Academic year 2021 - 2022 #1 | Dec

MOLLIER

Study Association
Building Physics and Services

# INSIDE INFORMATION

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# GREEN ROOFS PROVIDE EXCELLENT THERMAL INSULATION...

# Foreword

Nora Kuiper

Dearest reader,

It is my pleasure to present to you the first edition of INSide Information for the year 2021-2022. You may remember me as a commissioner of External Relations for two years in row, as well as already being in one of the biggest Mollier committees, the INSide Information committee. The INSide Information committee is responsible for the biannual magazine of s.v.b.p.s. Mollier, that is now in front you. I'm proud of the product that Menno, Laurens and I have again put together and we hope that you'll enjoy this magazine as much as we do.

First off, a new academic year also means that we have a new Mollier board, and I'm very positive that they'll make this year into a great success. Get to know them in the Meet the board column! We'll look back at the activities that have been organized so far and we'll give you the opportunity to meet one of our new students in the IceBreaker. What our students are up to during their studies, can be found in the articles written about their projects and the experience of studying abroad. What life has to offer after the completion of Building Physics and Services, is illustrated with the Alumni at work column, and two articles written by former BPS students that now have a job at our company partners.

Keep an eye out for all the educational-, fun- and career-related activities that are bound to happen in the second semester. I can assure you that many are coming up. Also keep an eye out for the next INSide Information edition, as change may be around the corner soon ;)

For now, I would like to thank my fellow committee members Menno and Laurens for their hard work and keeping up with me as the editor in chief for this edition. On behalf of the committee, I would like to wish all of you happy reading!

Yours sincerely,

Nora Kuiper
Editor in chief

**INSide Committee**
Left: Menno Peijnenborgh, Laurens Castenmiller, Nora Kuiper

## COLOPHON

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# This INSide


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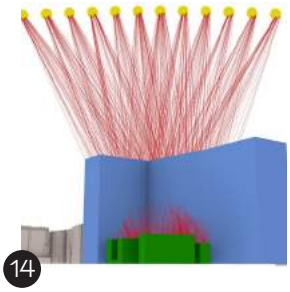
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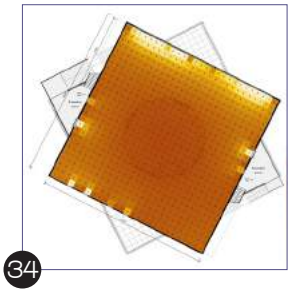
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MOLLIER & MEMBERS



BUILDING PHYSICS & SERVICES



COMPANIES

# Introduction to the 26th Board of Mollier

## LAURENS CASTENMILLER, CHAIRMAN AND COMMISSIONER OF EDUCATION

Heey reader, here I am again! You might know me as chairman of the 25th board of Mollier. I will react if you call me Laurens, if not shout 'coffee' to me and you have my attention for sure.

Last year I had many expectations of being your chairman, however due to COVID-19 my expectations did not come true. This did make me decide to apply for another year of chairman of the study association. Don't be afraid that I will become a dictator, because in January I go abroad to the DTU (Denmark) for 1 semester. This means that I will hand over the role of chairman to Pam, our current vice-chairman.

The tasks of my current role are, more or less, familiar to me, and I am happy to continue with those tasks this year as well. Next to the familiar tasks I try my best to hand over everything associated with the role of a chairman in a good way to Pam, and am pretty sure Pam will be an equally good, or even better, chairman of Mollier.

I am still a member of the cycling association, but due to some priority tasks at Mollier I was not much present at our training. This year I want to be more present, because I found out that those moments of spare time increase my energy level afterwards, which is beneficial for the study and Mollier as well. Next to the increase in energy level due to being sportive I also realized how important the game visits of Ajax are for me. During those game visits I have my attention focused on the game and don't need to think about my study for a few hours. After those few hours my energy bar is reloaded which can be spent to my study and the 26th board of Mollier.

With the new energy of the new board members I am pretty sure that this year will be an awesome year. If you have any questions don't hesitate and contact me via chairman@mollier.nl or walk by at floor 5 (also possible if you just want to take a break next to grabbing some coffee).

## MENNO PEIJNENBORGH, SECRETARY

Hi there, I am Menno Peijnenborgh. I am 21 years old originally from Houten though when I started my bachelor my parents moved to Waalwijk. This year I am starting my masters in building physics and services, currently still interested in most chairs so I will definitely need to work on narrowing this down.

After joining a few activities from Mollier I quite liked the people, but also just the fact that there are activities. Especially during covid, I could appreciate the change of meeting new people and doing other things besides sitting at home. So I hope that this year we can organize some fun activities that we all can enjoy.

I am a big believer that activities besides university are just as or even more important than university, I have my whole life ahead of me to work. So besides taking my studies more seriously I also started to focus more on my leisure activities. You might remember from my IceBreaker that I really enjoy gaming, sports (including chess), watching series and crafts. This year I joined Zephyr and am now part of one of their main teams to compete with other universities, which I am really excited about.

One of the reasons I wanted to do a board year is to get to know more people so feel free to challenge me to play a game of chess or mario kart or if you are looking for a sports buddy I am also open to learn new sports.

## JUDITH DE WILDE, TREASURER AND COMMISSIONER OF EDUCATION

Hi everyone! My name is Judith de Wilde and I am 25 year old. I am currently living in Eindhoven, but I grew up in De Meern, a few kilometers from Utrecht. One and a half year ago, I wrote an ice breaker for the Inside magazine. And now I am here as one of your board member!

I became an active member during the corona period, so I mostly was present during the pizza lectures. Joining the wine tasting, showed me how lively the Mollier community could be. I am very glad to join the Mollier and BPS community.
During my secondary schooling, I discovered building physics and the effects that buildings can have on people's health. After graduating, I went to Eindhoven University of Technology for my Bachelor's degree in Built Environment. At the moment I am finishing my Bachelor End Project and in February I will be starting my Master's.

In my spare time I enjoy spending time with my friends, cooking and reading. In the past year and a half I have found an new hobby: playing squash. For me it's a good way to stay active.

This year I will be filling the role of treasurer of the 26th board of Mollier. I am looking forward to a great year and meeting everyone.

## JESPER PRIESTER, COMMISSIONER OF EXTERNAL RELATIONS

About these difficult times, they are strange for everyone. Being responsible for activities last year that was no other. With all signatures and stamps ready I was good to go to KTH (Stock-holm). With the big spanner thrown in the works, all was cancelled. In return, I got an enthusi-astic board which made up for it. With a campus cautiously ready to receive students, this year with a carefully reopening world the opportunities are still on the rise.

Simultaneously with a new year comes my new role of external relations as I leave Activities and Vice-chairman. Next to my different role, this is definitely a different board year with a dif-ferent world. Now that activities is shared among the board members, I get into contact with our sponsors. There are still activities involved but now focussed on the more career-oriented side. I am happy to share these tasks with Wouter. Also with a lot of old members around at our sponsors, it's good to see lots of familiar faces around.

Simultaneously there is the final stretch of our 5th lustrum as a part of the committee that is known as "de gezelligste commissie van Mollier". The committee is existing way longer than imagined upfront but is still going strong. The successful party that was meant for opening the lustrum also became a midterm party. With this festivity in mind, we are very much looking forward to the Gala. This time at one of the fanciest locations of the city; Het Ketelhuis (Landgoed De Grote Beek). Think next to that complementary stylish clothing and it can only get better. I'm looking forward to suiting up and seeing everyone dressed up for the evening. Next to my board tasks, I work one day a week as a teaching assistant. The project is all about acoustic virtual reality in challenged based learning. We're busy using VR in a pilot to bachelor students get a feel for acoustics and trigger their interest. Hope to see you around!

## PAM VAN DIJK, VICE-CHAIRMAN

From doing a pre-master almost solely online to being vice-chairman for Mollier in a little less than a year. Who would've expected that? The online activities were so much fun and the group of active members is so 'gezellig' that I saw myself fit for this role, especially with the support of the rest of the board.

Still adjusting to being on campus, starting a new study, and moving to Eindhoven I'll be vice-chairman until January, where I support with some activity committees and fill in for Laurens when he's not available. From January on I'll take over from Laurens and become chairman, something I look forward to. Being chairman is the perfect role for developing professionally and in leadership skills, while also developing Mollier as a well-respected study association in the Building Physics and Services field.

Lastly, since the BPS exposition in Vertigo didn't go through at the very last moment last year, I'm very much looking forward to putting up something spectacular at the end of this school year, to show off the interesting research and design studies Building Physics and Services has to offer.

## WOUTER BRUGGEMAN, COMMISSIONER OF EXTERNAL RELATIONS

Hello everybody! My name is Wouter Bruggeman, 24 years old and I am a Master student Building Physics and Services here at Eindhoven university. Currently I am still living in Nijmegen right in the middle of the city. Nijmegen is also the place I have been born, but the most time during my childhood I spent my time in a village near Nijmegen.

During the corona pandemic, life was getting kind of boring, also school was a lot harder without surrounding students and the same spot in the house for so long. Luckily Mollier had a community where there was a better platform to talk to fellow students also in a non-formal way and just have fun. This was nice to keep up the good work for my pre-master back then.

Now I am already in my second year at the Eindhoven university and started off the Master Building Physics and Services going steady. Next to the Masters, I also work as a junior consultant at Volantis in Venlo. I have chosen this path to really learn at the university, but also apply the same knowledge in the field. This is always been the path I have walked, also during my bachelor program I have followed at AVANS University of Applied Sciences. The reason I have chose for BPS as Master program, is my interest in CO2 neutral building.

In my spare time, I usually am busy working out in the gym or play basketball. But the most fun is definitely the party's I attend together with my friends in Nijmegen.

During this study year I will be responsible for the external relations for Mollier. This will contain the contact between the sponsors. Arranging contracts, organize sponsor activities and be involved and act on the wishes of your sponsors. I will do this together with Jesper, to spread to workload for this part.

Kuijpers

Resultaat door betrokkenheid

# Kuijpers & Mollier


Robert Snoeren, trainee Kuijpers
Wouter Flach, recruiter Kuijpers

Kuijpers is een technisch dienstverlener, actief sinds 1921. We zijn altijd op zoek naar jong talent. Daarom bouwen we heel bewust aan contacten met studieverenigingen, scholen en technische opleidingen van alle niveaus. Robert Snoeren (voormalig lid van Mollier) studeerde building physics and services aan de TU Eindhoven. Stage lopen hoort er daar helaas niet bij. Om toch ervaring op te doen, deed hij mee aan de meet & greets met bedrijven, georganiseerd door Mollier. Zo kwam hij bij Kuijpers terecht, één dag in de week. Die ene dag per week werd na Roberts afstuderen (in 2016) een tweejarig traineeship bij Kuijpers. En dat door de meet & greet met Wouter!

*Echte mensen.*
*Echte oplossingen.*

**www.kuijpers.nl**

# Mollier Activity Calendar

### *ACTIVE MEMBER DINER*

On the 8th of July, a diner at café Bommel was organized to thank the active members of the association for all their hard work and time invested in the year. With nice food, drinks and weather it was a fun evening. To express the gratitude to all active members, everyone received a beautiful personalized lunch box, decorated with all the posters of the tea tables throughout the year. Also a specific message was given with the box as a memory for the active attitude last year.

### END/START ACTIVITY

To start off the new academic year we planned an awesome end/start activity weekend for all the members of Mollier. Like last year we stayed close to Eindhoven and set our camp at camping de Kuilen. We cycled to the location while solving various puzzles and visiting multiple bars to take breaks from the physical and brain activity. The route went through multiple towns and was nice altogether with the only hiccup being a certain dirt road at the end. At the location a large group accommodation was rented where everyone had their own bunk bed. After recovering from the tour with a nicely organized barbeque we had some rest and chill time before starting with the quiz rounds. Hosted by the committee, they dressed up accordingly and tested our architectural and musical knowledge. Afterwards we all catched up and got to know each other. The following day we had to rise early as we had a refreshing cycling tour to Weert where we spent the day. We started off by doing an escape room and exploring Weert and some café's. Next up we had a fun and interesting beer tasting tour with a nice guide. After the tour we stayed at the bar for a while playing games and exchanging stories while the guide helped putting together personalized beer packages for those who were interested. We dined at a great restaurant where we enjoyed three courses and our own company. To finish the end of the day we took a picture at Richard's bar where a group also went in for a drink or two while others took a head start on cycling tour back to the camping and relaxed there. Next morning we had a little more time to sleep before we went for a brunch at a nice brunch place where we congratulated Bas as the overall winner of the quiz and riddles with a tasty special beer package. To wrap up the weekend we visited Kasteel Heeze where we learned about the history and architecture of the castle. We want to thank the committee Kim, Brent and Laurens for organizing this amazing fun weekend!


## *LUSTRUM PARTY*

Due to the corona outbreak the lustrum party had to be delayed to the start of the new academic year. This delay only built more suspense for all the people looking forward to the party. Everybody had good fun and enjoyed their drinks. We listened to a speech of the founders of Mollier and learned that our purple color comes from the cold (blue) and heat (red) exchange which come together. This was followed up by a speech of the new chairmen. To commemorate the speeches we sang the Mollier song accompanied by shots of Jägermeister. We like to thank the Lustrum committee Brent, Jesper, Maud and Nora for putting together this great evening.

## *GMM #4 - CONSTITUTION*

On Friday, the 17th of September, we organized the last GMM of the 25th board, and the first GMM of the 26th board. The constitution of the 26th board took place, with the members of the 26th board voted in unanimously.

After the GMM, the board, members and alumni celebrated at the Belgisch Biercafe over diner and a few drinks. Because of Covid-19 the actual constitution drink had to be delayed till the 8th of October. The constitution drink also went successfully and we all went to have dinner at Happy Italy to celebrate.

## *MEET THE BOARD GAMES*

To get to know our members and board better we organized an afternoon of board games with beverages and snacks. We all had great fun together and played Machiavelli. As a bonus we learned more things about each other, such as who gets controlling over the rulebook, who lays back and sees where the flow takes them or who just really wants to win (but could not). All in all we thought it was successful and hope to see more of you and each other.

## *AERIAL HOOP WORKSHOP*

To test the core strength, flexibility and balance of our members we organized an aerial hoop workshop where, you guessed it, you learn your way around an elevated hoop. The workshop was given by Maud who made sure that everyone was safe and had a good time and showed multiple tricks. Somewhere surprised how agile they were while others got their leg stuck in the hoop, but all of us had fun. Afterwards we went for a drink in the sports cafe to share and commemorate the experience. Thank you Maud for giving the aerial hoop workshop.

## *PARAMETRIC DESIGN WORKSHOP*

As educational activity our old chairman Mark Tavenier gave a workshop on how to use the parametric design tools Ladybug and Grasshopper. Together we analyzed the impact of placing a high rise building in front of Vertigo on solar panels located on the roof of Vertigo. Besides the useful tutorial and tricks we also learned more about the use of parametric design and how Royal HaskoningDHV operates and the work environment looks like. There was a good atmosphere with a small tea table during the break.

## *GLOW TOUR WITH KOERS*

Following in the footsteps of the 25th board, we walked the GLOW tour together with KOers again. Before the tour started Sietse, Tim and Floor gave an educational presentation about the design ideas of multiple concepts. To keep ourselves warm during the walk we had warm glühwein so we could comfortably appreciate all the artworks on GLOW. After the tour we also went for a few drinks, people got so excited they also wanted to dance.


VALSTAR SIMONIS

ADVISEURS INSTALLATIETECHNIEK

Als adviseur bij Valstar Simonis houd ik mij bezig met het organiseren van projecten, zoals het aansturen van teams en het overleggen met onze klanten, maar ook met het maken van ontwerpen. We helpen onze opdrachtgevers dagelijks met het ontwikkelen van duurzame, gezonde gebouwen waarin hun medewerkers, studenten of patiënten zich prettig en comfortabel voelen. Zo was ik bij de renovatie van het gebouw Atlas op de TU/e campus eindverantwoordelijk voor het ontwerp van alle installaties.

Na 8 jaar bij Valstar Simonis blijf ik mij nog elke dag ontwikkelen. Er is veel aandacht voor persoonlijke ontwikkeling, waarbij het belangrijk is dat je kunt groeien in de dingen die je leuk vindt. Je merkt ook dat er naar je ideeën wordt geluisterd en krijgt de kans om die ideeën uit te proberen.

Valstar Simonis is een advies- en ingenieursbureau op het gebied van duurzaamheid, comfort en veiligheid in gebouwen. Gevestigd in Rijswijk, Apeldoorn, Eindhoven, Amsterdam en Groningen.

