Academic year 2019 - 2020 #1 | December

MOLLIER

Study Association
Building Physics and Services

INSIDE INFORMATION

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Foreword

Eugene Mamulova

Dear reader,

With great excitement and anticipation, I present to you the first edition of the INSide Information for the academic year of 2019-2020.

The INSide Information is a biannual magazine which breaches various topics within the built environment, including building physics, services, acoustics, lighting and more. This magazine is brought to you by passionate members of Mollier; the Study Association of Building Physics and Services, who fight relentlessly for the sharing of valuable information within and outside the university. It is my honour to serve as Chairman and Commissioner of Education of Mollier for this academic year. Before the INSide takes you on a thrilling journey of scientific discovery, I would like to give an overview of what you have to look forward to.

This edition features a series of articles, featuring the work of our students and alumni, as well as some personal pieces to introduce you to the minds behind the department of Building Physics and Services. The magazine also serves as an introduction to Mollier as a community that supports both fun and resilience in education. For this year, Mollier has already planned a variety of fun and educational activities, such as software workshops, sponsor lectures, debate evenings and a unit-wide exhibition. In addition, we are working on the launch of our very own podcast, in order to establish a better link between research and education. We would be very happy to see you during the events that we worked so hard to organize, so keep an eye out for them on our official website or Facebook pages.

You are now ready to set off on the rest of your literary journey. I would like to thank the INSide Information committee for their hard work and we all wish you happy reading!

Yours sincerely,

Eugene Mamulova
Chairman & Commissioner Education, 24th Board of s.v.b.p.s. Mollier

INSide Committee
From left to right: Bram, Meghana, Laurens and Nora

COLOPHON

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This INSide


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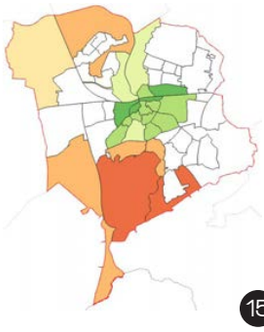
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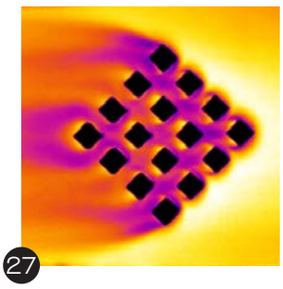
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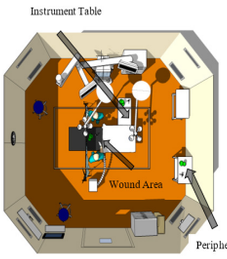

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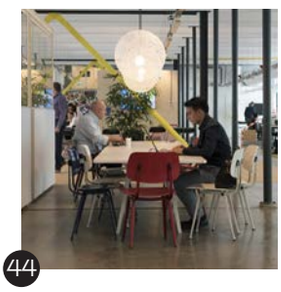
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MOLLIER & MEMBERS

BUILDING PHYSICS & SERVICES

COMPANIES

Introduction to the 24th Board of Mollier

EUGENE MAMULOVA, CHAIRMAN AND COMMISSIONER OF EDUCATION

Hello there, my name is Eugene Mamulova; 24 years wise. This academic year, I will be the Chairman and Commissioner Education of Mollier, alongside four of the finest board members. Together, we will do our best to support our fellow students, both socially and educationally.

I have a passion for sharing knowledge, which I hope to transmit both within and outside Mollier. Inside the study association, I help organize educational activities and I'm also the originator of the soon-to-be Building Physics podcast. Outside study hours, I enjoy my work as a teaching assistant for an undergraduate course in Building Physics and Services. I hadn't always studied engineering: I grew up surrounded by arts and languages and I began my education as an aspiring architect. For this precise reason, I'm fascinated by the prospect of uniting disciplines and greedily learning from everyone and everything.

You might say that my work-life balance is a work in progress. I'm passionate about making food and even more passionate about consuming it. Moreover, I like to experiment by taking up different sports, such as high-intensity interval training, squash and more. Likewise, I enjoy cinematography, music and art: Most of my days begin with music and end with a movie. Painting has taken a back seat to making graphics for Mollier but it never ceased to be my biggest and most intimate pleasure.

All things said, I hope that you have a wonderful year and I hope to play a role in making it so. If you're ever looking for me, you can find me in Vertigo, on the fifth floor. Otherwise, don't hesitate to contact me at chairman@mollier.nl.

JÚLIA CSEMEZOVÁ, SECRETARY

Hi everyone, my name is Júlia Csemezová! I am 25 years old and I come from the southernmost district of Slovakia, named Komárno.

At a time when I had to choose where to continue my studies after elementary education, my family was building a house. As I found the planning phase very interesting, I enrolled to the Secondary Technical School of Civil Engineering in Hurbanovo, nearby my hometown. Although I remember dreaming of becoming a famous architect, I quickly realised that it is more important to understand the technology behind the construction than creating an eye-catching building. Therefore, I continued my path at the Civil Engineering faculty of the Slovak University of Technology in Bratislava. After finishing the 4-years bachelor programme Building Construction and Architecture, I decided to challenge myself and start my master's abroad.

I was concerned that living abroad is not going to be my cup of tea, so I applied for a 6 months long Erasmus+ scholarship in the Netherlands. I must admit, in the first few months I really could not fit in any community until I actually started to interact with my fellow students and working together on a group project. Thanks to our amazing chairman Eugene, I got to know a few people fighting for their master's degree on Floor 5. They were all very welcoming, so I finally felt that I've found my place and group of friends.

When I experienced the atmosphere of Mollier, I thought that I could continue what the previous boards have built, a supportive and entertaining community. That's why I decided to fill in the position of secretary in the board, and I'm looking forward to making the student life a bit easier, exciting and definitely more fun for all of you!

SIETSE DE VRIES, TREASURER

Hello, I'm Sietse de Vries. I am 22 years old and originally from the beautiful province of Friesland. Exactly one year ago, I wrote an ice breaker for the Inside Information. In this ice breaker, I concluded with the note of possibly being in the next Mollier board. Well, here I am!

