</th>
<th>Aut'18</th>
<th>Win'19</th>
<th>Spr'19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsatisfactory 1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
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</table>

g) security?

- Unsatisfactory 1
- Satisfactory 5

Kadiatou Oumar

<table>
<thead>
<tr>
<th>Former Home</th>
<th>Aut'17</th>
<th>Win'18</th>
<th>Sum'18</th>
<th>Aut'18</th>
<th>Win'19</th>
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<tr>
<td>Unsatisfactory 1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
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</tr>
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</table>

h) quality of building materials?

- Unsatisfactory 1
- Satisfactory 5

Kadiatou Oumar

<table>
<thead>
<tr>
<th>Former Home</th>
<th>Aut'17</th>
<th>Win'18</th>
<th>Sum'18</th>
<th>Aut'18</th>
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<td>2</td>
<td>3</td>
<td>4</td>
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<td>1</td>
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</tr>
</tbody>
</table>

i) building equipment and appliances?

- Unsatisfactory 1
- Satisfactory 5

Kadiatou Oumar

<table>
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<tr>
<th>Former Home</th>
<th>Aut'17</th>
<th>Win'18</th>
<th>Sum'18</th>
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<td>Unsatisfactory 1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
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</table>
Figure 37: Need of improvement I (red=father; blue=mother)

In your opinion, which of the items below should be improved in your dwelling?

a) Indoor environmental comfort

b) Relationship of space/layout

c) Amount of space

d) Amount of storage

Kadiatou Oumar should definitely be improved could be improved no need to improve former home aut'17 win'18 sum'18 aut'18 win'19 spr'19
In your opinion, which of the items below should be improved in your dwelling?

- Level of privacy
- Sleeping situation
- Building equipment and appliances
- Home automation system

Figure 38: Need of improvement II (red=father; blue=mother)
3.10 Renovactive 2.0

During the last interview, we asked the family what could be done better if there would ever be a Renovactive 2.0 house. They came up with a few different points:

1) By far the most important point for the family, is more space to store bicycles. This has been already discussed in earlier parts of this report.

2) The water in the shower runs off incorrectly, meaning that they have to clean the bathroom after taking a shower.

3) The automatic windows should be closed automatically if there is a lot of wind, like they do as when it starts to rain. It already happened that the windows were still open in stormy weather, leading to slamming doors: “Le vent, il faut que Velux pense à ça, le détecteur de vent comme le détecteur de pluie parce que quand il pleut, si tu n’es pas à la maison, s’il pleut, ça se ferme, la fenêtre se ferme automatiquement. Et maintenant, le vent ce n’est pas le cas. Donc ça doit être encore mis dans les endroits, des trucs pour les prochains projets. C’est important pour éviter des dégâts” (father, spring 2019). According to Daidalos, it should be possible to introduce this, since there are already wind sensors available in windows that have sun blinds.

4) During summer, the family complains that there are insects entering while the windows are opening automatically, especially in the evening. Therefore, the family suggests that the windows will be equipped with a net against insects: “ça dérange, les moustiques, ça rentre et ça pique, oui. […] tu peux fermer mais voilà, quand, je sais pas, la nuit des fois, peut-être quand il fait chaud, s’il fait un peu chaud, peut-être en ouvrant les fenêtres, tu pourras bien dormir. C’est pourquoi peut-être les fenêtres s’ouvrent automatiquement, mais quand ça s’ouvre, il y a les moustiques qui rentrent, ça pique, ça dérange. […] C’est quelque chose parce que moi à la place de Velux, j’aurais pu mettre quelque chose comme une couche de grillage comme ça pour empêcher les de rentrer mais l’air peut rentrer. Donc c’est une très bonne chose de mettre ça en place dans leurs futurs projets” (father, spring 2019).

In addition to the question about concrete proposals to improve the house, the family was also asked about what was less necessary, what could be left out if the house of the neighbours were to be renovated, but with a more limited budget. This question was considered difficult. The family did not immediately give a concrete answer and it required some serious by questions. This indicates that it is difficult for the family to immediately give up achievements, something that they themselves will also indicate during the interview.
The mother suggests, if it is really necessary to cut down the budget, to first cut down the number of windows. As an example, she states that the stairwell has two windows, where only one would suffice. It is important, however, to notice that later on, she describes the windows as very important, but still, if she really had to bring down the costs, she would cut down the number of windows.