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***Let’s enhance society together!***

# Buildings Shaped by the Sun

*Lenny Mennen & Marc Tavenier*
*Consultants Acoustics and Building Physics*
*Royal HaskoningDHV*

The sun is essential for life on earth. Without the sun, there is no weather, no warmth, and... no wine! We see the sun as something that is always there, and we often take it for granted. However, due to urban densification and an increasing number of high-rise buildings, facades of buildings that receive sun are not so self-evident anymore. Designing the urban environment by looking at solar access, therefore, becomes more and more important. In this article, we would like to dwell on these sunlight qualities, and we would like to show our way of urban designing using the sun as a guideline.

## SOLAR EFFECTS ON HEALTH

Daylight has three routes through which it influences us as people: (1) the visual system: it enables us to see, (2) the biological system: it affects our circadian rhythm, and (3) the psychological system: it influences our mood and feeling of comfort [1]. Sufficient access to daylight has a positive influence on the first and the third route. Daylight benefits people's health because it sets the sleep-wake cycle (circadian rhythm). The health effects go even further: various studies are showing that sunlit hospital rooms decrease the length of stay and mortality rate [2].

Not only the effects on sickness and health are influenced by sunlight, but sunlight also positively influences our mood. It creates pleasant, delightful, and luminous environments where one's view is attracted to nicely lit surfaces. Sunlit interiors not only influence us consciously but also unconsciously. Sunlight provides orientation information giving us a secure feeling. Rooms where direct sunlight varies during the day are perceived as interesting, whereas rooms never receiving sunlight are perceived as "dull" [3].

## SUN AND THE BUILT ENVIRONMENT

Solar access is the ability of a building to (continue to) receive sunlight without obstruction from another building. In this explanation, sunlight is referred to as the direct component of daylight. The directionality, therefore, plays a role in solar access.

The building design, interior, and type of glass influence the quality of the sunlight that enters the building. These aspects can be influenced by building owners. What building owners cannot influence themselves, is the solar access on all facades. A new high-rise tower can be built next to your home casting a shadow on your facade.

Lenny Mennen (left) & Marc Tavenier (right)
Consultants Acoustics and Building Physics

Buildings are not very often designed with the sun as the main guideline. However, taking solar access into account becomes more and more important due to urban densification and the increase of high-rise buildings. In the Netherlands, there is a guideline that is often used to establish the ambition: "TNO-norm bezonning". However, it is a guideline and not a law: every municipality can decide for itself in which way they value this guideline or not.

The TNO guideline distinguishes a "light" and a "strict" guideline. In the light TNO guideline, a facade should receive a minimum of two hours of sunlight between 19 February and 21 October. In the strict TNO guideline, a facade should receive a minimum of three hours of sunlight between 21 January and 22 November. Only north facades can be excluded from the analysis because they will never receive that amount of sunlight. In urban environments, the light norm is normally adhered to.

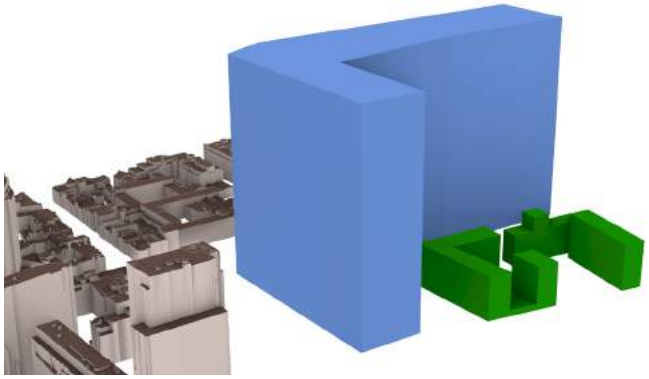

Figure 1. The hypothetical tall tower on the building plot (blue), affected surroundings (green), and other context (brown).

## FORM FOLLOWS FUNCTION

In the past, solar access studies always followed the building design. It was done as a test afterwards. However, with increasing computer power and the use of parametric design, building facades can also be entered as a parameter at the start of a project. Even before the zoning plan is designed. In this way, solar access doesn't follow building design, but building design is followed by solar access. In the following description the method of the script for determining the sun access. We created an algorithm in Grasshopper that creates a mass of the zoning envelope in which the building will meet the TNO guideline.

1. First, we create a hypothetical tall tower on the building plot of the to-be-built building (see figure 1).
2. Then, we simulate what the effect of this large hypothetical building is on its surroundings, and check which parts of the facade do not meet the minimum threshold from the TNO guideline (see figure 2).
3. Then, each of these points selects sun positions with the highest altitude that it still needs to meet the minimum threshold. The highest sun altitudes are chosen because of the larger angle with the horizon. This makes that the opposite building can be higher than when picking low sun positions. Lines are drawn between these high sun positions and the test points (see figure 3).
4. The lines that intersect the tall tower, cut the tower such that it does not shade the surroundings. The architect can use this mass and freely place building volumes within it (see figure 4).
5. When we simulate the solar access with the generated building mass, we can see that now there is sufficient solar access for the entire facade (see figure 5).

The fact that the algorithm chooses the highest sun positions makes that the building must stay below the defined mass to not shade the surroundings. Though sometimes the sun can also shine on facades from lower altitudes, early or late in the day. This means that we can play around a bit with creating a building that in some places exceeds the mass. This gives us more freedom to design something that still meets the threshold.

## SUFFICIENT BUILDINGS OR CREATING A HEALTHY ENVIRONMENT?

The TNO guideline states that the north facade can be excluded because it will never receive sunlight. This however brings up difficult situations. How do we deal with northeast and northwest facades? A north-east facade for example only receives sunlight from very low sun positions early in the day. This means that – if the building should meet the light TNO-guideline – the surrounding buildings are only allowed to be very low. It brings up the discussion of what is more important:

1. Build enough buildings, especially apartments. The housing shortage and the constitutional right to housing outweigh the maximum quality of the city's living environment. Therefore, we should build more (apartment) buildings even though it affects the living quality negatively.
2. A healthy living environment is paramount: we must build buildings in such a way that the maximum quality of the environment is guaranteed, even if that means that a building cannot be built if it just about does not meet the requirements.

We do not have the answer to which of these statements is (the most) correct. But it is an indication that there is not always a wrong or right way to approach these problems. Sometimes we have to juggle multiple stakeholders while creating the best solution for all parties involved. ■

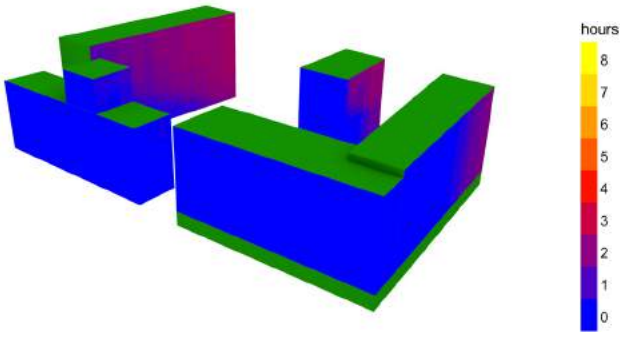


Figure 2. Resulting solar access. Parts with insufficient solar acces are blue (< 2 hours).

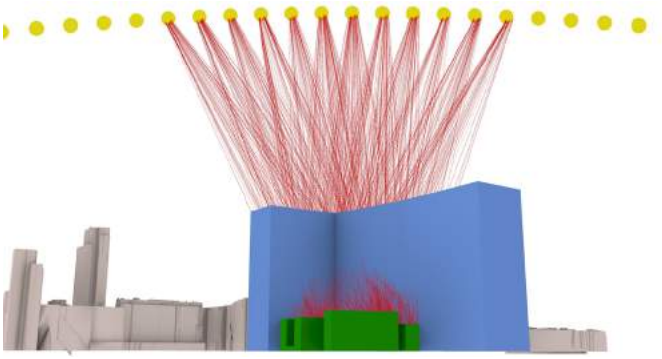

Figure 3. Lines are drawn between insufficient solar access parts and the highest sun positions that they still need.

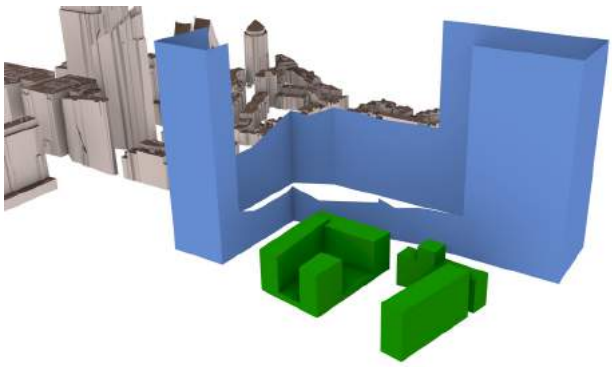

Figure 4. Resulting building mass to stay within.

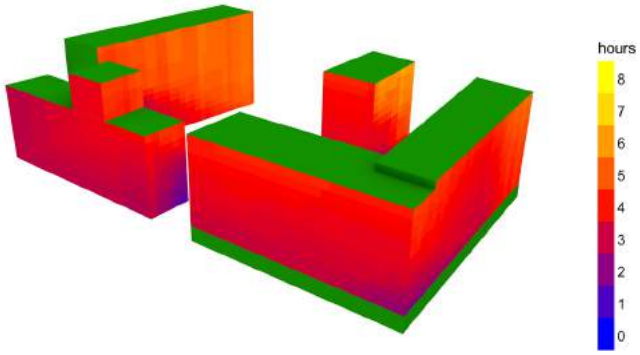


Figure 5. Solar access with the new building mass.

[1] P. R. Boyce, Human Factors in Lighting, April: 7, 2014.
[2] A. E. v. d. Berg, Health Impacts of Healing Environments: A review of evidence for benefits of nature, daylight, fresh air, and quiet in healthcare settings, Groningen: The Architecture of Hospitals, 2005.
[3] W. M. Lam, Sunlighting As Formgiver for Architecture, Van Nostrand Reinhold, 1986.

# Evaluation of the TOJuly Indicator

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## INTRODUCTION

In an effort to reduce the energy consumption of the building stock, the barrier between the indoor and outdoor space gets bigger. A combination of improved insulation properties, increased airtightness, and global warming increases the risk of overheating in the Dutch residential building stock. Moreover, this risk is expected to become bigger in the upcoming decades [1]. Using dynamic simulations, insight can be provided into the potential overheating risk. As defining the models for dynamic simulations is a labor-intensive task, executing these simulations for every new individual dwelling and apartment in the Netherlands is an unrealistic expectation. To solve this problem, the TOJuly (Temperature Overshoot July) indicator was initiated. This research aims to evaluate the robustness of the TOJuly indicator in relation to various building typologies and building characteristics.

### TOJuly

In the Netherlands, the level of overheating is generally expressed based on the Weighted Overheating Hours (WOHs). By means of providing a larger weight to hours with a lower level of thermal comfort, the extent of overheating is taken into account. As mentioned, determining the WOHs for a building or design is a detailed and labor-intensive task, due to the large number of input parameters used to generate the building models. The TOJuly provides an indication of the risk of overheating for newly built residential buildings, without the need for such detailed dynamic simulations.

The TOJuly indicator is part of the Dutch energy performance requirements (NZEB requirements) and was put into practice on January 1st, 2021. The calculation procedure for determining the energy performance is described in the NTA 8800, and is based on simplified monthly calculations. The same input parameters used for determining the energy performance are used to calculate the TOJuly indicator value [2]. This makes the practical application of the indicator rather straightforward and does not require additional labor or effort. The month July is used as a representative month for the summer, and the results are single values that expresses the risk of overheating. Based on a threshold of 450 WOHs, the threshold for TOJuly was set to 1.2 [3]. Additionally, the correlation between WOHs and TOJuly was determined and rated as high [4, 5]. If the TOJuly value is below 1.2, the risk of overheating is expected to be acceptable. If the threshold value of 1.2 is exceeded, the building design will not be provided with a building permit. Measures need to be applied to those designs, such as implementing shading devices, or the design itself can be adapted to reduce the risk of overheating. Moreover, dynamically determined WOHs may be used to demonstrate that the risk for overheating is acceptable and does not exceed 450 WOHs. The TOJuly is determined for all newly built houses without active cooling in the Netherlands [2].

## METHODOLOGY

In this research, variant compositions for seven building typologies are designed, relating to building characteristics, occupant behavior, and future climate. The set of 7 reference buildings consists of 4 types of dwellings and 3 types of apartments (Figure 1). The main building geometry parameters are indicated in Table 1. By means of a comparative analysis between TOJuly and WOHs, the assessment of the risk of overheating for different situations is analyzed. A total of 1610 individual variants are designed, and subdivided into different variant categories. The main variant categories include: envelope properties (Table 2), internal heat capacity, glass and shading device properties, internal heat load, and climate data. To determine the WOHs, dynamic simulations were performed in EnergyPlus. The TOJuly values were calculated using the NTA 8800

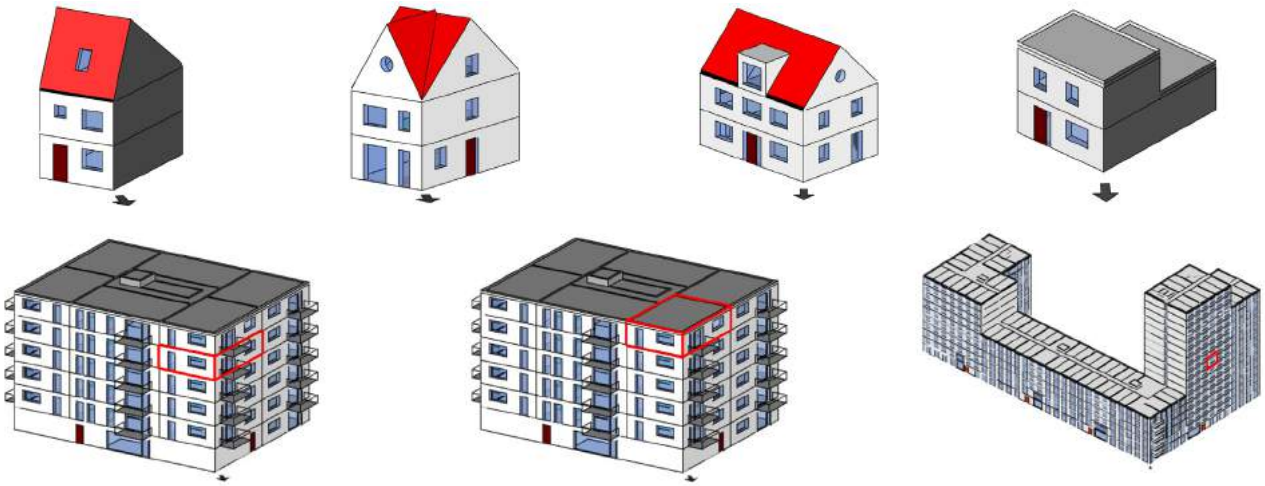

Figure 1. Visual impression dwellings and apartment buildings (individual apartments indicated in red) [6]

Table 1. Main building geometry parameters

| Parameter | Value or description | | | | | | |
|---|---|---|---|---|---|---|---|
| Building typology | Terraced small | Semi-detached | Detached | Terraced medium | Apartment middle floor | Apartment top floor | Studio |
| Net Floor Area [m²] | 110 | 133 | 181 | 87 | 76 | 76 | 30 |
| Window to Wall ratio [-] | 0.27 | 0.20 | 0.24 | 0.24 | 0.32 | 0.32 | 0.43 |

Table 2. Envelope properties for the variants

| Parameter | Minimum Building Decree | Passive House |
|---|---|---|
| Rc ground floor [m²K/W] | 3.7 | 8.0 |
| Rc façade [m²K/W] | 4.7 | 8.0 |
| Rc roof [m²K/W] | 6.3 | 10.0 |
| U value windows [W/m²K] | 1.65 | 0.7 |
| Glass panes [-] | 2 | 3 |
| g-value glass [-] | 0.6 | 0.5 |
| U value door [W/m²K] | 1.65 | 0.7 |
| Infiltration qv10 [dm³/m²s] | 0.40 | 0.15 |

calculation tool. Applying this overall methodology, a TOJuly value and the WOHs are determined for each variant.