In December, I became an active member of Mollier when I joined the meet and greet committee. This committee showed me what being a member of Mollier is about. Around the same time, I did a group project together with Margo from the 23rd board, who showed me the nice things about being a board member. After joining the study trip to Russia, I was convinced being a board member was a good fit for me.

For my board year, I wanted to do something I hadn't done before. Being the treasurer of the board fulfills this requirement quite well. Alongside being the treasurer, I'll organize some activities and have my very own botanical committee. While this may sound fancy, it is essentially turning the aquarium on floor 2 into a miniature purple vegetable garden.

In my free time, I enjoy being outdoors, cooking, drinking a beer with friends, playing tennis and running. During the week, I work at the university as a student assistant and spend a lot of time on my student team, IGNITE. Apart from that, I'll be on the fifth floor studying and working on Mollier stuff. So, if you ever need something from me, you can find me there!

BAS TURK, COMMISSIONER OF EXTERNAL RELATIONS, EDUCATION AND VICE CHAIRMAN

Hi reader of this INSide information! My name is Bas Turk, 22 years old, born and raised in a small village called Pijnacker near Delft. I used to say that Pijnacker is located in between Rotterdam and the Hague, since people constantly ask me the question: "Why didn't you choose to study in Delft?" Well, Eindhoven felt more like a challenge to me and they were, in contrast to Delft, very welcoming on the open day.

Although I've wanted to become an architect since I was around the age of 10, I quickly found out in the bachelor that architectural quotes like "If the roof doesn't leak, the architect hasn't been creative enough" didn't make sense in my head. Since Delft is completely focused on architecture, I can now say that I made the right choice by going to TU/e.

Two years ago, I became part of team VIRTUe, where I quickly got to know many Mollier members. They were very convincing in telling me I should become a member of Mollier too, and then also a member of the 24th board. Although I know next year will be quite busy with all the Mollier related work and activities, you can always ask me to play sports, especially handball or squash.

NORA KUIPER, COMMISSIONER OF EXTERNAL RELATIONS

Dearest readers! My name is Nora Kuiper and I've recently turned 23 years old. I was born and raised in Voorburg, near The Hague. When I went to high school, my parents, my younger brother Mark and I moved to a town near Utrecht, where I completed my VWO in six years. A trip with my high school to Delft made me realize that I really wanted to go to a University of Technology, back then preferably to Delft. I always thought I wanted to study something medical at the TU, so I also gave biomedical engineering at the TU Eindhoven a chance, along with architecture, urbanism and building sciences as I found the traveling time too much to only visit one study. As it turned out, I liked the bachelor AUBS a lot better than BMT and also liked the particular study better in Eindhoven than in Delft. This is how I ended up here in Eindhoven, in 2015.

My disliking of creating architectural designs made me chose the technology direction within our faculty. After doing my multidisciplinary project and BEP in the direction BPS, I knew that I wanted to study BPS during my masters. Due to my study delay of exactly one year, I was not very active within Mollier yet last year. However, I enjoyed the study trip so much, that I wanted to invest my time in this amazing study association as Commissioner of External Relations of Mollier.

In my free time, I'm still around a lot at SSRE as a member of a sorority. I also like to try a lot of different sports, what made me start kayaking at Okawa a few years ago, and tennis last year. Now, I'm very excited to mix my ambition to sport a lot with the initiative to have a Mollier running team for the 10K of Rotterdam. We'll see how that works out for me!

Concluding, I'm very excited to be on this journey that is our board year, together with Eugene, Júlia, Sietse and Bas, and of course together with all the amazing Mollier-members! I hope to see you around a lot in Vertigo on floor 5!

S:7"

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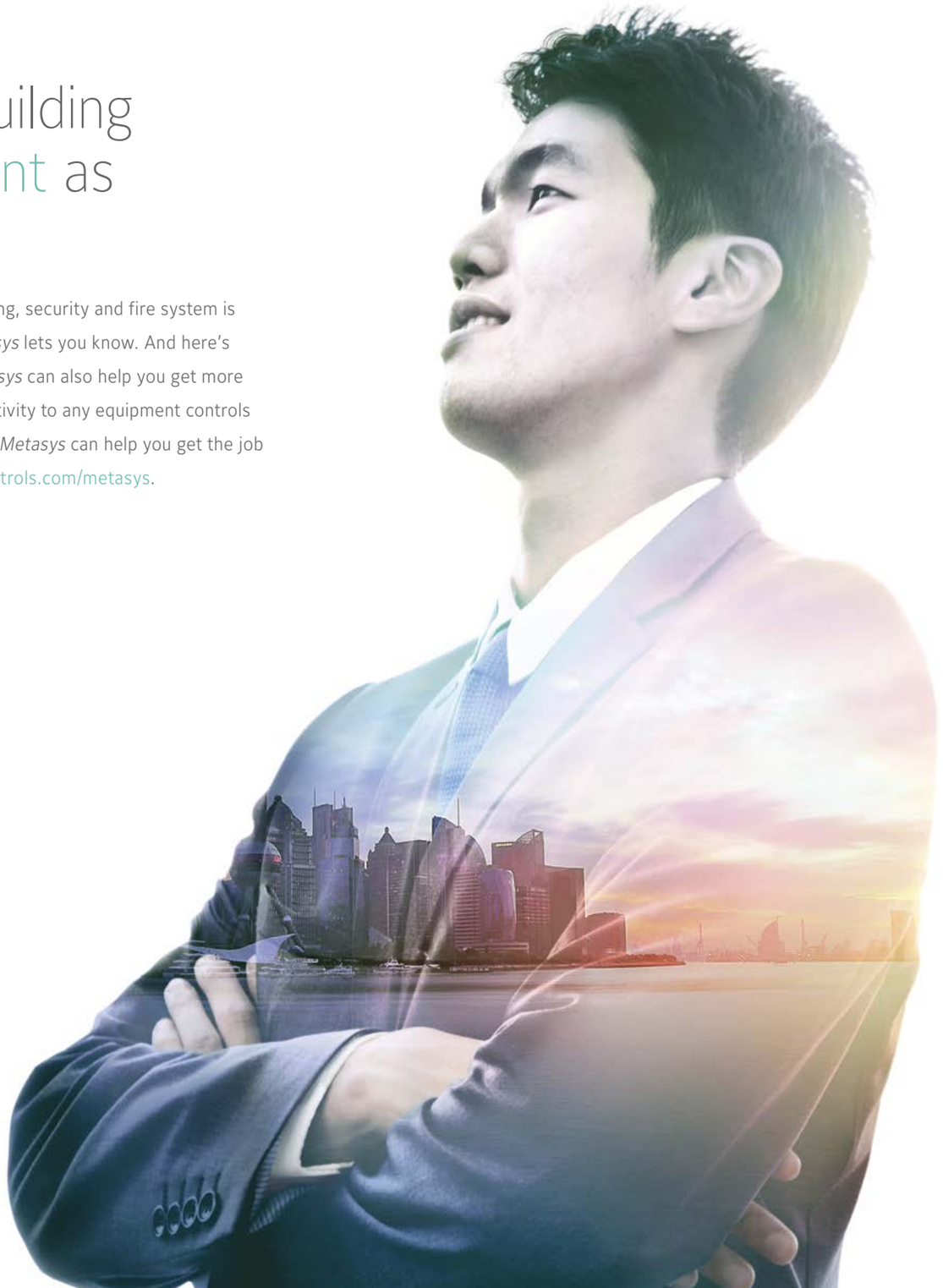