Just like the mother, the father was reluctant to give a concrete answer. After asking him several times, he indicated that if it was really necessary to save, he would do this on the automatic windows. He does not consider it strictly necessary for these to open and close automatically: “Écoutez, s’il y a un petit budget et qu’ils veulent rénover une maison exactement comme ça, il faut diminuer la chose. Par exemple, les fenêtres qui s’ouvrent automatiquement, c’est pas, c’est vrai que c’est bon, mais voilà. Tu peux ne pas le faire, il suffit que les fenêtres soient les fenêtres des doubles vitrages pour pouvoir garder la chaleur, c’est-à-dire l’isolation” (father, spring 2019).

3.11 Environmental awareness

When moving into the Renovactive building the family was already somehow aware of environmental issues and the importance of individual actions, but only on a medium level. After being confronted with a low energy house and all the technical equipment that is designed to reduce the amount of energy dissipation, they seem to have increased their sensibility for sustainable living. Comparing the results from the before and the last interview you can see that different actions to reduce energy consumption became more important, more modern and more necessarily to them (Figures 40-42). Living in a low-energy house seem to encourage the residents’ responsibility and make them more aware of their ecological footprint.
Figure 40: Environmental Attitudes and Behaviours I (red=father; blue=mother)

What is your attitude towards the following actions?

a) To cut back on driving a car for environmental reasons is...

b) To reduce the energy or fuel you use at home for environmental reasons...

c) To save or re-use water for environmental reasons is...
What is your attitude towards the following actions?

**d)** To cut back on driving a car for environmental reasons is...

**e)** To reduce the energy or fuel you use at home for environmental reasons...

**f)** To save or re-use water for environmental reasons is...
Figure 42: Environmental Attitudes and Behaviours II (red=father; blue=mother)

What is your attitude towards the following actions?

8) To cut back on driving a car for environmental reasons is...

h) To reduce the energy or fuel you use at home for environmental reasons...

i) To save or re-use water for environmental reasons is...
4 Conclusion

The most general, but also the most important conclusion is the positive evaluation of the Renovactive house by the test family. The main advantage of the concept is the increased mental comfort which leads to better health and a high level of housing well-being. If we sum up the findings we can state the following:

1) The perceived level of comfort and the quality of indoor climate in the Renovactive building is very high. Both parents are very satisfied with the indoor temperature, the indoor air quality and the natural light in autumn and in winter. They experienced a big improvement compared to their old home.

2) The family has control over their indoor climate and can (somewhat) adjust it according to their needs, something they didn’t experience in their old home where they felt more or less controlled by the house instead of controlling it. If they try to make adaptations, the house seems to react to their actions in a way they want it to. Nevertheless, the usage of the ventilation system by the family, and their behaviour when they are less happy with the indoor comfort also indicates that the family has a lot of trust in experts handling the system for them. The family also says that they are a bit nervous about what the future will bring and what will happen when they cannot rely on others if something doesn’t work properly anymore. It would thus be useful to provide a leaflet with information about what to do in case of specific situations.

3) Their use of the house is not always in line with the expectations of the technical monitoring team. The comfort behaviour of the family does not always lead to optimal indoor comfort. However, achieving an optimal indoor comfort is not always the goal of the family. Whereas the technical monitoring team expects instrumental-rational behaviour in function of increasing indoor comfort, the family appears to have a different priority setting. In that case, actions are regularly taken that do not necessarily increase indoor comfort, but that do meet other wishes, such as silence or avoiding viewing. The family also puts different actions out of habit (traditional behaviour) rather than enhancing comfort.

4) Parents and kids enjoy the additional space gained from moving into the Renovactive building and its overall appearance, which affected their internal and external social interactions in a positive way. They also praise the layout of the house and its convenience.

5) Both parents rate their overall sleep quality in the Renovactive house as very good. Sleep disturbing causes decreased compared to their old home, such as cold temperatures, light and bad air.

6) The health situation of the mother, who suffered from hay fever, and other respiratory issues, greatly improved after moving. She indicates that her health problems disappeared.

7) Overall the family is very satisfied with their new home, proud of it and happy to present it to their friends and relatives. To them, moving into the Renovactive building is associated with an enormous increase of happiness, health level and overall wellbeing.

All the results highlighted in this report indicate the positive affect of the Renovactive concept. There are hardly any critical aspects discovered from the monitoring process.
5 Literature