To quantify the results and the relation between TOJuly and WOHs, four quadrants are used. The division of the quadrants is shown in Figure 2. The first and fourth quadrants describe results that fit the reasoning behind the TOJuly method and indicate cohesion of the results within the variant. The third quadrant relates to a situation in which the WOH threshold of 450 hours is met, but TOJuly exceeds 1.2. In other words, TOJuly overestimates the risk of overheating when compared to the results of a dynamic simulation. The second quadrant categorizes designs for which the TOJuly underestimates the risk of overheating. According to the TOJuly indicator, these designs would be rated an acceptable risk for overheating, whereas the WOHs indicate that this risk is larger than 450 hours. Regarding the performance of the TOJuly, this is an undesired outcome. As the calculations and simulations come with a certain level of uncertainty, the results entail a level of uncertainty as well. Therefore a 10% deviation margin is included during the categorization of the results.


Figure 2. Categorization of results in quadrants.

## RESULTS

Besides the outcomes in terms of the categorization of results and the assessment of the robustness, this research allows a more detailed insight for each design variant category. Before presenting the main outcomes of this study, a selection of the secondary results is presented. Figure 2 shows the effect of the future climate (2050-2085) on the risk of overheating, in combination with different building properties. Two main variant categories are shown: internal heat capacity and envelope properties. The variants with a high internal heat capacity (brick and concrete-based designs) and a low internal heat capacity (timber frame structure and CLT-based designs) are indicated with heavy and light, respectively. The different envelope properties relating to the current minimum Building Decree guidelines and Passive House standards are indicated with BD and PH, respectively. Today's climate is represented using the NEN 5060 Energy weather data for TOJuly calculations (TOJuly,max) and NEN 5060 5% for WOHs simulations, as prescribed in the NTA 8800 guideline [2]. For the results related to future climate variants, the method was adapted by integrating the NEN 5060 1% weather data (TOJuly,max,adapted).

For all typologies, the highest WOHs and TOJuly values are generated by designs with a low internal heat capacity. For the apartments, the passive house building envelope reduces the amount of WOHs, whereas the TOJuly values increase. Nonetheless, the thermal comfort levels are exceeded. Concerning current and predicted building trends, more timber and/or CLT-based buildings are expected to be built. As shown in Figure 3, this introduces a higher risk for overheating for all building typologies. In a future climate, this can result in exceeding the thermal comfort levels of 450 WOHs.

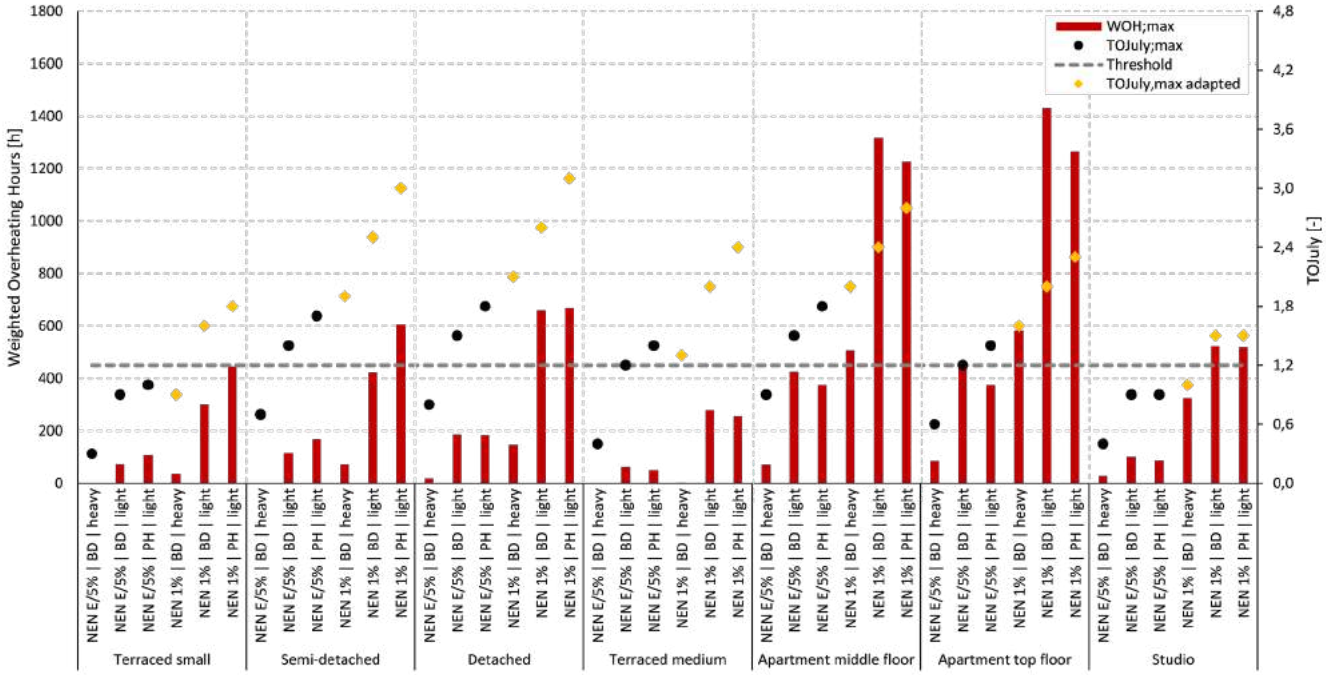


Figure 3. Effect of envelope properties and internal heat capacity on TOJuly and WOHs, for future climate, for seven building typologies. The horizontal dotted line indicates the thresholds of 450 WOHs and TOJuly 1,2.

When discussing the robustness of the TOJuly indicator using the four-quadrant method, not all individual results can be included. As the TOJuly method does not provide or prescribe varying occupant behavior nor integration of a future climate scenario, subsequent results do not contribute towards the final assessment of the robustness of the TOJuly. This way, the assessment of its robustness relates to the method as is currently deployed in the built environment in the Netherlands. Consequently, the WOHs and TOJuly values of 336 variants are distributed among the four quadrants in Figure 4. For a majority of these variants, the TOJuly method functions as it has been designed. 44.0% and 34.2% indicate a similar categorization of the overheating risk based on both the TOJuly and dynamically determined WOHs. Indicated by means of the third quadrant, 53 variants exceed the TOJuly threshold, but the risk of overheating is determined to be within the limits based on the dynamic simulations. 6.0% of the variants are placed in the second quadrant, indicating that the TOJuly threshold is met, but the WOHs exceed the 450-hour limit even though a margin of 10% is applied. In other words, the TOJuly underestimates the risk of overheating for these variants when compared to an assessment on dynamic simulations. Table 3 presents the number of variants within each quadrant for the individual building typologies.

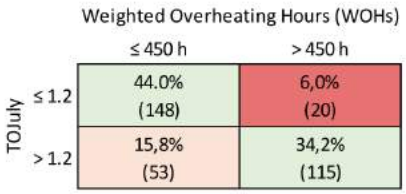


Figure 4. Results classification in quadrants.

As the second quadrant is of the largest interest in this research, the variants within this quadrant are discussed in more detail. For 7 of the 20 variants in this quadrant, the WOHs do not exceed 550 hours. Focusing on the variants with the largest deviation between the estimated risk for overheating for TOJuly and WOHs, the studio is the most prominent building typology, followed by the apartments. Moreover, 16 out of 20 variants include summer night ventilation. In total, 10 of the 20 variants in the third quadrant are related to the studio, overrepresenting this building typology compared to the other building typologies.

## CONCLUSION

The results of this research indicate that the TOJuly is a useful indicator for gaining insight into the risk of overheating in newly built residential buildings. Moreover, the TOJuly is a relatively uncomplicated method for determining the risk for overheating in the Dutch residential building stock. Among the variants for which the TOJuly method was implemented as intended, the TOJuly value underestimated the risk of overheating for 6.0% of the variants. Half of the variants within this percentage are related to the studio. The highest level of cohesion in the assessment for the risk of overheating between the two methods is attributed to the small terraced dwelling. Overall, the robustness of the TOJuly indicator for the apartments is lower compared to the dwellings.

It is concluded that, given the assumptions and simplifications embedded in the TOJuly method, TOJuly is a fairly robust indicator for determining the risk of overheating in residential buildings. Nonetheless, the overheating risk of some building typologies and parameters may be over- or underestimated. Further finetuning of the method may improve the robustness as a whole.

Although not discussed in detail in this article, the additional key findings of this research will be touched upon. Concerning individual building characteristics, the addition of an overhang above a window is the most underestimated parameter in the TOJuly method. This is caused by the generalizations embedded in the calculation method for determining the TOJuly. Results related to occupant behavior indicate that both the internal heat load and purge ventilation have a significant effect on the level of overheating in all building typologies. However, building characteristics show a larger contribution towards affecting the risk of overheating compared to occupant behavior. These observations were made in both the current and future climate scenarios.

Current building trends, such as timber frame structures and CLT structures show to increase the risk of overheating. Gaining insight into the potential overheating, albeit on a superficial level, will become increasingly important and relevant. Moreover, employing the TOJuly indicator, the summer season will gain increased importance during the design stage compared to a few years ago. It should be acknowledged that dynamic simulations provide more detailed insight into the risk of overheating, but the tradeoff between time, effort, and the resulting level of detailed information is a delicate balance. ■

Table 3. Number of variants per quadrant, for the seven building typologies.

| | Terraced small | Semi-detached | Detached | Terraced medium | Apartment middle floor | Apartment top floor | Studio |
|---|---|---|---|---|---|---|---|
| Q1 | 31 | 17 | 16 | 24 | 14 | 17 | 29 |
| Q2 | 2 | 0 | 1 | 0 | 3 | 4 | 10 |
| Q3 | 6 | 11 | 8 | 17 | 6 | 3 | 1 |
| Q4 | 9 | 20 | 23 | 6 | 25 | 24 | 9 |


[1] M. Taleghani, M. Tenpierik, and A. Van den Dobbelsteen, "Energy performance and thermal comfort of courtyard/atrium dwellings in the Netherlands in the light of climate change", Renewable Energy, 63, 486–497, 2014.

[2] NEN, "Nederlandse technische afspraak NTA 8800+A1 (nl) Energieprestatie van gebouwen – Bepalingsmethode", December 2020.

[3] RVO, "Energieprestatie indicatoren – BENG", 2020. [Online]. Available: https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/wetten-en-regels/nieuwbouw/energieprestatie-beng/indicatoren

[4] C. Leenaerts, and P. Nuiten, "Grenswaarden zomercomfort nieuwe woningen in Bouwbesluit", 2019. [Online]. Available: https://www.rvo.nl/sites/default/files/2019/08/Rapport Grenswaarden zomercomfort nieuw woningen in Bouwbesluit.pdf

[5] P. Nuiten, and C. Leenaerts, "Temperatuuroverschrijding in nieuwe woningen in relatie tot voorgenomen BENG-eisen", 2019. [Online]. Available: https://www.rvo.nl/sites/default/files/2019/05/Temperatuuroverschrijding in nieuwe woningen in relatie tot voorgenomen.pdf

[6] DGMR, "Referentie gebouwen BENG", 2016. [Online]. Available: https://www.rvo.nl/sites/default/files/2017/02/Referentiegebouwen BENG.pdf

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# Studying in the Global Hub of Acoustics

*Mats Rekswinkel*

Hej allesammen! My name is Mats, currently a second semester student in Engineering Acoustics at DTU in Denmark. As of now, I am feeling quite settled up here in the far north but in this column I'd like to explain you how and above all, why, I took the step to come here for my Masters.

First I'll take a little step back in time. In early 2019 I finished my bachelor's degree AUBS in wonderful Eindhoven. Because I wanted to see if I should pursue my interest in acoustics, I decided to gain some experience at a small acoustics consultancy company near Utrecht. End of 2020 however, I made the decision to further pursue this path, so I applied for the Engineering Acoustics MSc at DTU. I was absolutely thrilled when I received my acceptance and, despite some roadblocks due to the covid-situation, I arrived in Kongens Lyngby, just north of Copenhagen, last April.

In my eyes, the Acoustics Masters here is the most versatile and in-depth program that I could choose from. For example, at the moment I have a packed semester with courses looking into loudspeaker and microphone systems, the workings of human hearing and the mechanics behind musical instruments, amongst others. Besides, Denmark is in itself a hub of acoustics worldwide, especially in the hearing aid industry, but also audio equipment developers such as Bang & Olufsen and renowned measurement equipment manufacturer Brüel & Kjaer are located in and around Lyngby.

During the first semester I was involved in performing room impulse measurements in quite a special church hall in the north west of Copenhagen, called Bagsvaerd Kirke. It was designed in the 1970s by famous Danish architect Jørn Utzon, perhaps better known for designing a certain opera building in Sydney. The hall in itself is a spectacular sight due to the special curved, concrete roof structure and the amount of natural light coming in. For the acoustics we found room for improvement in terms of musical clarity as well as speech intelligibility in large parts of the hall. After modelling several design solutions using ray-tracing simulation software ODEON, we could substantially improve the situation by generally lowering the reverberation time and altering the direction and placement of the existing PA system.

Even though it was massively much fun to do this project I've also enjoyed my time here so far by exploring the surroundings through hiking and running. Recently I actually ran the Copenhagen half marathon, which, seeing the huge crowds, was an absolutely amazing experience after such a long time of restrictions. During the summer I especially enjoyed the closeness of the beach, even though the sea, even in summer, can still be quite cold!

All in all, I find Denmark to be an undeniably beautiful country with lovely and open people. Before I am able to strike up a full conversation in fluent Danish, I will need some more practice, but I will get there. I'm sure. Furthermore I feel extremely happy about my choice for this master's program and I am eager to see what this place can bring for my future career.

Venlig hilsen! ■

# Evaluation of Electric Vehicles Charging Profiles and Smart Charging Potential

*Supervisors:*
*Prof. ir. W. (Wim) Zeiler*
*Ir. W. (Waqas) Khan*
*Ir. K. (Kevin) de Bont (Kropman)*

*Author*
*ing. W.P.A. (Ward) Somers*

## INTRODUCTION

Electric vehicles (EVs) are increasingly adopted as an alternative for internal combustion engine vehicles (ICEVs) to comply with the Paris Agreement on climate change aiming to reduce carbon $CO_2$ emissions. Findings indicate that approximately 30% of the passenger fleet will consist of EVs in 2032 [1]. Besides the rapid growth, EVs often charge at their maximum power rate until the battery is fully charged, which can be characterized as uncoordinated charging. The growing EV fleet in combination with uncoordinated charging, results in an increasing power demand and increasing power peaks, which endangers the reliability and quality of the power supply [2, 3]. Specifically, at commercial buildings, EVs cause large power peaks since a typical occupancy pattern is noticeable among employees, where they arrive in the morning and depart late in the afternoon [4]. This occupancy pattern in combination with uncoordinated charging results in power peaks in the morning and long idle times in the afternoon. However, EVs can offer significant load flexibility with smart charging and thereby regulate the voltage frequency of the grid or on a smaller scale the voltage frequency of a building as shown in Figure 1. Therefore, this study aims to evaluate individual EV charging load profiles, based on real-world data, and smart charging to flatten the EV charging load at a case study – the office building of Kropman Breda.

## DATASET

The used dataset is obtained from the EV chargers of the Kropman office building in Breda and contain approximately six months of data (November 2020 – May 2021) from five EVs in total. The dataset only consists of unidirectional charging events, since discharging with bidirectional charging events is currently not supported by most EVs. The datasets contain a lot of parameters, but only data about datetime, charging rate (kW) and ID number are necessary.

## ELECTRIC VEHICLES' LOAD PROFILES

To gain knowledge about the individual charging behaviour of EVs, daily charging load profiles are constituted per weekday for each EV. Common daily charging load profiles are extracted with k-means data clustering techniques and validated with the silhouette score and elbow method. In total, five EVs are considered in this study.