Johnson Controls

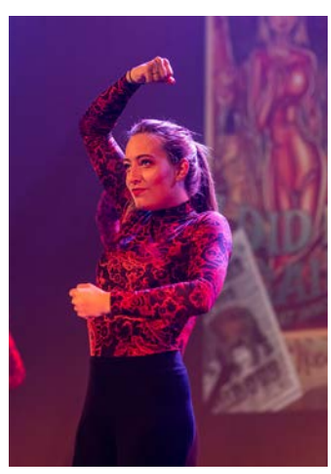
Ice Breaker Maud Staassen

Hello, my name is Maud, I am 22 years old and a premaster student for the master track Building Physics and Services. I have lived in Eindhoven my entire life. When I finished high school I went to Tilburg to study the bachelor building engineering at Avans Hogeschool. I have lived there for three years and I am very happy to be back in Eindhoven!

You could say that I am a very busy person. Right now I am a member of four associations, including Mollier of course. I am also a member at the ZES, where I have been gliding for almost ten years now (yes, I became a member when I was 13 years old). Furthermore I have been dancing for my entire life (okay, since I was 3 years old) and I also started poledancing 3,5 years ago at the Tilburg Student Dance Association Dancenation. Nowadays I also practice poledancing at SVP Blue at the TU/e and I am really enjoying it.

When I was 13, I bought my first 'real' camera and that is when photographing also became another passion. A few years ago people started asking me to take photos for all kind of events. This happened more and more, so I decided to start my own 'business' in photographing (Maud Staassen Fotografie, really original, I know). Nowadays I photograph many different things. I am the housephotographer of the student sports centre in Tilburg and I work on many different event and in pubs via Wildschieters. Some-times I have architecture bookings and all other different stuff like food or seminars and talks. I really like variety in everything and as you can see, also in my hobbies!

Next to my hobbies I also have a passion for buildings and people. That is why I want to combine the master Building Physics with courses from the master Human Technology Interaction. I think it is really important to create a healthy environment in buildings for people. That is also why I graduated on micro-climatisation in open offices. I am already enjoying the heat, air and coffee of Mollier. ■



Mollier Activity Calendar

CONSTITUTION OF THE 24TH BOARD

On Thursday the 12th of September, the "Say goodbye to the old board"- drink took place in the Skybar!Underground. It was an emotional last drink organized by the 23rd board; we are going to miss them. The next day, on Friday the 13th (spooky, we know), the constitution of the 24th board took place during the General Meeting of Members. Afterwards, the new board really pushed their luck during the constitution drink in the Skybar!Underground. In the evening, the celebrations continued with an amazing dinner at FAB (one that not everyone remembers) and of course, with some more beers at Stratumseind.

MEET MOLLIER DRINK

On the 9th of October, the 24th board hosted their first drink at the Skybar!Underground, where several sub-association board members and Mollier members enjoyed some beers over the provided board games.

We used this opportunity to present our committee poster and recruit some new members to help us out with the fun activities, the study trip, the annual exhibition and more. Sadly, Richard Mollier didn't show, but it was still great to see so many faces.

GLOW GOLF

One thing is now certain: not everyone is a talented golfer.

On the 17th of October, Mollier set off to play a friendly game of glow golf. Hidden talents were discovered, as well as a lack thereof. It was all in good fun, although glow in the dark people look more terrifying than anything, really. After the game, everyone went out for some drinks at Spijker, where two outcasts ordered a hot chocolate.

START ACTIVITY

What a weekend! The first week of November was put to good use via our start activity. What we were going to do stayed a surprise till the 8th of November. On the 8th, we went to Antwerp by hitchhiking (most of us made it there without any need for rescue). After a night of Belgian beers and other fun business, we woke up to a surprise trip to the zoo. After that we bravely set off, Albert Heijn goodie bags on our shoulders, to explore the city. What followed was, indubitably, a very harsh leg workout; remedied by hearty amounts of beer. Beer-cycling (don't try this at home, kids). A big thanks for organizing this trip to Bas and Gert-Jan!

GLOW TOUR WITH KOERS

In light of the Eindhoven GLOW week (pun intended), Mollier hosted a tour around the exhibits, in collaboration with Team IGNITE and KOers. The evening began with a presentation on the structural aspects of Hypar, after which team manager Sietse led us into the cold night to admire the exhibits. The highlight was, of course, the Hypar installation, which will hopefully travel the world in the next years.

LUNCH LECTURE #1

On Tuesday, 19 November 2019, ABT bv and Cauberg Huygen gave a captivating lunch lecture on integral design and modular design, respectively. They presented a relevant working case and indulged Mollier in the technical intricacies of their projects. We would like to thank ABT, Cauberg Huygen and last, but not least, the Meet&Eat Committee for organizing the event!

BOUWKUNDE BEDRIJVENDAGEN CAREER EVENT

On Wednesday, 20 November 2019, Mollier took part in the grand career market, organized by the Board of Bouwkunde Bedrijvendagen. We presented ourselves in the Vertigo Plaza, where our fellow students gathered to ask questions and participate in the introductory tour. During the market we visited Ballast Nedam, Cauberg Huygen, Royal HaskoningDHV, Nelissen, LBP Sight, ZRi, Sweco and more. Thank you for organizing this event and thank you for all the companies for giving us a warm welcome!

ARCADIS CASE STUDY

On Monday the 25th of November, Arcadis welcomed Mollier to their office in Rotterdam for a case study. We first got a short introduction to the company. The case study itself, on District-E in Eindhoven, was presented by old Mollier members Stefan Koenders and Suzanne Deckers. During this case study, we were challenged to think about the ventilation concepts in the towers and the parking garage of District-E and on how to reach the three BENG-norms regarding the energy demand of the towers. After working on the cases, it was time for us to pitch our ideas to senior advisors of Arcadis and have a networking drink with a cool VR-experience. We look back on a successful day in Rotterdam and would like to thank Arcadis once more for inviting us for the case study on District-E!

PYTHON WORKSHOP BY MARC TAVENIER

From a Facebook poll, it turned out that most members of Mollier were interested in a Python workshop. On the 27th of November, this workshop was held and very well attended by Mollier members. The workshop was held by our very own Python-master, Marc Tavenier. With the Python workshop done, workshop season is officially open (and we have more in store for you)!

We hope you enjoyed it and are ready to embark on the adventure that is programming! Big shout-out to Marc, who was kind enough to share his wisdom.

WEEKLY TEA TABLE

Every week, the Mollier tea table takes place. The 24th board is doing their best to do as many themed tea tables as possible, for example the wafle party and of course, Richard's birthday to celebrate his 156th birthday!

THE FIFTH LUSTRUM IS COMING...

s.v.b.p.s. Mollier is turning 25 next year
Stay posted for updates!

MOLLIER
Study Association Building Physics and Services

Samen maken we je start op de arbeidsmarkt grensverleggend

Of het nu gaat om afstuderen of een startersfunctie, bij Ballast Nedam krijg je de kans om je installatietechnische loopbaan vorm te geven. Zo krijg je de mogelijkheid om te werken aan grensverleggende projecten. We zijn benieuwd naar jouw visie en geven je unieke kansen om je ideeën daadwerkelijk te ontwikkelen.

Werken bij Ballast Nedam

Onze medewerkers zijn onze belangrijkste succesfactor. Vanuit deze overtuiging bieden we een gezonde, veilige en motiverende werkomgeving waar ruimte is voor persoonlijke ontwikkeling. Ons snelgroeiende bedrijfsonderdeel installatietechniek is altijd op zoek naar jonge professionals. Inmiddels werken er al drie ex-Mollier leden in ons gezellige team. Binnen Ballast Nedam draag je niet alleen bij aan het integrale installatie-ontwerp, ook zie je van dichtbij hoe het daadwerkelijk gerealiseerd wordt!

Tijdens of na je studie

Bij Ballast Nedam maken we graag kennis met studenten die zich willen oriënteren op hun toekomst. Het is dan ook mogelijk om bij Ballast Nedam een masterproject uit te voeren, een traineeship te starten (waarin je aan verschillende fasen van het project kan proeven) of te beginnen met een vaste baan bij ons team van installatietechnici.

Ben je enthousiast en wil je met ons meebouwen? Kijk dan voor de mogelijkheden op onze website: **www.ballast-nedam.nl** of neem direct contact op met onze Ballast Nedam Campus Recruiter Damia Carli via **d.carli@ballast-nedam.nl**.

Ballast Nedam

Energy Transition through Surface and Sewage Water

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INTRODUCTION

Municipalities in the Netherlands are getting more control and responsibility over the energy transition of the country. This transition demands eventual disposal of fossil fuel-based energy systems which have a massive effect on the heating demand of the built environment. As alternatives, the focus of this study is on thermal energy from waste water (WW) and surface water (SW). Even though some studies have already shown the national and local energy potential of WW and SW, for a lot of local policymakers, the energy potential and how and where it can be applied in their community is unclear. This study explored current methods of extraction, storage and distribution of thermal energy from WW and SW and how and where it can be applied in a local region (the municipality of Breda).
Key performance indicators (KPI) for the systems are the location, flow rates, volume, recharge capability and the possible temperature change of the water. Other than that, the possibility of seasonal energy storage, the current energy label and waters with botulism and/or algae problems also have an impact on the application of the system.

RESULTS

The monthly heating/cooling demand of the neighborhoods within the municipality and the energy that can be supplied by different energy sources has been calculated. This has been done for the current situation, but also for future scenarios, see Figure 1 where it is calculated for the whole municipality of Breda. The energy demand is calculated using gas data and degree days to make an estimation over the year. The potential supplied energy is calculated by using monthly averaged flows and temperatures based on measured data. Furthermore, by calculating the coefficient of performance (COP) values, averaged inlet temperatures and efficiency factors for the heat pump and the district heating network. Using these results and the other KPI's potency maps have been made showing which areas one could look at to implement these technologies, see Figure 2.