## SMART CHARGING SCENARIO

A smart charging scenario is proposed based on the behaviour of the electrical building load. The scenario aims to flatten the EV charging load, since the electrical building load is already flattened by the battery energy storage system (BESS). To simplify the scenario, multiple assumptions are made:

- A default charging power of 7 kW is set for the individual EVs, based on assumptions from earlier research [2].
- The maximum charging power at the case study is limited to 14 kW, which corresponds to two EVs charging simultaneously at the default charging rate.
- Only 'morning' clusters of the EVs are evaluated. The morning clusters seem

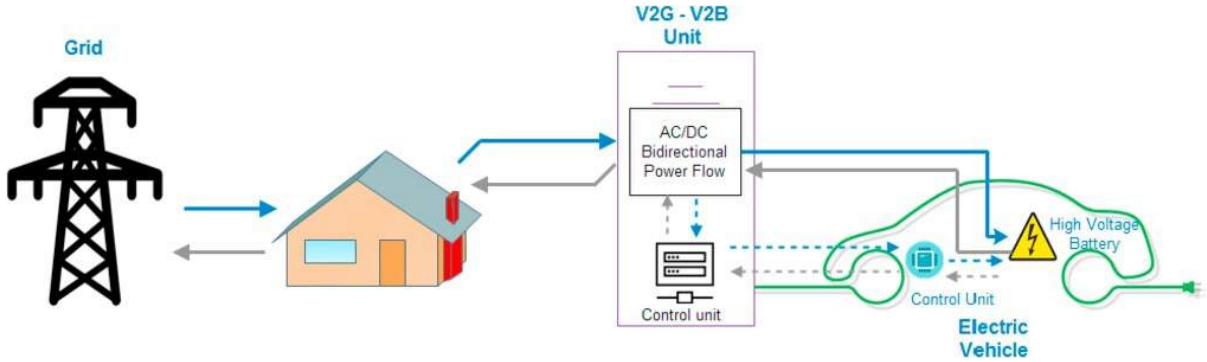



Figure 1: Vehicle-to-building (V2B) concept [5]. In this study, only unidirectional energy exchange (charging) is considered.

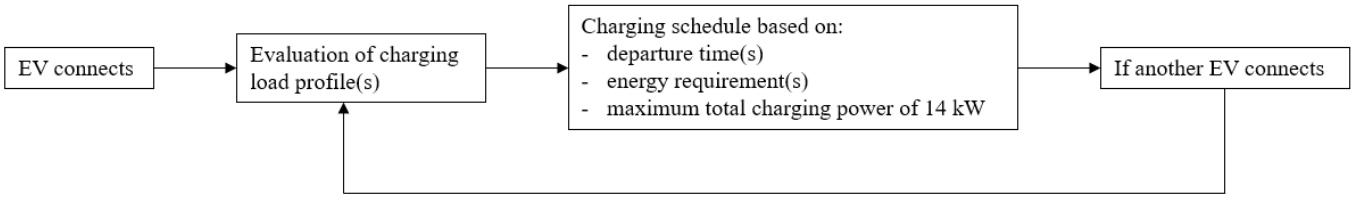



Figure 2: Smart charging scheduling.

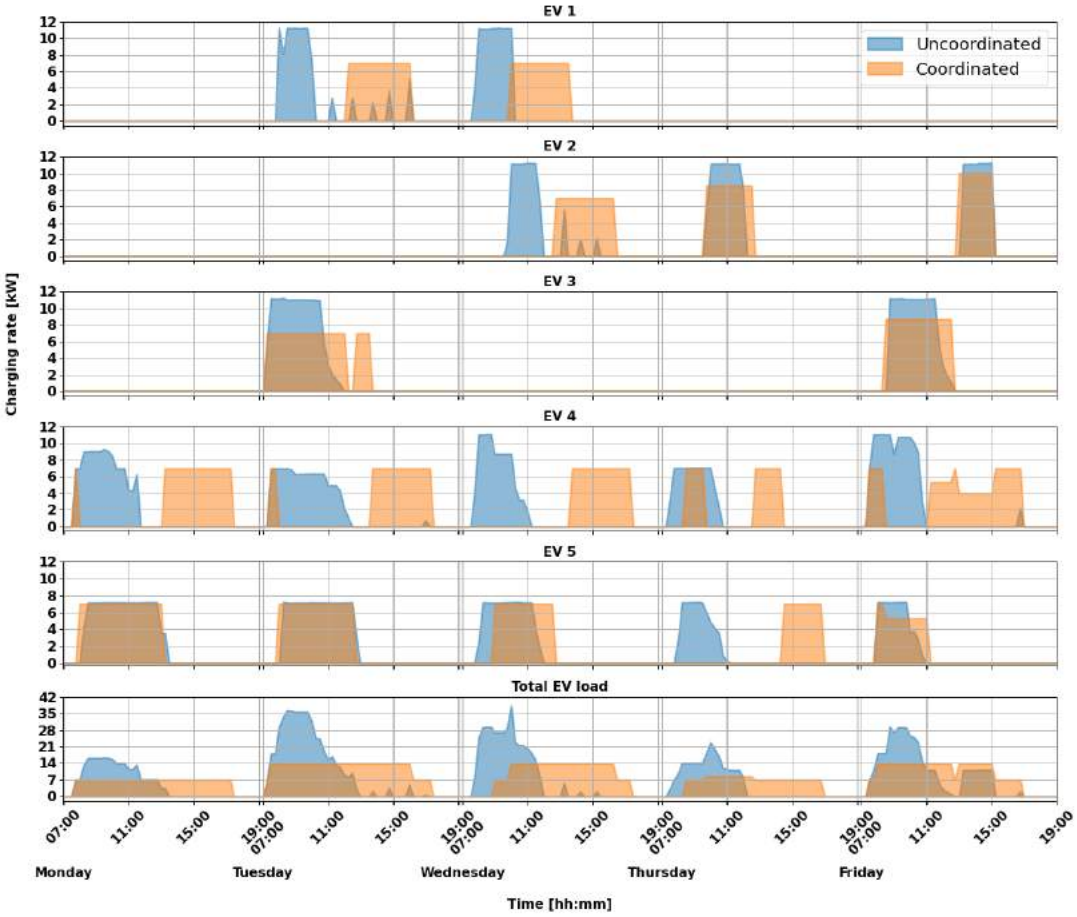



Figure 3. Smart charging potential Tuesdays

most realistic because earlier research [4] indicates that most power peaks at offices occur in the morning.

- The energy requirements of EVs are determined with the integral of the investigated cluster.
- The number of charging events throughout a week is assumed to be worst-case, meaning that an EV charges at all workdays on which it has charged previously.
- The determination of the charging sequence is based on priority by continuously monitoring the presence and energy requirements of EVs as illustrated in Figure 2.

## RESULTS

To quantify the smart charging potential at a commercial building, power peaks of uncoordinated charging profiles are compared with coordinated charging profiles as shown in Figure 3. Overall, it is possible to reduce the power peaks in the morning by spreading the EV load over the day. The average individual power peak reductions vary from a slight decrease of 2.83% up to 37.8%, where the average power peak reduction of the total EV load equals 59.6% as shown in Table 1 ('–' indicates absence). Therefore, the smart charging potential of this scenario shows very promising results.

Table 1. Results smart charging potential.

| EV | Monday | Tuesday | Wednesday | Thursday | Friday | Average |
|---|---|---|---|---|---|---|
| EV1 | - | -37.7% | -37.8% | - | - | -37.8% |
| EV2 | - | - | -37.7% | -23.9% | -11.0% | -24.3% |
| EV3 | - | -37.7% | - | - | -22.2% | -30.0% |
| EV4 | -24.4% | +0.24% | -37.1% | -1.19% | -37.1% | -19.9% |
| EV5 | -2.45% | -3.06% | -2.89% | -2.80% | -2.94% | -2.83% |
| Total | -57.4% | -61.5% | -63.4% | -63.1% | -52.4% | -59.6% |

## DISCUSSION

The results of the smart charging potential are very promising. However, the smart charging potential is accompanied by certain uncertainties and limitations. First, the used datasets have a limited number of charging events. Only 122 charging sessions are registered since the operation of the EV chargers. A larger dataset would increase the reliability of the clustered charging profiles. Second, in most cases it is unknown how much energy an EV needs to charge, since state of charge values are often not available due to a lack of open protocols. Therefore, this study determined the energy requirement of an EV at a specific weekday by the integral of the obtained cluster. ■

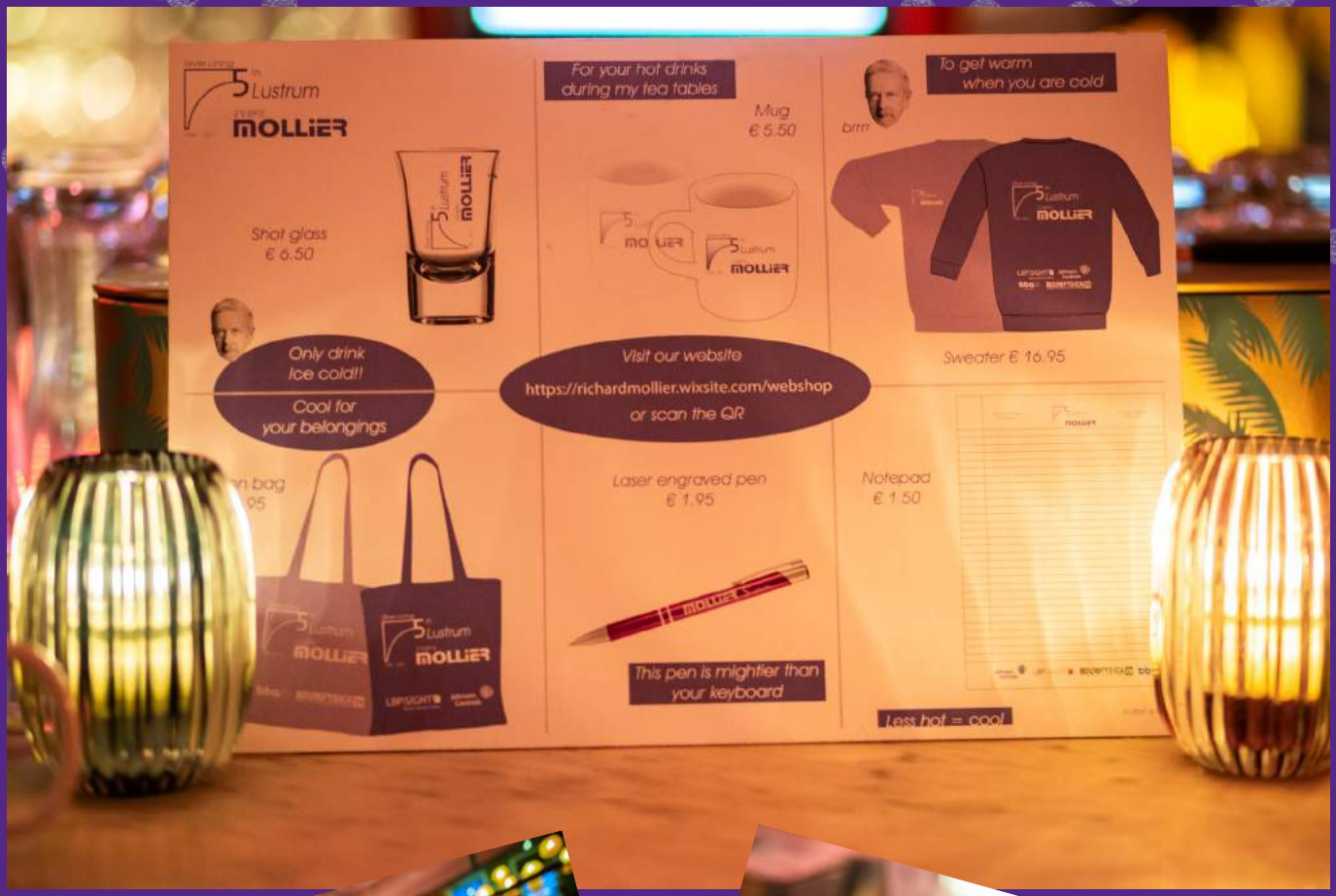

[1] N. Rietmann, B. Hügler and T. Lieven, "Forecasting the trajectory of electric vehicle sales and consequences for worldwide CO2 emissions," Journal of Cleaner Production, vol. 261, pp. 1-16, 2020.

[2] C. Crozier, T. Morstyn and M. McCulloch, "The opportunity for smart charging to mitigate the impact of electric vehicles on transmission and distribution systems," Applied Energy, vol. 268, pp. 1-11, 2020.

[3] R. Jovanovic, S. Bayhan and I. S. Bayram, "A multiobjective analysis of the potential of scheduling electrical vehicle charging for flattening the duck curve," Journal of Computational Science, vol. 48, pp. 1-9, 2021.

[4] N. Sadeghianpourhamami, N. Refa, M. Strobbe and C. Develder, "Quantitive analysis of electric vehicle flexibility: A data-driven approach," International Journal of Electrical Power & Energy Systems, vol. 95, pp. 451-462, 2018.

[5] C. S. Loakimidis, D. Thomas, P. Rycerski and K. N. Genikomsakis, "Peak shaving and valley filling of power consumption profile in non-residential buildings using an electric vehicle parking lot," Energy, vol. 148, pp. 148-158, 2018.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# One-day Makeover, a Novel Concept to Housing Refurbishment

*Author*
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*prof.dr.ir. J.L.M. (Jan) Hensen*

## INTRODUCTION

In August 2021, I started working on a PhD project that explores a novel solution to housing refurbishment. The proposed solution is a [\polymer-based] integrated system that enables the replacement of existing roofs within a day's time. The integrated system provides shelter, thermal insulation, and incorporates photovoltaics to generate electricity. The project is conducted at the Building Performance group at the department of the Built Environment at the Eindhoven University of Technology.

First, the context of this project is drafted by discussing societal challenges in the field of energy and resources. Then, the proposed solution to housing refurbishment is discussed in some more detail, to the extent possible at this stage of the project. Finally, a short outline of the PhD project itself is included.

## HOUSES AND ENERGY

Societies of today recognize that they are facing various challenges concerning their relation to the world around them. Those challenges are often denoted 'crises': climate crisis, housing crisis, construction crisis, energy crisis, agricultural crisis, to name some popular ones. I would personally prefer to remove the alarmist ring that the word crisis brings about and reduce the perceived threats to simply 'a resource challenge'. This is a matter of pure economics: the human pursuit of prosperity in the face of limited resources.

Resources include tangible things like material feedstock to industries and fuels to propel power plants and transportation, and may also refer to more abstract aspects such as time, labor, and a healthy environment.

Let us limit our scope to the field of housing and energy in the Netherlands. The Dutch housing sector consumes approximately 250 to 300 PJ (petajoules) of energy per year for heating, depending on the severity of winter conditions in our temperate climate. Heating of houses therefore accounts for roughly 10% of the 3 EJ (exajoules) that the country consumes annually, rendering houses a significant contributor to the Dutch domestic energy consumption [1]

Awareness about energy efficiency of buildings has only started to emerge around the seventies. Since then, legislation around the insulation of buildings has been becoming increasingly strict. The building stock of the Netherlands consists of many dated objects, as is shown in Figure 1. Notice that the bins get narrower as the building age decreases. The arrow on the left indicates that the first bin includes all objects constructed before 1850. The total number of dwellings is roughly 7.6 million [2]. Many of these objects are poorly insulated, causing them to lose heat during the colder seasons, for example.

Having established that the Dutch building stock is dated and consumes a significant amount of energy, it may be worthwhile

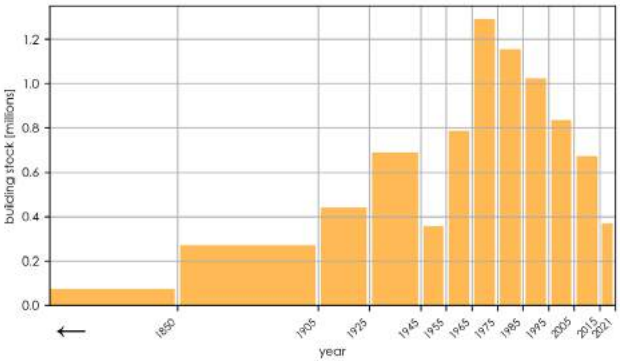


Figure 1. A 2021 composition of the Dutch housing stock as a function of construction era [1].

to improve its energy efficiency. To substantiate the call for improvements, the Dutch government has formulated some objectives related to the built environment in a 2019 directive 'Klimaatakkoord', or Climate Agreement, which was derived from the 2015 Paris Climate Agreement [3]. These objectives are related to the emissions of greenhouse gases (primarily carbon dioxide, which is emitted when burning fuels to heat houses or generate electricity). The objectives related to the built environment are to refurbish 1.5 million dwellings before the year 2030, and to completely diminish the greenhouse gas emissions before 2050. To refurbish 1.5 milliion dwellings before 2030, would require an accelerated renovation rate by more than a factor of one hundred on average, relative to the current rate (2021) [4].

## MATERIALS

Buildings being dated, does not necessarily mean that they are outdated. The existing building stock can be viewed as precious set of capital assets. The capital is represented by the materials and labor that went into constructing these very durable and functional structures. Existing houses should therefore be considered part of the solution to the energy transition for the built environment. The remainder of this text introduces a solution to housing refurbishment that may support part of the achievement of the ambitious goals.