CONCLUSIONS

The results showed that currently, based on averaged values, around 41% of the heating demand for residential buildings can be supplied with energy coming from river water (surface water), and in the future when the houses are more energy efficient, this could be 69%. The water has to be at least 12°C to use SW sources, this causes that only during the summer months there is an energy supply for SW. For WW, the energy supply is probably lower with for the current value 25% and future values of 44%. The WW sources are however more stable. With more energy efficient housing the heating demand will go down and the cooling demand will go up. This cooling demand can also be supplied by using the WW or SW. However, a separate network will have to be made as the houses need heating at the same time as cooling.

LIMITATIONS

There are limitations and matters for discussion to this method and the results. The method is more an indication than an actual prediction. The river water (SW) potential seems quite high, as at the moment the whole river was used for the calculation. In reality, it is likely that this percentage is a tenfold lesser as the intake pump or heat exchanger will only use a small part of the river. Also, averaged values were used for the calculation and in some years the amount of energy can be more than others which means that some sort of storage or second energy source is necessary. In the future the WW potential can go down, as household equipment and manufacturing processes become more efficient causing lower water temperatures and lesser water to be used. Also, to be able to efficiently make use of the LT energy sources, buildings have to be fitted with LT-radiators. It is considered that this is only possible with a building that has at least an insulation level appropriate to label B. On the short term, new neighborhoods can make use of these energy sources, as for the future it will be easier to make use of these sources for all neighborhoods as more houses become energy efficient. Although the study is a preliminary analysis and a follow up study is needed, the results, methods and gathered information, can be used by water boards and municipalities in their energy policies and compared with other energy sources to identify the most sustainable energy sources. ■

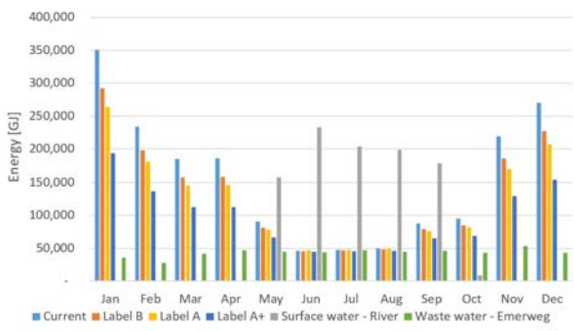

Figure 1. Average monthly demand for the whole municipality of Breda and heating energy supply from a SF and a WW point

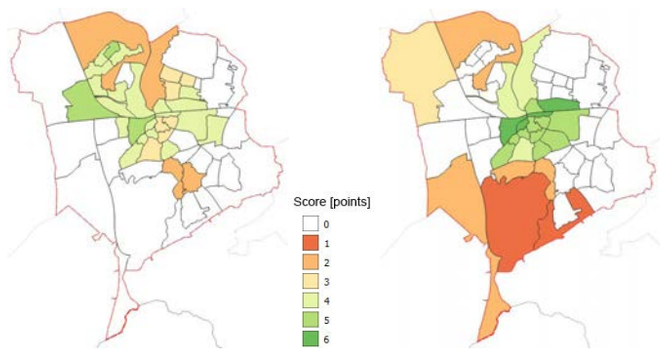

Figure 2. Potency map for waste water (left) and surface water (right)

The Insulation Challenge

Hugo Verboven
Senior advisor at Cauberg-Huygen

Sometimes you come across an opportunity that you really want to seize with both hands, because of its expected impact on the construction sector and the innovation that is being asked for. Earlier this year, the social housing corporations Mitros, Portaal and Bo-Ex challenged the Dutch building world to come up with a new way to insulate existing houses built between 1940 and 1970. This 'Insulation Challenge' (De Isolatie Uitdaging) gave Cauberg Huygen and QBuild, sister companies since the end of 2018, the possibility to join forces to invent an innovative solution for this question...and with success.

THERMAL INSULATION FOR NEW OR EXISTING BUILDINGS

Compared to existing buildings, new developments are already relatively energy efficienter due to public regulations that are continuously being sharpened. In newly developed buildings, sustainability measures can be integrated into the design, whereas for existing ones, this is not the case since they were designed and built based on ideas and thoughts about sustainability from a different era. Suddenly, an improved thermal boundary is being asked for to lower the energy needs for heating (and cooling), and to make a switch to gasless utilities possible in the near future. The remodeling of a diverse stock of buildings with these new sustainability goals in mind is not as easy as one might think.

Vacuum insulation materials are already on the market today and very high R_c-values can be reached with just a few centimeters of the product, but these solutions are interesting mainly for newly built houses, since they cannot be inserted in a cavity of existing houses. Therefore, a new solution is necessary for a cavity. We found this solution in the form of a sack that is being inserted into the cavity and filled with an insulating material. When this sack is then vacuum sealed, heat transport by convection and conduction can be minimized.

WHY AN UPGRADE IS NOT THAT EASY

An architect sees his original design being corroded. The municipality's aesthetics committee is afraid of unwelcome changes in the streetscape. A project developer sees the rentable m² being diminished. An occupant had just done the redesign of her bedroom. New, sustainable technical installations often ask for more space and can cause noise complaints. Even then, what about the investment capital that is needed?

WHERE'S THE BREAKTHROUGH?

The existing stock provides us with a big opportunity for lowering our energy

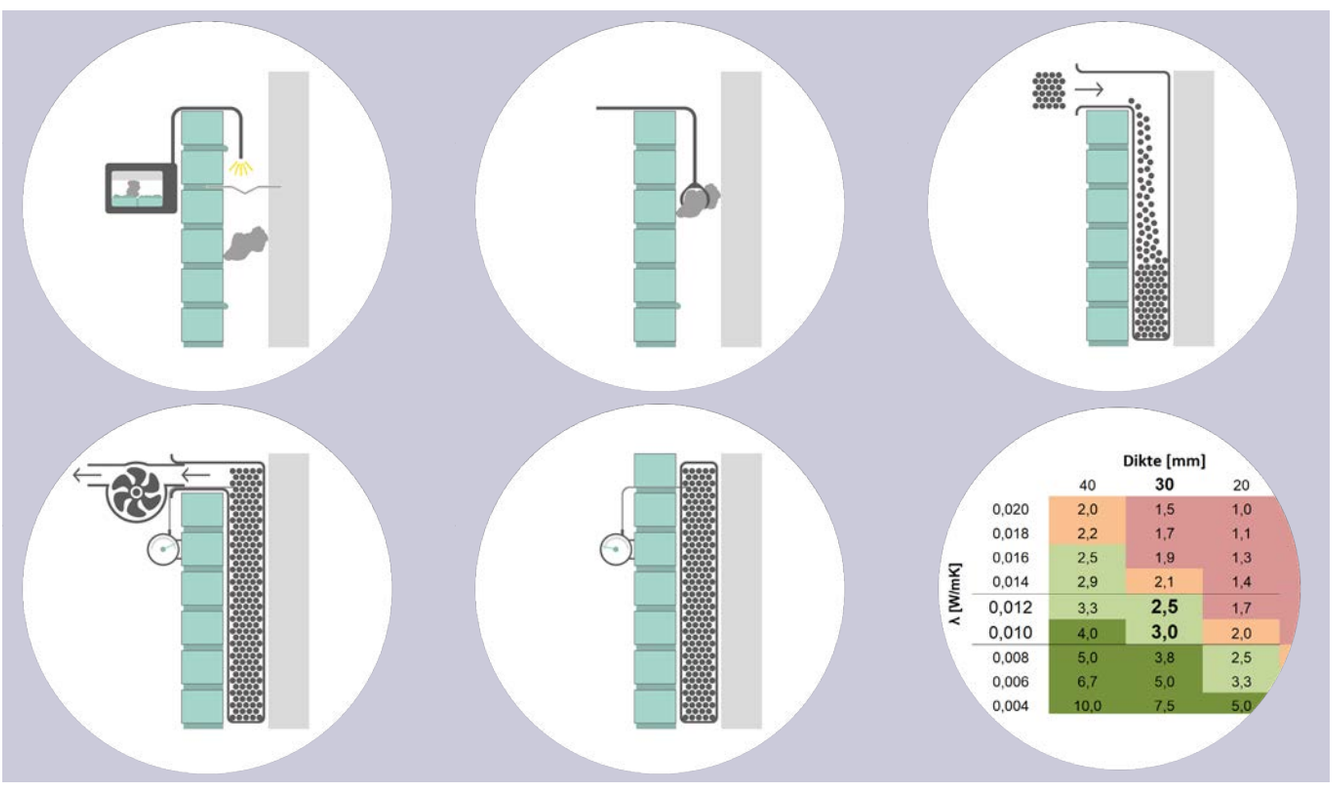

Figure 1. Schematic description of the Qavity insulation method

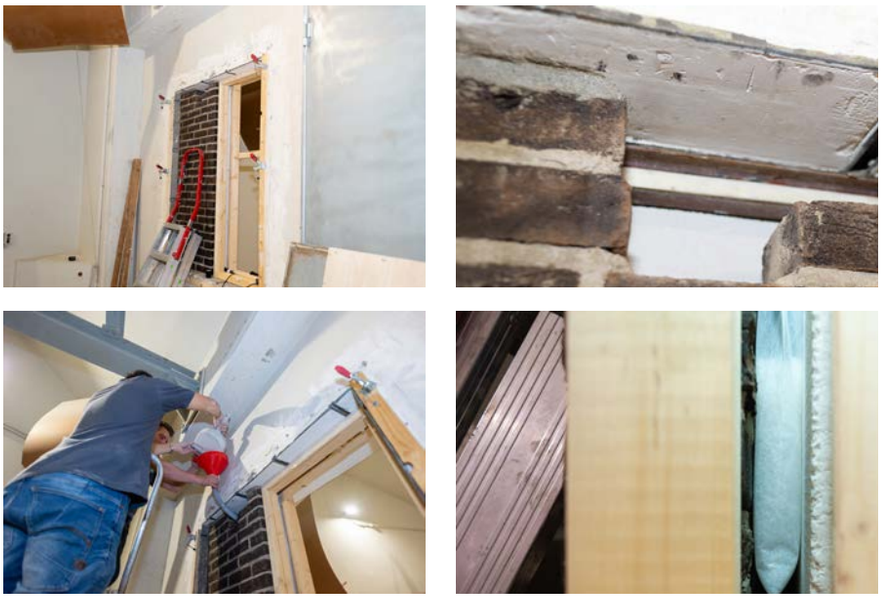

Figure 2. Product development in our laboratory

consumption, because most of it is still very inefficient energy-wise and there are simply much more old buildings in the building stock now than what is newly being built each year. That is the reason why the three mentioned corporations started the insulation challenge and formulated some conditions and requirements. For example, the intervention could not be thicker than 30 mm and should be possible to install within one day. Of course, it cannot introduce any new moisture or fire safety hindrances.

SMART USE OF THE CAVITY

A solution that limits the disturbance of occupants and does not change the appearance of the building is making use of the wall cavity. Naturally, not all dwellings have a cavity wall structure, but a big part of the corporation's properties do. Traditionally, a cavity can be filled with insulation flecks or pearls, for example. The thermal quality rises, but it still gives only a limited effect: with a 40 mm cavity a R_c-value of circa 1 m²K/W could be the maximum achievable result.

BETTER RESULTS WITH A VACUUM

What if we could improve the thermal quality of a filled cavity? Inspiration for our submission in the end came from a coffee break and an aluminum coffee brick: could it be possible to introduce the vacuum technique into a cavity wall? This intervention could then improve the R_c-value of the insulated cavity wall to 3 m²K/W or more. (Figure 1)

Of course, it easier said than done. Is it really that easy to introduce a sack into a cavity? What about all the rubbish you mostly find in there? What should we do with the cavity anchors? What material should the sack be made of? What insulation material could work best? Will it all stay in place? Will it work for a longer period of time? Can it all be executed efficiently and quickly? Are there really no moisture risks?