## ONE-DAY MAKEOVER

To realize a hundred-fold increased rate of renovation well before the year 2030, is challenging, if at all possible. To accommodate (part of) this ambitious objective, a novel approach to roof refurbishment is proposed: One-day Makeover, or ODMO. ODMO is a renovation service concept, initiated by the chemicals manufacturer Sabic, and further developed in cooperation with construction company Heijmans, PV module manufacturer Solarge, and the housing corporation Zowonen. ODMO aims to replace a roof by an integrated roof system within a day's time. The process is depicted schematically in Figure 2. Figure 2 shows a sequence of refurbishment steps taken when applying the One-day Makeover concept.

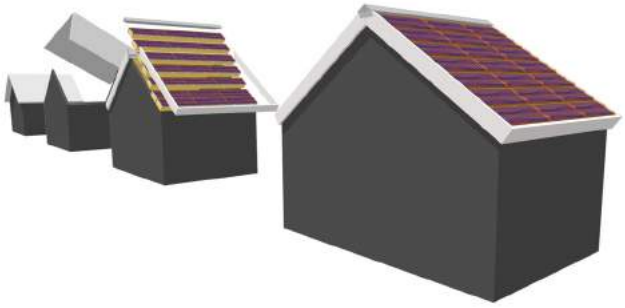

Figure 2. . A schematic presentation of the ODMO process.

from left to right, the old roof cladding is removed, leaving the substructure intact (including the beams/rafters/girders), then the IRS is installed by mounting the separate system segments, forming a self-carrying structure. Finally, the whole is completed by applying the proper finishing.

At the heart of ODMO we find the Integrated Roof Structure, or IRS. The IRS integrates (modern) roof-related functionality into a single construction component: shelter, insulation, and energy generation. The IRS is depicted schematically in Figure 3. The left-hand side of the figure shows a renovated roof, where one of the IRS segments is isolated; the right-hand side of the figure shows the main sub-components. The Integrated Roof Structure concept can be produced in an industrial context, reducing the need for manual labor required to conduct renovation in a classical manner. Industrial production also enhances scalability and therefore widespread application of the ODMO concept.

The ODMO service addresses some of the resource aspects mentioned in the introduction: time and labor. It thereby provides a financially feasible solution to renovation for house owners and housing corporations in their endeavor to improve the sustainability of the built environment.

## NARROWING DOWN: THE PHD PROJECT

Now that we have drafted the framework of sustainability challenges in the built environment, we will discuss the future PhD-related work, concerning renovation and the ODMO concept.

The aim of the research comprises of objectives at high and low levels of abstraction. On the one hand, we want to increase our understanding of how existing dwellings are best refurbished when using an integrated approach to resource accounting, or Life Cycle Assessment (LCA). On the other hand, we wonder how the ODMO concept can be used to achieve improved sustainability, by critically evaluating the performance of the IRS and optimizing its design. A brief description of the two perspectives is given.

**Building renovation**

The challenge ahead can be summarized as follows: to optimize the current building stock to effectively improve its overall life cycle performance. Such optimizations will be based on building performance simulations. This challenge is approached by identifying the main contributors to inefficiencies. Inefficiencies are related to resource consumption, be it material feedstock or fuels. To identify these contributors, the energy use and construction properties of some (not yet specified) common dwelling types will be evaluated.

Based on such an evaluation, the possibilities of overall performance optimization are explored, looking at various intervention techniques to improve buildings. Applying the IRS will of course be one of the visited technologies. Questions can be posed like "For what building types can mere roof refurbishment be a solution to integrated sustainability?" or "Can the ODMO concept compete with other available refurbishment solutions, when considering overall sustainability?"

**IRS design**

At the lower end of the abstraction scale, a closer look will be taken at the IRS itself. Since the IRS is a totally novel product in construction, still many of its performance characteristics are unknown. Performance topics include thermal insulation, energy generation capacity, structural integrity, air tightness, acoustics, and fire safety. During the PhD project, I will mainly focus on thermal insulation and energy generation. In conjunction to the building performance simulation studies, experimental work is carried out on a prototype setup at SolarBEAT (Solar Building Energy Application Test site) on the TU/e Vertigo building.

**Contribution to academics**

The academic challenge of this project lies in the connection between building performance and life cycle assessment. It is a matter of how building performance simulation/evaluation can be used in life cycle assessment and how uncertainties must be appreciated when communicating results. It will be interesting, for instance, to look into the methods of treating the multiple criteria or performance aspects that are involved in an integrated sustainability assessment, some of which were touched upon in this short introductory text. ■

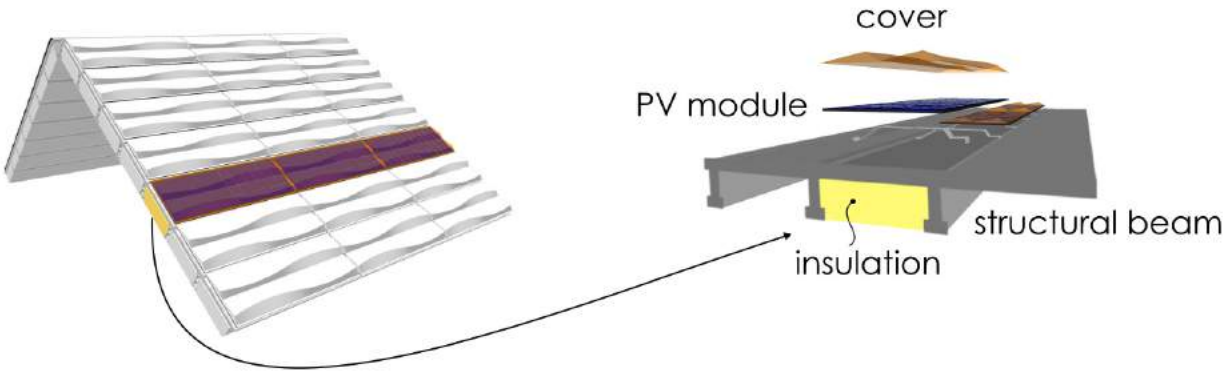


Figure 3. A schematic presentation of an IRS segment in isolation.

[1] Centraal Bureau voor de Statistiek, CBS StatLine, Voorraad woningen en gebouwen, consulted online November 2021
[2] Centraal Bureau voor de Statistiek, CBS StatLine, Energieverbruik naar sector, consulted online November 2021
[3] Ministerie van Economische Zaken en Klimaat. Klimaatakkoord (Climate Agreement). Ministerie van Economische Zaken en Klimaat, 2019.
[4] IEBB. Programma Integrale Energietransitie Bestaande Bouw, 2021

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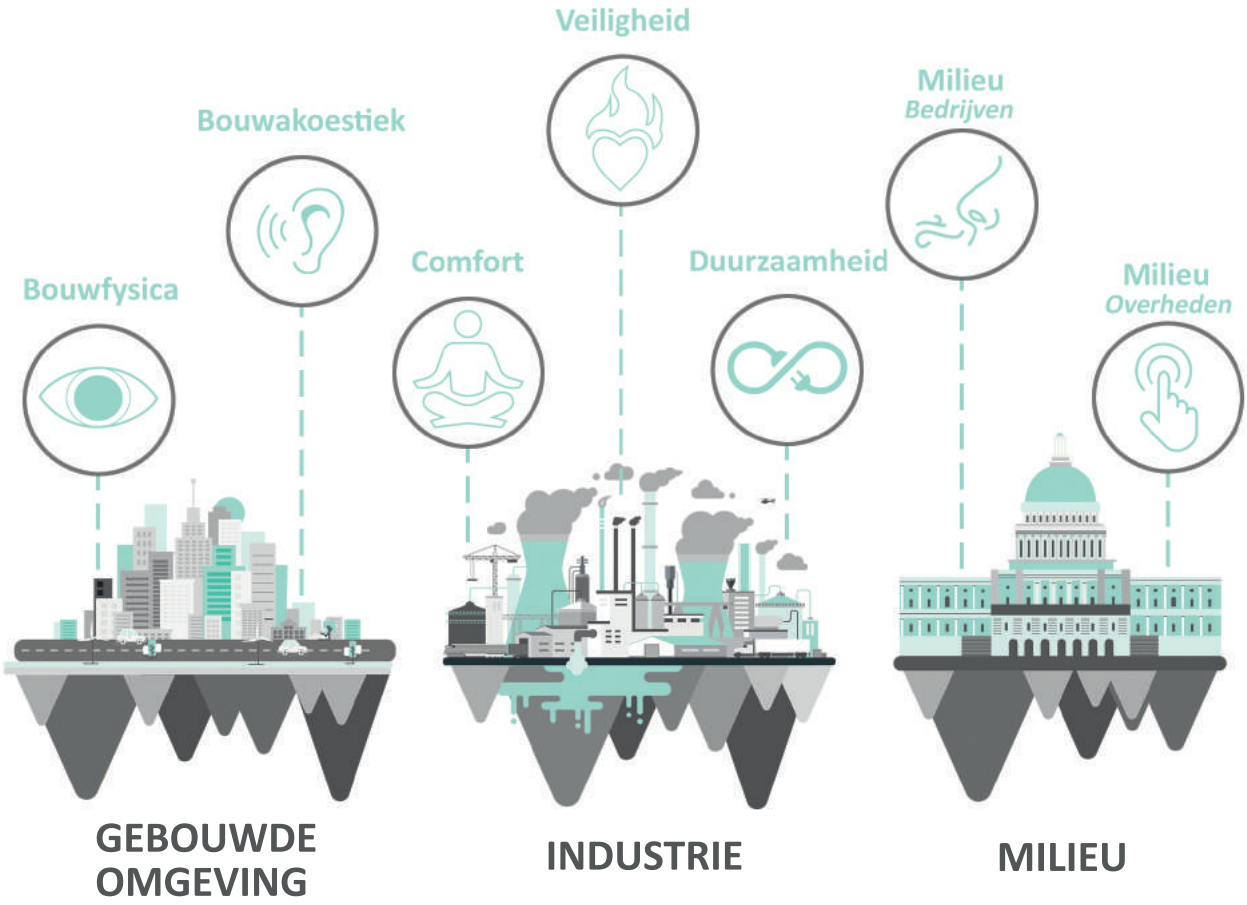


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# BPS Basics 'The Rise of Acoustic VR techniques'

*Author*
*prof.dr.ir. M. (Maarten) Hornikx*

## ACOUSTICS AND LEGISLATION IN BUILDINGS

An environmental factor that is difficult to turn off while we work, study or relax is the sound around us. There is always sound around us, and it affects us. It provides us with information (your colleague asking if you want coffee), it distracts us from our work (that annoying fly in your office), it triggers high stress levels (the continuous sound of that air conditioning unit) and it serves as a relaxing environment (the sounds of nature during your Saturday morning walk in the woods). Since noise leads to adverse health effects, from annoyance to premature death [1], the government must protect us from it, especially from environmental noise (noise from road, rail and air traffic), and noise from neighbors. Legislation requires, among other things, sound insulation between houses. Acoustic consultants play a very important role in the Architecture, Engineering and Construction (AEC) world, because they have to ensure that the codes that acoustic regulations prescribe are met. When they have the technical resources to do this, it sounds like we have solved the problem of environmental noise. Well, not really.

The legislation does not adequately account for all adverse health effects. For example, the effect of low-frequency noise in buildings is underestimated, especially in wooden buildings [2]. Also, the harmful effects of sound are usually quantified in terms of some kind of time-averaged sound level, while other characteristics of sound such as its spectral content, fluctuation and origin play an important role. The many people who have complaints about aircraft noise from Schiphol Airport prove this [3].

In addition to legislation, there are acoustic guidelines that acousticians strive to meet, such as the room acoustic parameters of a concert hall. In order to meet these guidelines, the acousticians often have to convince architects to change materials, arguing that the desired room acoustic parameters can be achieved. This can be a difficult discussion.

## COMMUNICATION

Certainly, building acoustics is in practice a story of physics. Quantifying the room acoustics of a space, or the sound insulation between two apartments, requires a good command of experimental and computational acoustical techniques as an acoustical consultant. In addition, communication skills are involved. For the design of that concert hall, the architect might not be persuaded to change his mind about the materials he would like to use. For him, acoustics might play a less prominent role, and besides, he really doesn't know the difference between a reverberation time of 1.5s and 2s. Also, you can tell the citizens of a residential area that the planned noise barrier will do its job for them, but how can you really reassure them about that? There are many ways to develop a communication strategy in such cases, and acousticians usually use numbers to support their arguments. These are absolutely supportive, because, for example, a sound level in decibels can be related to other more familiar sounds, and with site visits an acoustic environment can be experienced in real life.

While visualization is a familiar concept, auralization (the process of making audible the sound field due to a sound source in a room) is a relatively young expression [4]. Auralization is used by acousticians to make, for example, a musical instrument audible in the concert hall being designed. It is based on the calculated acoustic characteristics of the space (using its impulse response) and a sound signal recorded in a space free of reflections (anechoic space) or a synthesized sound. The sound can be produced binaurally, meaning that the computation delivers the signals to the two eardrums. Auralization can serve as a more natural way to talk about acoustics, because it, for example, allows all involved stakholders to experience the sound of a concert hall. This experience can be offered through headphones, among other ways. Auralization is the core of Acoustic VR, and has received increasing attention over the past decade and a half.

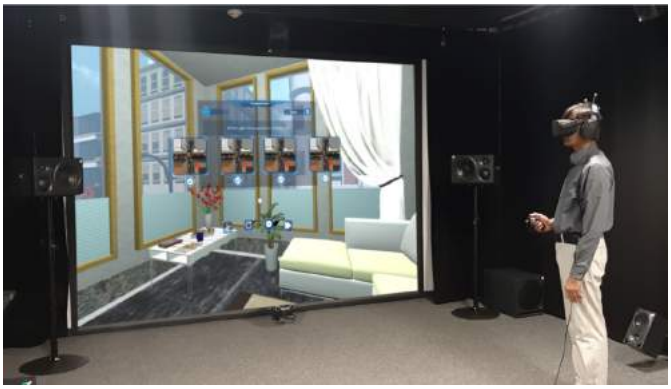

Figure 1. Listening test setup for pass-by sounds of outdoor sources using the Virtual Building Acoustics platform of RWTH.

## ACOUSTIC VR TOOLS, CURRENT DEVELOPMENTS.

In addition to auralizing sounds through headphones, Acoustic VR typically couples visualization and auralization and captures head tracking. This means that the user is immersed in a virtual world that can resemble the real world to some extent in both the visual and sound parts, see Figure 1. The rapid increase in attention to Acoustic VR is certainly being accelerated by the gaming industry, where game engines like Unity can be used to develop a wealth of applications [5].

Two types of Acoustic VR applications are based on an existing environment, or on a design of a new environment. In the first case, an existing situation can be captured through a 3D video and 3D audio recording, which can then be played back in VR. A recent example of this is capturing the video and audio in an apartment with high noise levels due to road traffic noise. The recorded audio can then be adjusted to resemble different levels of sound insulation of the facade and this is then integrated into a listening experience that a user of the VR platform can experience to evaluate how much sound insulation is preferable in that scenario [6].

Examples of the second type are virtual environments based entirely on acoustic prediction, such as the virtual building acoustics platform [7], or our own Eindhoven Acoustics Virtual Reality platform for educational purposes, see Figure 2 [8]. These platforms allow users to experience a space that does not yet exist and to gain insight into the influence of different materials on the sound in that space.

Apart from its application in consulting practice and education, Acoustic VR opens up a whole range of possibilities for research. On the one hand, there is the development of tools. Acoustic consultants are looking for tools that they can use in their daily practice. For this, it is important to develop tools that fit the purpose, in other words, that provide the realistic acoustics (experience) of spaces. This requires both research on acoustic prediction methods and on the perception of the outcomes of these methods.

In terms of research on the perception of sound and its effect on people, acoustic VR offers much more potential than has been the case recently because it is much easier to change acoustic and visual scenarios in VR than in reality.

## WHAT IS THE NEXT STEP?

First, in ten years from now, all acoustical consultants will have better communication tools for their daily practice. While still performing measurements and calculations according to standards, acoustic VR tools will become commonplace in communicating with stakeholders, helping to improve acoustic environments.

Although this article is about acoustic VR, it will probably be mentioned together with acoustic Augmented Reality (AR) in the future: instead of making both image and sound virtual, a virtual acoustic experience can also be provided in a real environment, for example through bone conduction headphones. Image that you physically sit in a lecture hall and hear a speaker speaking in that space, but with different acoustic properties than the room actually has. Such experiences would avoid virtual reality sickness, which is equivalent to seasickness. Further expectations are the increased level of interactivity, such as the ability to have a real-time conversation with your stakeholder in acoustic VR! The Building Acoustics research group will continue to be active in this research field, stay tuned for more developments! ■

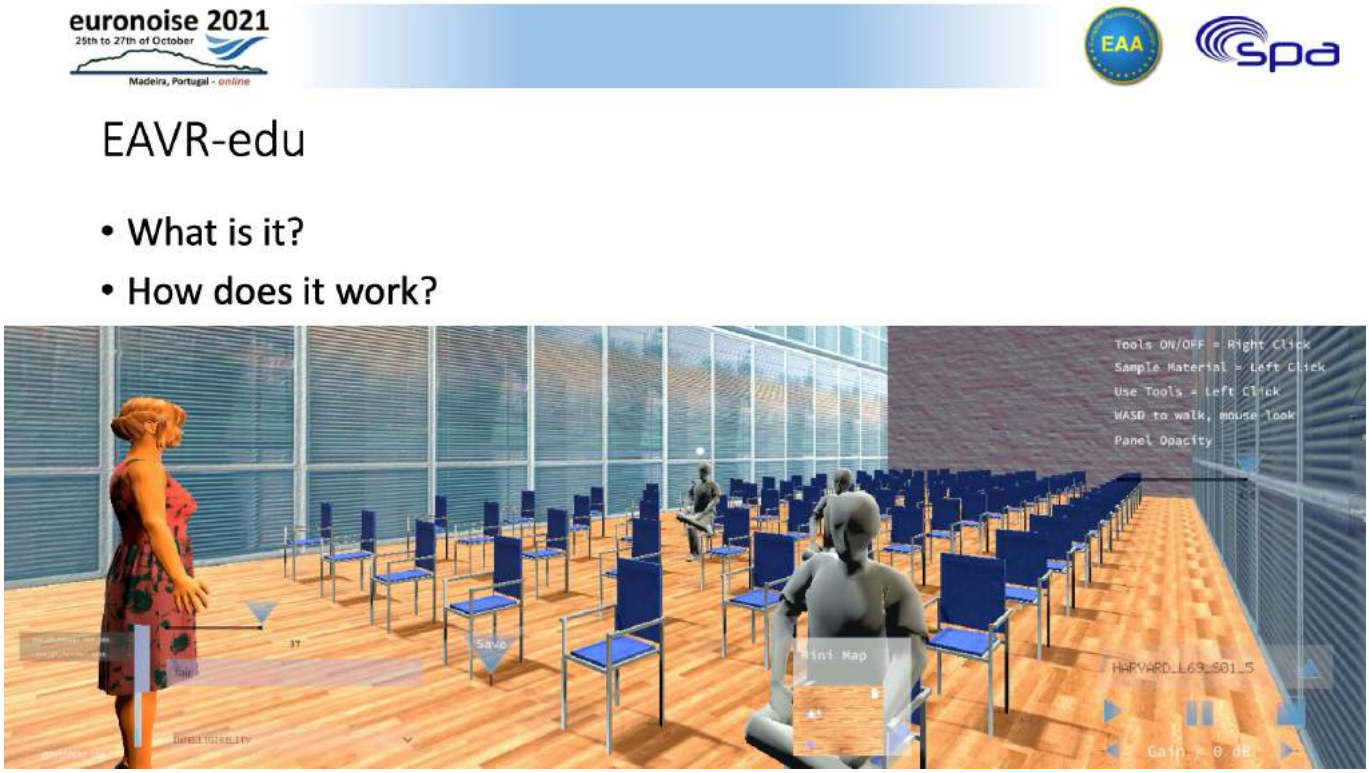

Figure 2. The Eindhoven Acoustic VR system of educational purposes was presented at Euronoise in October of this year.


[1] Peris, E., 2020. Environmental noise in Europe: 2020. Eur. Environ. Agency, 1, p. 104.

[2] Hagberg, K. and Bard, D., 2014, October. Low frequency sound transmission in multifamily wooden houses. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 249, No. 1, pp. 5990-5996). Institute of Noise Control Engineering.

[3] https://nos.nl/artikel/2256825-meer-mensen-hebben-last-van-schiphol-officieel-bestaat-mijn-geluidsoverlast-niet

[4] Kleiner, M., Dalenbäck, B.I. and Svensson, P., 1993. Auralization-an overview. Journal of the Audio Engineering Society, 41(11), pp.861-875.

[5] Oreskovic, Alexei (September 14, 2018). "Why EA's former boss believes the 3D tech that powers video games will make way more money outside of gaming". Business Insider. Archived from the original on September 15, 2018. Retrieved October 17, 2018.

[6] Vos, V., Milo, A. and Hornikx, M., Towards a method for subjectively evaluating the impact of facade insulation interventions by acoustic virtual reality. 13th ICBEN Congress on Noise as a Public Health Problem, Online, June 14-17, (2021)

[7] Muhammad, I., Heimes, A. and Vorländer, M., 2021. Interactive real-time auralization of airborne sound insulation in buildings. Acta Acustica, 5, p.19., http://virtualbuildingacoustics.org

[8] https://boost.tue.nl/projects/acoustic-virtual-reality-in-challenged-based-learning/


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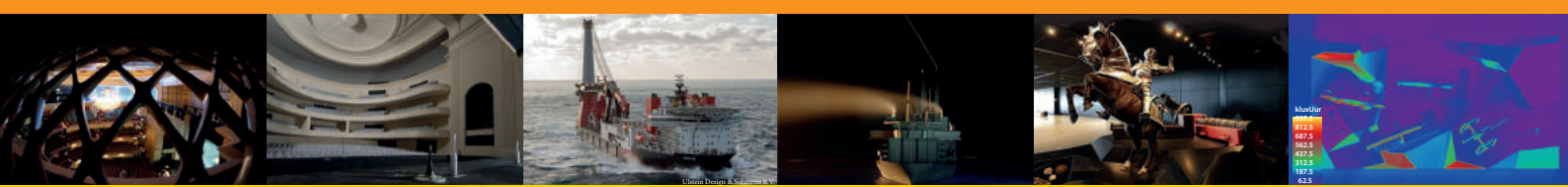

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# Thermal Insulation Performance of Green Roofs

*Author*
*E.J. (Evi) Coenen*

*Supervisors*
*dr. F. (Florent) Gauvin*

## INTRODUCTION

The need for more efficient and environmentally friendly buildings has prompted researchers to investigate green roof technology. A green roof is a combination of biotic and abiotic components which covers the building envelope. In comparison with conventional roofs, green roofs tend to retain greater quantities of stormwater, have a bigger air purification capability, decrease noise levels to a greater extend, and prolong the life span of roofing systems. However, high initial cost, technical issues and maintenance are challenges which limit the use of green roofs [1,2]. One of the main advantages of green roofs is the thermal insulation performance. Due to the enhanced thermal insulation and the occurrence of evapotranspiration (evaporation and transpiration of water), surface and indoor temperatures decrease. This results in reduced heating and cooling loads and mitigation of the urban heat island effect [3].

The aim of this study is to quantify the thermal insulation performance of green roofs on new and existing buildings. The attempt to research the performance is set up as an experimental approach, which includes both a case study and a lab study.

## METHODOLOGY

The research started with a case study, which was part of the project 'Groendak Gasvrij'. Together with Havensteder, Sempergreen and Sobolt, the TU/e started the project in 2018 to study the effect of green roofs on the energy consumption of buildings and to develop a tool that analyses roofs on their suitability to implement a green roof. For more than a year, measurements have been performed on four conventional and four green roofs, see Figure 1, both with an Rc-value of 6.3 m2K/W. This included surface temperatures of the roofs, heat fluxes through the roofs and real time weather data [4].

In addition to the case study, a lab study has been conducted. The study is performed within a climate chamber with a scale model of an extensive green roof developed and validated by students in earlier projects. For the experiments, the indoor temperature of the scale model and the heat flux through the roof are measured.

The experiments are performed with the same set of conditions and two varying parameters: the thermal resistance of the roof and the presence or absence of the green roof. The temperatures in the climate chamber, the soil saturation and the light settings were equal for all experiments, while the thermal resistance of the roof varied between 0.0 m2K/W, 0.9 m2K/W and 2.6 m2K/W for respectively 0, 1 and 3 layers of XPS. In total, six experiments have been caried out, of which three with and three without green roof.

Figure 1. Green roofs from the project 'Groendak Gasvrij' (Groendak Gasvrij, 2020)

## RESULTS

In the case study, three seasons have been analyzed: winter, spring and summer. During all seasons, the ceiling temperature was lower for buildings with green roofs. Both in winter and summer, the temperature difference is a result of the enhanced thermal insulation. In spring, the cool and wet weather resulted in lower indoor temperatures due to the evapotranspiration effect of the green roof.

The lab study shows that for all three insulation values, the presence of the green roof results in lower indoor temperatures in comparison with the experiments carried out without the green roof, see Figure 2. Based on the measured data, this effect can be attributed to evapotranspiration. Furthermore, the results show an increased evapotranspiration rate with decreased thermal resistance value of the roof.

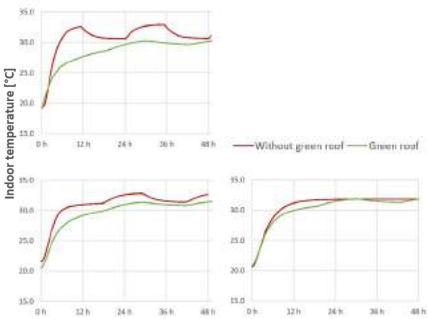


Figure 2. Indoor temperature with 0, 1 and 3 layers of XPS respectively after increasing the temperature from 18°C to 30 °C

## CONCLUSION

It can be concluded that installing green roofs on both new and existing buildings will have a positive effect on the energy consumption, as the thermal insulation performance causes lower heating and cooling loads. Furthermore, the implementation will have a bigger effect on non- or low-insulated roofs compared to well insulated buildings. ■

[1] U. Berardi, A. GhaffarianHoseini, and A. GhaffarianHoseini, "State-of-the-art analysis of the environmental benefits of green roofs," Applied Energy, vol. 115, pp. 411-428, 2014.

[2] M. Shafique, R. Kim and M. Rafiq, "Green roof benefits, opportunities and challenges – A review," Renewable and Sustainable Energy Reviews, vol. 90, pp. 757-773, 2018.

[3] T. Theodosiou, "Green Roofs in Buildings: Thermal and Environmental Behaviour," Advances in Building Energy Research, vol. 3, pp. 271-288, 2009.

[4] J. van der Auweraert, H. Brouwers, P. Fokkens, and S. Scheper, "Groendak Gasvrij: Eindrapportage," 2020.

# The Integral Design of the Rotterdam Port Experience Centre

*ir. J.V.F. (Jeroen) Houben*
*ir. M.L. (Margo) van den Eijnde*

At one of the most western parts of the Netherlands, the Port of Rotterdam has planned the realisation of a building that represents the port and exhibits all aspects of the port of Rotterdam and its current and future developments. This experience centre at Maasvlakte 2 will be attractive and informative for the wider public: students and representative for all companies, relations and stakeholders of the Port of Rotterdam. Besides that, the building will be a place where people can meet and exchange knowledge and experiences.

## NELISSEN INGENIEUSBUREAU

Nelissen Ingenieursbureau was engaged in the design process of the experience centre, fulfilling the role of integrated consultant concerning Building Physics & Services. Nelissen works based on a multidisciplinary approach among the departments of building services, electrical engineering and building physics (including acoustics, fire safety and sustainability). For each individual project, a tailor-made design team is put together, which fits the team members' experience and professional development goals. This approach allows effective communication, knowledge transfer and design coordination between disciplines.

As part of the Nelissen design team, we - Jeroen Houben and Margo van den Eijnde - cooperated on both the conceptual and technical part of the design. In particular, Jeroen was responsible for the integrated design of the building services and Margo was accompanied by an experienced consultant to take care of the advice for the building physics, acoustics and fire safety. Both Jeroen (2010) and Margo (2020) graduated at the Master Building Physics and Services at the Eindhoven University of Technology. In following paragraphs they will introduce their role and the related challenges they experienced during the design process of the Experience Centre.

## EXPERIENCE CENTRE

The structural design of the centre was made by MVRDV architects and consists of five floors, each sequentially rotated, creating a unique panoramic viewing experience on every floor. When entering the building, the ground floor accommodates a public area, café and back office area. Going upstairs, MVRDV located exhibition areas around the heart of the building: a central atrium with a spiral staircase going all the way up to the panorama roof. Besides the internal route, the visitor can also explore the port experience via the open air route that is created by the combination of the external terraces (staggered because of the rotating floorplans) connected by stairways that go all the way up to the rooftop deck. On the journey to the top the visitor will experience the present and future of the port of Rotterdam, accompanied by astonishing 360° panoramic views of the port area and the sea.

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Figure 1. The Harbor Experience Centre at Maasvlakte 2 in Rotterdam (MVRDV Architects)

## BUILDING PHYSICS

As a junior advisor in building physics, I, Margo van den Eijnde, had several challenging subjects that are being addressed during the first part of the design process. One of them was the daylight environment because of the one-sided glace facade. Most projects I did so far were projects where I checked if the amount of daylight inside meets the current building code (next to the program of the client). But in this building the distribution of the daylight and preventing daylight hindrance were more important. Partly based on the information of the new daylight standard (NEN-EN 17037_2018) the hindrance of daylight was examined based on hindrance by glare caused by direct glare, reflections and contrasts. The analysis is conducted by using the simulation software Radiance that calculates the daylight environment of a beforehand created model of the building by given parameters. The results of the simulation gave the architect a tool to optimize their design and prevent hindrance.

*"THERE ARE MORE CHALLENGES TO THE DESIGN OF A BUILDING AT THE COAST THAN I THOUGHT IN ADVANCE"* ~ Margo v/d Eijnde, Building Physics Consultant

Secondly, the location of the building along the coast resulted in a specific climate with corresponding challenges. Especially the prevailing wind speed should not create uncomfortable, let alone dangerous situations for the users of the building. Based on the NEN 8100 the first analysis is been conducted. In this document wind nuisance is analysed for different quality grades of the wind speed for different activities (walking, saunter and sitting). Based on this given information I recommended the necessary locations for measures to protect visitors from wind.

Lastly, the desired flexibility needed some additional attention. Because the requested flexibility and the designed atrium, the building was implemented as one fire compartment with an open air escape route via the staircases at the outside. Besides that the industrial and flexible design principle with hard surfaces and large connected volumes resulted in a high reverberation time that concludes in uncomfortable acoustical climate. This was solved by covering the cannelures of the steel frame floor with absorbing material to create a larger absorbing area than only the ceiling area.

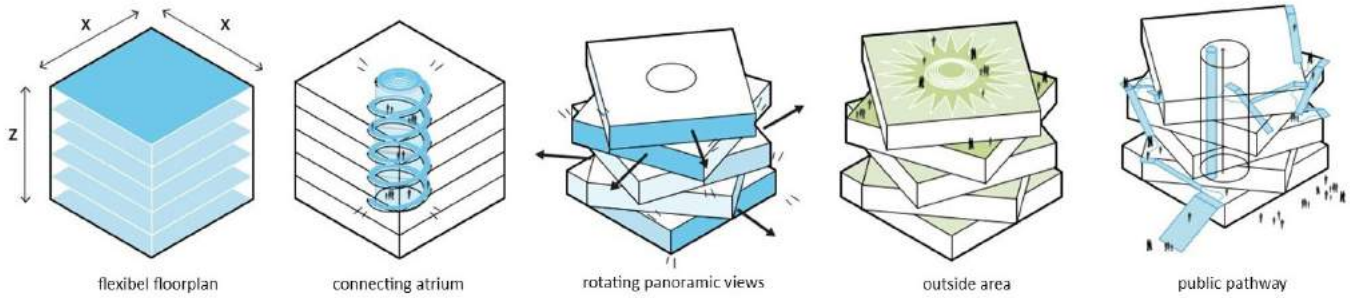


Figure 2. Design features of the Harbor Experience Centre (MVRDV Architects)

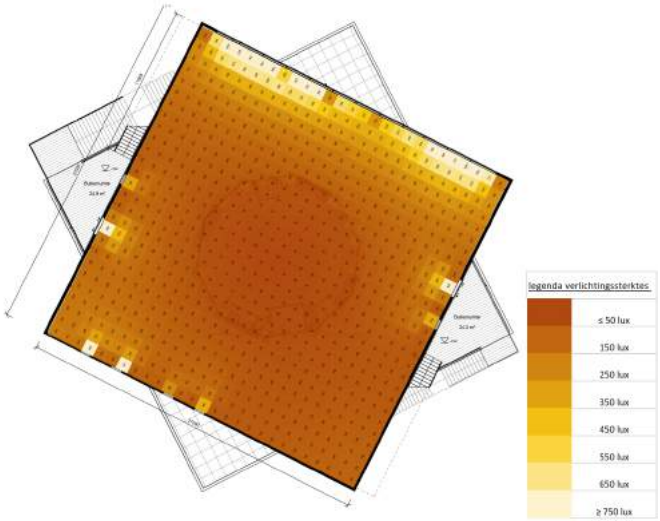


Figure 3. Visual results of a radiance simulation

## BUILDING SERVICES AND FACADE DESIGN

In my role as integral building services consultant I, Jeroen Houben, was already engaged in the early stages of the design process. One of the first steps is inspiring the design team in the brainstorm sessions, about possible energy concepts, façade design principles and promising concepts for heating and cooling. MVRDV's twisted massing principle lead to an ambitious form factor (surface/volume factor), especially in the windy Maasvlakte 2 environment. We performed energy performance (NTA8800) and thermal comfort simulation studies in order to investigate the combined impact of thermal façade design variants (g-value, façade orientation, insulation value, glazing percentages) and heating and cooling concepts (concrete core activation vs. all-air vs. fan coil system) and on a number of key performance metrics: heating and cooling demand, peak loads, thermal comfort (weighted overheating hours) and 'BENG'-criteria. In close collaboration with MVRDV we optimized the façade design and the orientations of the volumes themselves. A high performance solar control triple glazing, passive house quality insulation ($R_c$-values > 8 $m^2$•K/W) and an airtight structural connection ($q_{v;10}$ = 0,15 $dm^3/s•m^2$ surface area) resulted in a weighted balance between thermal and visual comfort, while being able to meet the latest energy performance criteria: in particular BENG 1.