PRODUCT DEVELOPMENT IN OUR LABORATORY

For this reason and to answer the posed questions, we started with the theory behind our idea. We set up a step-by-step design process and we used our laboratory to build small test setups for measuring and trying out ideas to see if the thought-out concept would really work. A practical approach (Figure 2) gave us new insights and introduced new questions to be answered. In the end, we found an answer to most of the risen questions.

FULL SCALE TESTING: END OF 2019

By bundling our combined engineering capabilities - Cauberg Huygen with its building physics experience, calculations and laboratory facilities and QBuild as the specialist on maintenance and damage repair, our idea Qavity won the Insulation Challenge. The other two winning solutions were EWS (VolkerWessels, NieuwWonen) and Isoleren met Nanotechnologie (Vesta Chemicals, Barozzi Group, Svenska Aerogel).

In close contact with suppliers and manufacturers, we have chosen an insulation material, foil and other relevant products that will be used for full scale testing in a house in Utrecht.

As a preparation for this testing the house was fully inspected and mapped to prevent unnecessary problems during the testing and to create the best chance for a positive result. Cauberg Huygen will use these measurements on site to research the practical effect of the vacuum pumped cavity. Hopefully, the results will be promising for the future. ■

Figure 3. Winning the Insulation Challenge with Qavity

“Duurzaam bouwen aan je carrière”

cauberghuygen.nl
werk@cauberghuygen.nl
088-5152505

Collega’s gezocht!

Wij zijn Cauberg Huygen. Onze ingenieurs bundelen dagelijks hun krachten en werken samen met onze klanten aan de uitdagingen van morgen.
Als adviseur zorg je er samen met je team voor veilige, comfortabele en toekomstbestendige gebouwen

Wie/wat ben je?

- Een ambitieuze student/starter Bouwkunde of Civiele Techniek
- Enthousiast over akoestiek, brandveiligheid en bouwfysica
- Loopt over van de ideeën
- Proactief en gedreven

Wat krijg je ervoor terug?

- Onmisbare kennis
- Marktcomform salaris
- Uitstekend bereikbaar met het openbaar vervoer

CAUBERG HUYGEN

EXPERTISES

BOUWFYSICA
- Binnenklimaat
- Thermisch comfort
- Thermische isolatie
- Daglichttoetreding
- Bezonning
- Verlichting
- Windhinder

AKOESTIEK
- Bouwakoestiek
- Omgevingsgeluid
- Industrielawaai
- Zaal- en ruimteakoestiek
- Trillingen
- Laboratiorium

DUURZAAMHEID
- Energieconcepten
- BENG / NOM
- Energieaudits
- Circulariteit
- Materialisering
- Duurzaamheids-certificering

VEILIGHEID
- Brandveiligheid
- Fire Safety Engineering
- Omgevingsrisico’s
- Externe veiligheid
- Omgevings-vergunningen
- Bouwveiligheid

MILIEU
- Ruimtelijke ordening
- Vergunningen en toezicht
- Omgevingsgeluid
- Industrielawaai
- Trillingen
- Luchtkwaliteit

BOUWKWALITEIT
- Vochtonderzoek
- Kwaliteitsborging
- Bouwplantoetsing
- Productonwikkeling
- Toezicht
- Laboratoriumonder-zoek

Minimum Acceptable Dimming Levels in an Open-Plan Office

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INTRODUCTION

In Northern European offices, open-plan office spaces are the norm for commercial office buildings, where occupants have an unrestricted view of the space [1]. Occupancy-driven light control strategy could lead to uncomfortable non-uniformity in the lit space for occupants by switching of lights on and off automatically when a workspace is occupied or unoccupied [2] [3]. Our study expanded upon research from Bakker et al. [2] through an experiment in a daylit office laboratory in which 31 occupants had to set their preferred dimming level of the task, surrounding and background area with different virtual occupancy scenarios, workspace orientation and daylight scenes. The aim was to investigate the effect of occupant's position in the room in relation to windows, walls, occupancy and daylight on luminance ratio and thus on average preferred light levels of the task, surrounding, and background areas.

METHODOLOGY

In 9 measurements, 3x occupancy scenarios for 3x positions, participant set their preferred dimming levels in each area by exploring the range of dimming levels and uniformity themselves. The effect of non-uniform electric lighting distribution due to occupancy is tested with three virtual occupancy scenarios limiting participants control of the surrounding and background area luminaires. All of the 22 luminaires where connected through WIFI with the experimental lighting control program. A laptop running the experimental control program logged participants dimming levels and controlled the luminaires to create the different lighting scenarios. The Bee-Eye HDR camera on a tripod at 1.22m height at the participant's right recorded the fish-eye luminance distribution images and on the participants left a horizontal lux meter at desk height. Besides the workspace lux measurements, the daylight intensity was also logged in the middle of the north façade, facing outwards.

DATA ANALYSIS

A Linear Mixed Model (LMM) is used order to describe the relationship between the dependent variables and the independent variables. Linear mixed models allow both fixed and random effects, and are particularly used due to the non-independence in the preferred dimming levels, as a consequence of the repeated measurements design used in this experiment. Another consideration is LMM hass an advantage in dealing with the unbalanced data due the day light intensity levels

Figure 1. 9 senarios. Green = participant & Red = virtual occcupant

CONCLUSION

The results show that, regardless of position, the preferred dimming levels seems to get lower as Daylight intensity increases. Confirming that users with a relative higher amount of window area in their visual field will prefer higher task dimming levels. In addition, users with a higher wall area in their visual field will prefer a lower surrounding and background dimming levels. The virtual occupancy scenarios had no significant effect on the preferred lighting dimming level of, and the luminance ratio between, task, surrounding and background area. Future research should focus on the validation of this results in similar day lit laboratory test and field studies. ■

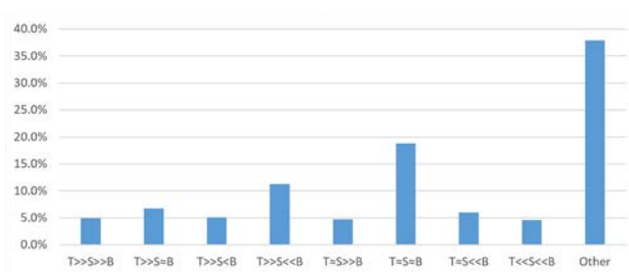

Figure 2. Results: percentages preferred ratio types

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[3] C. de Bakker, M. Aarts, H. Kort, and A. Rosemann, "The feasibility of highly granular lighting control in open-plan offices: Exploring the comfort and energy saving potential," Build. Environ., vol. 142, no. April, pp. 427–438, 2018.