The varying occupation patterns and internal heat gains demanded for a climate concept with a fast response time in terms of heating and cooling capacity. Moreover, a high degree of flexibility in room layouts because of changing exhibitions was desired by our client. A fan coil system seemed to be the most cost effective solution for the exhibition spaces. In the office and conference rooms we applied radiant ceiling systems and near the large panoramic windows we applied additional floor heating to prevent local downdraught.

*"MVRDV'S TWISTED MASSING PRINCIPLE MADE IT CHALLENGING TO COMPLY WITH THE OBLIGATORY 'BENG 1' REQUIREMENTS, ESPECIALLY IN THE WINDY MAASVLAKTE 2 ENVIRONMENT."*
~ Jeroen Houben, Building Services Consultant

Our client had the desire to expose sustainability in a creative way, we therefore put solar panels on the viewing deck and applied a wind turbine. In the first instance we also investigated the potential of sea water heating and cooling and/or application of an aquifer thermal wells, but unfortunately the life cycle costs were too high concerning the footprint of the Experience Centre.

## INTEGRATED RESULT

In the end all parties of the design team have to communicate and collaborate to deliver the most optimal design that fulfills the demands of the client. It often gives some challenges to create an optimum between the architectural design, the comfort and the energy related goals. In the design process of the Experience Centre the design of the façade is an example of a part were some integral challenges occurred. The request to create a 360° view resulted in façade filling glass surfaces that were realized at different orientations. Initially, these large translucent facades did not cooperate with the specified comfort goals because the openings created an overload of entering sunlight which results in both a high illuminance and increased local temperatures. After several meetings of the design team the design has been optimized to create the optimal design in both esthetics, comfort and energy efficiency.

The Experience Centre is an example of one of the hundreds of projects Nelissen Ingenieursbureau participates in in a year. Do you want to know more about Nelissen Ingenieursbureau or the project of the Experience Centre, don't hesitate to contact us via nelissen@nelissenbv.nl or meet us in person at the lunch lecture of study association Mollier on the 22th of February 2022. ■

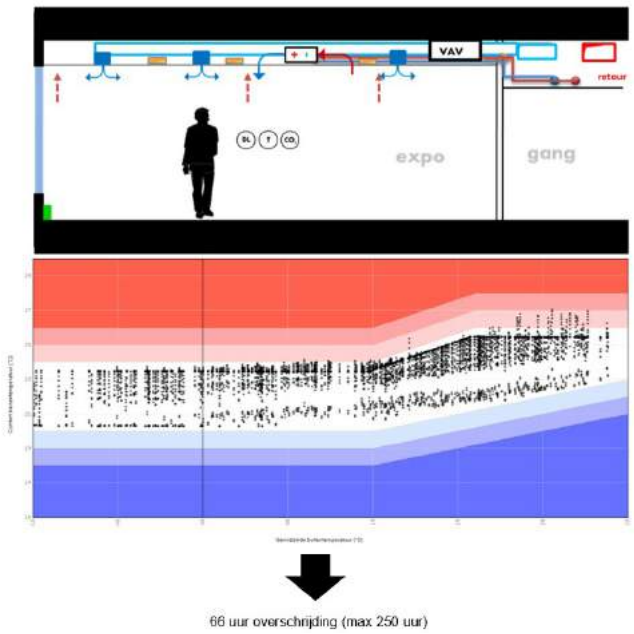


Figure 4. Climate simulation

unica

*samen maken we de toekomst*

# Wij bieden je geen stage of een baan maar een carrière!

Wil jij samen met ons het verschil gaan maken in de toekomst? Wij zijn in ons vakgebied uniek van soort, daar wij met onze specialisme een totaal oplossing kunnen bieden aan onze klanten. Van projecten in data centers tot renovaties in de zorg en van onderhoud tot gebouwbeveiliging, van specialist in brandbeveiliging tot partner in ICT solutions; kortom een netwerk van bedrijven! Wist jij trouwens dat het nieuwe hoofdgebouw door Unica is ontworpen en gerealiseerd?

Binnen Unica is er genoeg ruimte voor persoonlijke ontwikkeling, waarbij het belangrijk is dat je kunt groeien. Als jij groeit, dan groeien wij met je mee! Wij willen je ook geen baan aanbieden maar een carrière. Er zijn inmiddels al heel wat TU/e voorgangers zoals Marc Scholman, Gert Jan Braun en Ricardo Poortvliet die een uitdaging hebben gevonden bij ons; wellicht kunnen zij jou wegwijs maken?

Wil je bij ons stage lopen, afstuderen of werken. Neem dan gerust contact op met onze recruiter via **info@werkenbijunica.nl**, één van de andere ex TU/ers of kijk op onze websites voor meer informatie; **unica.nl** en **werkenbijunica.nl.**

# Alumni at Work

*G.J. (Gert-Jan) Braun MSc*

Hi, I was asked to write something about my life after I graduated from the TU/e. First, a short introduction. My name is Gert-Jan Braun, and I finished my master on March 2020. I'm 28 and currently live in Zeist with my girlfriend who I met at Mollier.

Before my master, I studied at the University of applied sciences in Arnhem, where I wanted to become a project manager for a building contractor. During my last internship however I decided that I wanted to focus more on the installations inside the building, rather than the building itself. So that's how I ended up in Eindhoven, joining the pre-master of Building Physics and Services. I also joined Mollier during this pre-master but never expected to also join the board of Mollier (especially when I saw the 21st board of Mollier giving a promotion talk at the lecture of Prof. Henk Schellen in their way to big white blouses) but I joined the 22nd board of Mollier anyway and can honestly say it has been one of the best periods in my life.

Figure 1. 22nd board.

Figure 2. Chicago study trip.

During my time in Eindhoven, I learned a lot but also lost a few brain cells at Stratum. Starting with a Mollier drink with a couple of Jupilers ended up as some crazy nights in the Thomas. Where another student dancing to the music of ABBA once gave me a bloody nose without him noticing.

Due to Mollier, I was able to see some amazing projects and places which not many people will be able to see. We, for example, went to Chicago (Figure 2.), Moscow and Sint Petersburg on our study trips. Visited the Naturalis, the test lab of Peutz, het Havenkwartier in Rotterdam (Figure 3), Hermitage museum in Amsterdam, etc. and went on a beer bike tour through Antwerpen. In Moscow, we visited the Neva Towers where we could visit the sky deck at 320 meters height, which was incredible. And these old study trip shirts also come in quite handy when you are working around the house (Figure 4).

Besides these amazing projects and places I also met a lot of people, I think there are not many companies in our field at the moment where there is no 'Alumni at work'.

I finished my master with a graduation project in the prediction of consumption patterns of occupants in dwellings by using machine learning in Python. This is of course something I never apply anymore in my job. During the master I learned a lot, but to be honest, I mostly learned that I also don't know

Figure 3. Site-visit Havenkwartier.

Figure 5. Site-visit datacenter.

Figure 4. Good use of the Mollier shirt.

a lot. Like many other old Molliers I'm currently following the TVVL 'luchtbehandelingstechniek' study. This really provides a lot of practical information about technical installations which sometimes is missing in the master. And in my experience so far everybody is willing to learn and help you. I guess what I'm trying to say, if you feel the same, no worries there are more than enough possibilities to get up to speed!

I now work at Unica, more specifically Unica datacenters (Figure 5). This is a division of Unica focused, as the name already suggests, on datacenters. We design, construct, operate and maintain datacenters from small clients to really big clients. I joined as a tender support engineer and am now a technical developer. Which basically is an engineer but then in the tender phase of a project. I really like working in this short period at the beginning of a project (for contractors) in which a lot of decisions and assumptions have to be made, keeping in mind the type of contract and information provided.

We currently have two really big projects and several smaller projects, both having their own challenges. Our main office is in Amsterdam but we also have an office in Hoevelaken which is only 20 minutes from my house. Due to Covid, we are all free to work where we want, so from home or the office. And try to plan fixed periods for the bigger projects to work in the office if the Covid regulations allow it. I think, besides all the negative, this free way of working is one of the really positive things that has come from Covid and will be the new normal.

That is enough about me, if you ever want more information about me, TVVL, Unica or something else feel free to contact me! I hope to see you next year at the Lustrum gala, Schoone Leij activity or one of the activities that Unica will be providing.

Maak hem koud! ■

# INSide Information Committee Vacancy

Are you interested in sharing knowledge and bringing the latest news of our field by creating an attractive magazine, filled with articles by our students, our alumni, the unit BPS and our partners? And at the same time developing your editorial and Adobe InDesign skills (yes, we will provide you with a free license ;))?

We are looking for someone with some fresh perspectives on the design of INSide Information to strengthen our committee. Becoming an INSide Information committee member gives you the freedom to design the magazine however you like, everything lay-out-related is possible in that department.

Would you like to have a say in what the next edition will look like? Let us know!

# Ice Breaker
# Manvydas Mikulėnas

Hi, Everyone,
I am Manvydas Mikulėnas.

My bio shortly: Born in Kaunas- Lithuania- Baltics in 1999. Went to a specialized musical school from 7-15 years old, played piano, violin, and lastly classical guitar. I was good in STEM, thus further entered and graduated Gymnasium of Kaunas University of Technology, which lead to further studies in TUe during 2018-2021. I am a fresh graduate now, who decided to continue to study further to Masters ABP, specializing in BPS.

The decision to narrow the broad choices that BAU program offers to BPS was not an easy journey for me. At first I thought I wanted to be an architect. I was a good in Arts (music and painting) and STEM (mathematics, physics, chemistry), often got compliments for my creativity and believed it is a good combination to be a future Architect/Urbanist. After graduating second year of studies, during summer vacations, I took a position of intern in a leading Lithuanian architect's studio. The practical experience allowed me to understand the specifics of the work in my home country and my own capacities and motivation „to be or not to be" in this career path. In the next (last) year of bachelor the change happened. During multi project we had 3 architects but no BPS student. I am a teamplayer and took the „other" important, but apparently less sexy role of BPS and liked it, also helped the ‚architects' to complete their work... after which I continued on to go for bachelor BPS end project and got to where I am now.

And by the way, I have a part-time job as software developer. I learned programming in a month during summer, after finishing my last courses, and started to work. I develop software solutions with React technologies.

I believe in the future, all the dots will connect. Maybe I will be writing software related to BPS... or maybe I'll get bored with coding and will dive into the sustainability and circularity 100%. We'll see.

Hobbies? Gaming is my primary hobby – I grew up with video games and therefore I enjoy playing a big variety of them, ranging from classic g(old) ones HoMM3/NFSU2/Stronghold Crusader etc to "newer" games such as Factorio/Oxygen not included/WoW classic (and others), the main connection being that most games include resource management. Reading novels is the second – more present during the summer, less so during studies. Looking for suggestions for novels in fantasy genre with good character development! The final hobby of the top of my head is cooking. I actually developed it during my study period in the Netherlands. It started off with me wanting to manage my money better and reduce living costs, due to which I started to always cook my own food rather than getting takeouts or going to restaurants/ cafes. But I didn't really understand the effects ingredients have on food and combinations (can't say I know everything now either but I do know more than before). I started watching youtube videos related to cooking, both for entertainment and for pure curiosity. So slowly, my cooking became better. Nowadays, I still follow recipes, but I can more easily swap materials in if I don't have the exact ingredients the recipe asks for. I have baked a few cakes (it was quite tiring ngl 4-5h active process, just because of the recipe, at least they turned out edible as dessert), apple pies and brownies (they turned out nice). Since last year I have been cooking tortilas when I'm back at my home country (simple ingredients just custom-made sauce), so I've got that going for me which is nice. Oh yeah, I also used to play volleyball in my city team while in middle school, nowadays I still play it casually with friends, on the occassion.

Glad to join your association and get introduced. Find me also on Linkedin and connect.

Sincerely, Manvydas. ■

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## Bouwen aan ambities

**Wil jij werken aan toonaangevende projecten in een professionele organisatie? ABT ontwikkelt samen met haar klanten de gebouwen van de toekomst!**

Wij werken aan projecten die er toe doen. Denk aan het Depot Boijmans van Beuningen, waar we o.a. de optimale technische vorm van de spiegelende gevel berekenden. En voor Huis van Delft wist ons integraal team een solide, voorlopig ontwerp te realiseren in drie maanden tijd.

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Wat ons als ABT'ers kenmerkt, is onze nieuwsgierigheid, onze leergierigheid en onze passie voor techniek. We investeren in kennisontwikkeling en innovatie. Building envelope engineering, BIM, conceptontwikkeling, computational design, refurbishment, parametrisch ontwerpen en AR: we passen het allemaal toe in onze projecten.

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Ben jij op zoek naar een passende stage, afstudeerplek of kans om je carrière te starten? Laat ons weten wat jouw ultieme uitdaging is! Wij voegen je graag toe aan ons team in Delft, Enschede of Velp (Gld.).

Op www.werkenbijabt.eu vind je onze actuele stage- en afstudeeronderwerpen en vacatures. We zien je sollicitatie graag verschijnen!

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# De volgende stap in jouw loopbaan.

Klictet is hét innovatieve installatie adviesbureau dat altijd een stap verder gaat. Daarom zijn wij continu op zoek naar talent om ons ambitieuze team te versterken. In ons gloednieuwe kantoor in de Schoenfabriek in Oisterwijk hangt een informele en inspirerende sfeer en werken we samen hard om onze dromen en ideeën waar te maken. Doorgroeimogelijkheden vind je hier dan ook volop! Groei jij met ons mee?

**Breng samen met ons techniek tot leven. Mail je CV en motivatie naar info@klictet.nl of kijk op klictet.nl/werken-bij-klictet**

KLICTET

# Design of the UXE Toolbox for Smart Urban Lighting

*Author*
*S. (Sila), Akman Asik, PDEng*

*dr. ir. J. (Juliëtte) van Duijnhoven*
*dr. ir. R. (Rianne) Valkenburg*

## INTRODUCTION

Urban lighting has become an important issue for cities in terms of public safety, livability, and sustainability. Research shows that lighting has many benefits for the safety and livability of cities. These benefits are the prevention of road accidents [1], reduced -fear of- crime [2], greater sense of safety [3], [4], active use of outdoor facilities after dark [5], [6], and enhancement of urban spaces [7]. Besides these benefits, there are also some concerns related to the negative environmental impact of lighting. Excessive and/or inappropriate use of light leads to energy waste, carbon emission, and light pollution in cities. Conventional street lighting, which is switched on from dusk to dawn, is not energy efficient and detrimental considering these concerns. Fortunately, new lighting solutions, smart urban lighting, combining light-emitting diodes (LED), sensors, and information and communication technologies (ICT) can improve the benefits of light at night while minimizing the negative impact on the environment [8].

Although smart urban lighting looks very promising considering the envisaged energy efficiency, environmental, and social benefits, investment costs seem to be an obstacle for municipalities. Moreover, they have some concerns related to the social acceptance of smart urban lighting. If smart lighting provides social benefits besides energy efficiency and maintenance cost, it will be a driving force for municipalities to adopt smart lighting. Thus, municipalities need to become aware of the social impacts of this change. The uptake of smart urban lighting highly depends on its social and economic benefits and its acceptance. The Smart Space, an Interreg North-West Europe project, aims to facilitate the uptake of smart lighting in small/mid-size municipalities to increase energy efficiency and reduce $CO_2$ emissions while ensuring wellbeing of the citizens.

In Smart Space Project, there are three key activities to achieve its objectives: (1) the design of smart lighting applications regarding citizens' needs, (2) the implementation of smart lighting in pilot sites, and (3) and the evaluation of implementation in pilot sites considering energy consumption, light quality, and citizens' perspective. Joint monitoring and evaluation is one of the work packages defined in the Smart Space Project and this PDEng project is part of this work package. In the joint monitoring and evaluation work package, Katholieke Universiteit Leuven , as the work package leader, carries out assessments of light quality, Université de Picardie Jules Verdes deals with the calculation of the energy use and $CO_2$ emissions and Eindhoven University of Technology responsible for the assessment of citizen's perspective.

This project proposes a toolbox to support municipalities in the evaluation and monitoring of user experience with smart lighting solutions in urban areas. This toolbox is entitled the User Experience Evaluation (UXE) Toolbox. The UXE Toolbox presents 25 tools in five categories (i.e., self-report technique, measuring body signals, information and communication technologies, statistics of official documents, and site observations) to measure 23 sub-parameters under seven parameters (i.e., acceptance, visual performance, visual comfort, perceived safety, attractiveness, liveliness, and safety) in three dimensions (i.e., attitude, perception, and behavior).

## DESIGN METHODOLOGY

The double diamond design method [9] was used to develop the UXE Toolbox. This method consists of two diamonds (analysis and design) and four phases (discover, define, develop, and deliver). In this study, these phases were conducted in an iterative way to stay aligned with the dynamics of the Smart Space project and to maximize lessons learned from the innovation process.

The first diamond shows the analysis phase consisting of research and its synthesis, while the second diamond shows the design phase containing ideation, creation, demonstration, and delivery. Both analysis and design are conducted with diverging and converging processes. The first diamond starts with a general problem statement derived from the Smart Space Project. The general problem is the lack of knowledge about the acceptance of smart lighting and its effect on citizens. It continues to discover the problem further via literature research in the field of outdoor lighting, urban studies, and environmental psychology. The first diamond ends with the definition of the specific problem which is small and mid-sized municipalities' need for validated methods to measure user experience with smart urban lighting. The specific problem sets functional design specifications shaped through three anticipated uses of smart urban lighting (i.e., A- Improving safety for all road users, B- Enhancing leisure activities, and C-Increasing security in nightlife) and three dimensions of UX (i.e., D1-Attitude, D2-Perception, and D3-Behavior).

In the design phase, the upper diamond presents the develop and deliver phases of the UXE toolbox consisting of a UX

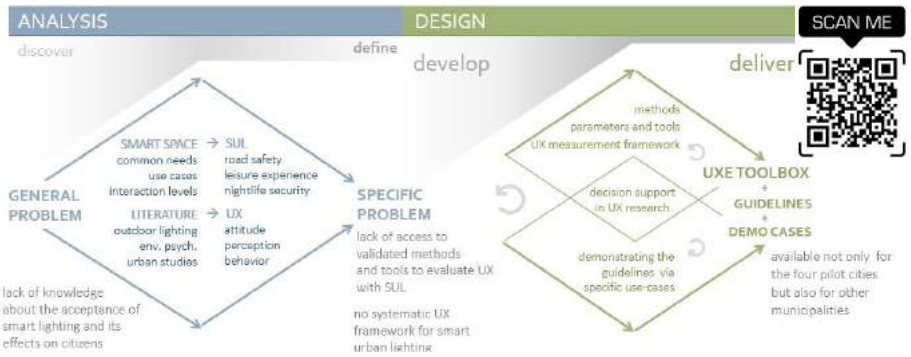


Figure 1. Double Diamond Design Model for the PDEng Design Project (access the thesis via the QR code)

measurement framework and a list of parameters, methods, and tools for user experience referring to attitude, perception, and behavior in the context of smart urban lighting covering all three anticipated uses. The bottom diamond represents the demonstration of the toolbox through selected lighting scenes. The intersection of design diamonds is the development of the guidelines that are used both in the UXE Toolbox and demo cases explaining how to evaluate UX step-by-step using the UXE Toolbox. As a result, the deliverables of this project are (1) the project report, (2) the UXE Toolbox (an excel workbook) together with guidelines, and (3) demo cases (in the form of video records) as shown in Figure 1.

## USER EXPERIENCE EVALUATION TOOLBOX

UX is defined by the International Organization for Standardization[10] as a person's perception and response resulting from the use or anticipated use of a product, system, or service. In this study, UX refers to what users think about and how they perceive and respond to the smart lighting system in the context of urban areas at night. UXE refers to the monitoring and evaluation of users' attitudes, perceptions, and behaviors over time with the right tools in line with the results of literature research.

This study proposes a measurement framework as shown in Figure 2. This framework consists of two measurement categories (i.e., person-centered (PEC) and place-centered (PLC)) in three timeframes (i.e., before, test, and after) for a comprehensive UX assessment. Measurements are defined under two categories in terms of the source of the data. PEC measurements are based on personal experiences obtained through self-report techniques and/or physical and physiological measurements of the individual. While PLC measurements provide collective data from a location via smart lighting system elements such as ICT and IoT, official reports such as traffic reports, police reports, and via site observations conducted by an observer. This framework covers the measurement of attitude, perception, and behavior as

Figure 2. Measurement framework for UX.

user experience and suggests including environmental measurements (e.g., temperature, humidity, ambient light, air quality, noise level) to make better sense of user experience in an outdoor lit environment.

The excel platform hosts the UXE content generated in this PDEng project. The UXE content is presented under four main sections: (1) Guidelines, (2) Definitions, (3) Tools, and (4) User experience Evaluation. These sections take place on the main page ( i.e., "Content Box") at the navigation pane on the left. The user is informed about how to proceed through the explanation boxes as shown in Figure 3.

## CONCLUSION

The goal of this project was to design a toolbox to support municipalities in finding appropriate methods and tools to monitor and evaluate their citizens' experience with the smart lighting system. The UXE Toolbox was designed prioritizing the needs of the small and mid-sized municipalities. The functional requirements were based on the relevant activities within the Smart Space Project and the literature review in the field of urban lighting and environmental psychology. At the end of this study, eight requirements out of ten was achieved. The rest is planned to be finalized by the end of the Smart Space Project. ■

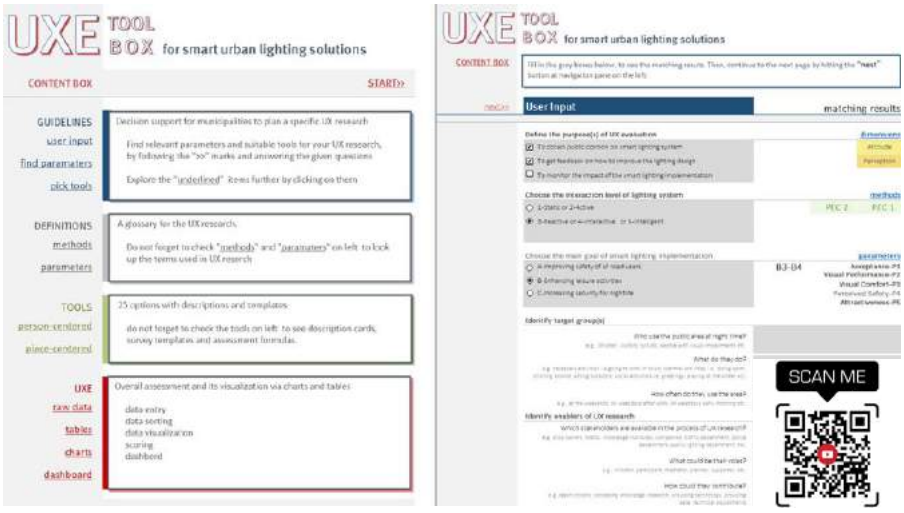

Figure 3. Previews of the interface. (access the demo videos via QR code)


[1] M. S. Rea, J. D. Bullough, C. R. Fay, J. A. Brons, J. Van Derlofske, and E. T. Donnell, "Review of the safety benefits and other effects of roadway lighting," no. 5, pp. 1–61, 2009.

[2] B. C. Welsh and D. P. Farrington, "Effects of Improved Street Lighting on Crime," Campbell Syst. Rev., vol. 4, no. 1, pp. 1–51, Jan. 2008.

[3] P. Boyce, N. H. Eklund, B. J. Hamilton, and L. D. Bruno, "Perceptions of safety at night in different lighting conditions," Light. Res. Technol., vol. 32, no. 2, pp. 79–91, 2000.

[4] A. Haans and Y. de Kort, "Light distribution in dynamic street lighting: Two experimental studies on its effects on perceived safety, prospect, concealment, and escape," J. Environ. Psychol., vol. 32, no. 4, pp. 342–352, 2012.

[5] S. Fotios and H. F. Castleton, "Lighting for cycling in the UK - A review," Lighting Research and Technology, vol. 49, no. 3. SAGE Publications Ltd, pp. 381–395, 06-May-2017.

[6] J. Rahm, C. Sternudd, and M. Johansson, "'In the evening, I don't walk in the park': The interplay between street lighting and greenery in perceived safety," Urban Des. Int., pp. 1–11, May 2020.

[7] J. Nasar and S. Bokharaei, "Lighting modes and their effects on impressions of public squares," J. Environ. Psychol., vol. 49, pp. 96–105, Apr. 2017.

[8] P. Boyce, "The benefits of light at night," Building and Environment, vol. 151. Elsevier Ltd, pp. 356–367, 15-Mar-2019.

[9] British Design Council, "What is the framework for innovation? Design Council's evolved Double Diamond," UK Design Council, 2015. [Online]. Available: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond. [Accessed: 03-Aug-2021].

[10] ISO, "ISO 9241-210: Ergonomics of human–system interaction - Human-centred design for interactive systems," 2010.

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Onze cultuur? We werken in een informele setting en vinden het belangrijk dat je het bij ons naar je zin hebt. Dus: vrijheid, verantwoordelijkheid, **uitdagende projecten** met **volop doorgroeimogelijkheden** en aandacht voor de balans tussen werk en privé.

Ook fijn: ons kantoor ligt **op fietsafstand van Utrecht**. Wil je meer weten? Kijk dan op onze website.

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Silver Lining

5th Lustrum

1996 - 2021

SVBPS MOLLIER

Dearest reader,

This year, Mollier has celebrated its 25th birthday with the first two Lustrum activities. We opened the Lustrum year in March with a spectacular online Lustrum Symposium, broadcasted from De Blauwe Zaal. A recap to this succesful event can be found in the previous edition of INSide Information. We were also very happy and proud that we could welcome you in real life during the Lustrum Party in Café Thomas, that took place in September. With the use of CoronaCheck QR-codes, we were flexible in changing seats throughout the evening to finally meet all our friends again in person. These pages contain some more impressions on the amazing atmosphere during the party, captured by Momenttom Photography. We are looking very much forward to celebrate the 5th Lustrum of Mollier one more time on the 19th of March, with the Lustrum Gala that will be held in Het Ketelhuis (located at Landgoed De Grote Beek). If you haven't done so yet, grab your tickets before March 1st. We hope that we will see you there!

Of course, we couldn't have organized the Lustrum for Mollier the way we wanted to without our Lustrum sponsors, bba binnenmilieu, Johnson Controls, LBP|SIGHT and NVBV. Thank you again for making the 5th Lustrum of Mollier as memorable as it truly was!

See you on the 19th of March, during our final event!

Yours truly,
The 5th Lustrumcommittee of s.v.b.p.s. Mollier
Maud, Jesper & Nora

TICKETS NOW AVAILABLE FOR THE MOLLIER

# LUSTRUM GALA

19TH OF MARCH 2022 | 20:00 - 01:00

DRESSCODE: BLACK TIE

LOCATION: HET KETELHUIS (LANDGOED DE GROTE BEEK)
DOCTOR POLETLAAN 45, 5626AB EINDHOVEN

SCAN THE QR CODE FOR TICKETS AND INFO

Silver Lining 5th Lustrum 1996 - 2021

SVBPS MOLLIER

WE WOULD LIKE TO THANK OUR LUSTRUM SPONSORS FOR MAKING OUR LUSTRUM EVENTS POSSIBLE:

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Johnson Controls

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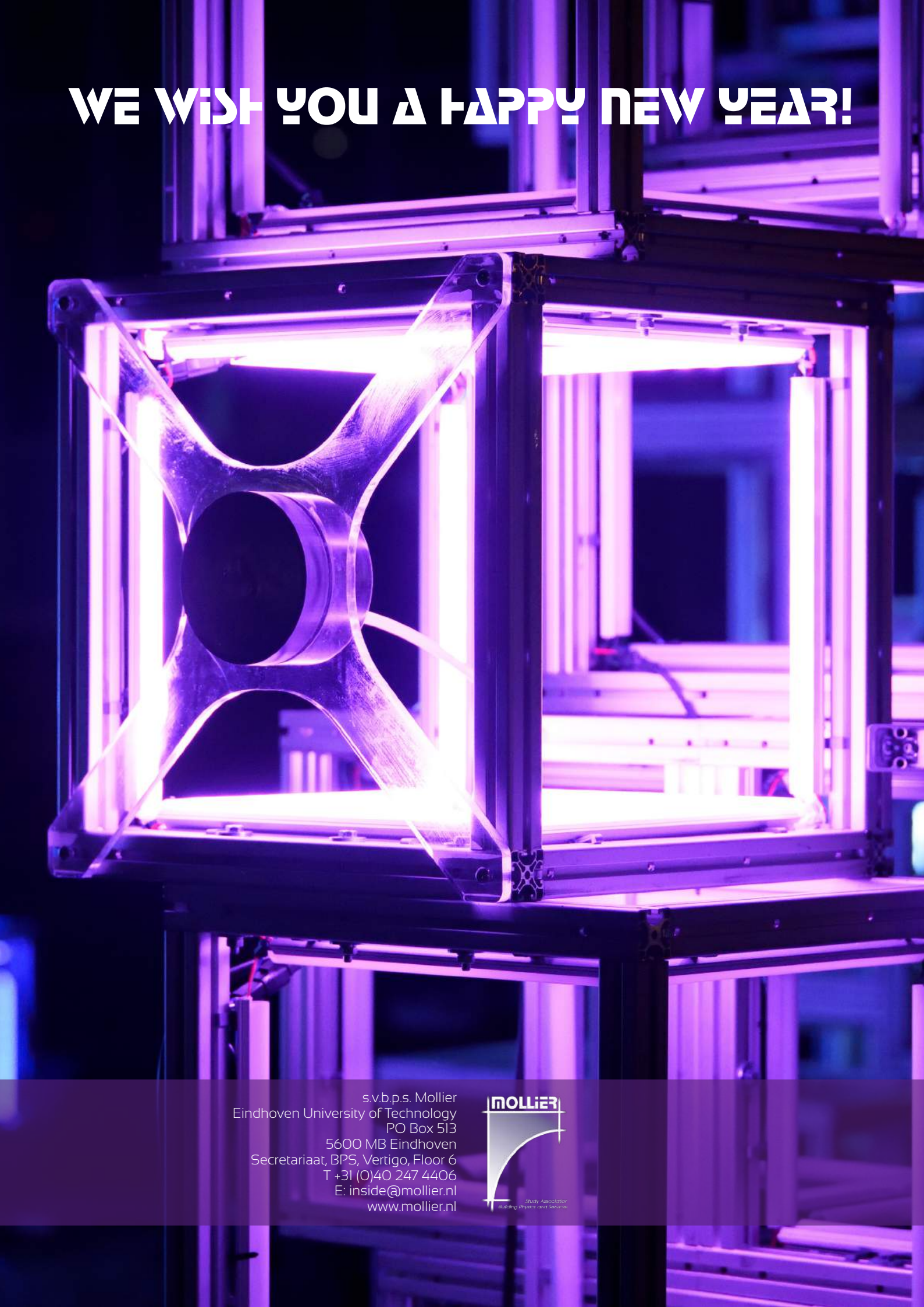


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