Voor installatiedeskundigen in de gebouwde omgeving

Het aandeel installatietechniek in de gebouwde omgeving neemt toe en innovatieve technieken en ontwikkelingen vragen behalve om toelichting ook om een kritische benadering. Daarvoor geeft Techniek Nederland onder meer het vakblad VV+ uit, met een gratis digitale nieuwsbrief. Abonnees op het magazine hebben de beschikking over een rijk online archief met verhelderende artikelen.

De onderwerpen strekken zich uit over Klimaattechniek - Zonne-energiesystemen - Energietransitie - Lichttechnologie - Digitalisering - Circulariteit - Smart Buildings.

Acht keer per jaar vind je de verdieping in het magazine. Op de website **www.vvplus.nl** en in de gratis digitale nieuwsbrief word je op de hoogte gehouden van de laatste ontwikkelingen.

Techniek Nederland

Temperature effect on sound propagation over an urban area

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INTRODUCTION

The effect of noise on the health of people has caused an interest in environmental noise problems [1]. Sound propagation through the urban environment can be influenced by numerous factors, such as building topology, (urban) vegetation and meteorological conditions [1]. While the effect of sound refraction due to vertical temperature gradients in the ground is well known, the actual effect on sound propagation over urban environments is not yet thoroughly investigated [2]. This research investigated the effect of temperature inversion, when the air near the ground is colder than higher in the air, on the sound propagation over an urban area.

METHODOLOGY

It was expected that the time of the project was too short to design, execute, and analyse a sound measurement with suffcient data for a reliable study, existing sound measurements performed by Trikootam & Hornikx from November 2017 till May 2018 were analysed [1]. These measurements were performed in Strijp, Eindhoven. The bells of the St. Trudo church were used as a sound source. The bells are situated 38 meters above the ground. A microphone was mounted one meter from the bell. The measured values from 23:00 to 7:00 are used. Three microphones are located at different distances from the source, 178m for the first receiver position, 442m for the second receiver position and 527m for the third receiver position. The sound pressure level measurements at the first minute of each hour, the second minute of each hour and last minute of each previous hour were used.

Meteorological data were taken from the open-source KNMI measurements at Eindhoven Airport [3]. The data used were the cloud cover factor, wind speed at 10m altitude and temperature at 1.5m altitude. As the temperature gradient is not measured directly, an approximated temperature profile has been used. To calculate the temperature at 60m altitude, the calculation methodology proposed by Rossing [2] is used, based on the wind speed, cloud cover and an assumed ground temperature of 10°C. The temperature difference between the two altitudes have been calculated by considering the measured temperature at 1.5m altitude from the KNMI data and the calculated temperature at 60m.

To ensure that the sound of the churchbells is loud enough compared to background noise, only the frequency bands at the receiver position registrering 80dB or more are used. Furthermore, to ensure that the sound of the churchbells at the receiver position is higher than the background noise, only the hours where the sound pressure level difference between L_5 (5%) and L_{95} (95%) in the first minute is at least 3dB higher than that of the previous and following minute. Lastly, to ensure that there is a temperature inversion, the data points with a cloud cover factor was higher than 6 octants or where the wind speed was higher than 5m/s were excluded. A regression analysis of the L5 difference between the source and receiver position over the temperature difference is performed.

RESULTS

The calculated increase of the sound level in dB per °C difference in temperature between 1.5m altitude and 60m altitude is shown in figure 1. However, for receiver 3, very few data points were available, making the regression unreliable. For the first receiver position, the average slope is approximately 0.62dB/°C and approximately 0.37dB/°C for the first second position. The difference between the smallest and largest temperature inversion was equal to 30°C. According to the regression, the differences in sound pressure levels on average across all frequency bands between the smallest and largest temperature inversions should be 18.6dB for the first receiver position and 11.1 dB for the second receiver . The standard deviation of more than 10 dB for most frequency bands at the first receiver position and around 7,5dB for the second receiver position, shown in figure 2, are very high, compared to the regression model discussed above. Performing a measurement with a greater number of usable data points and measuring the actual temperature gradient during the measurements, should reduce the standard deviation and increase the number of available data points for regression instead of calculating it. ■

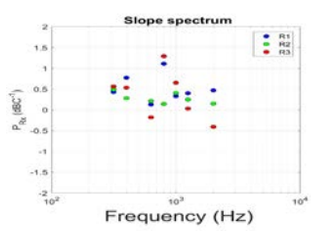

Figure 1. Temperature dependency of the received sound levels

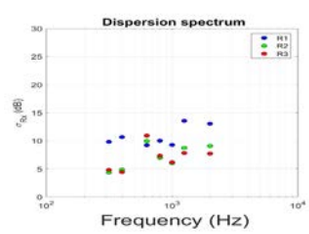

Figure 2. Standard deviations of the sound measurement

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The Effects of Window Luminance on the use of Shading Devices

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INTRODUCTION

Energy consumption has been increasing over the past few decades and has been predicted to continue growing further in the foreseeable future. The growth of the consumption is mainly taking place in the residential, and commercial and public sector [1]. Currently, approximately 5-15% of total energy demand in industrialized countries originates from lighting systems within these buildings. [2]. As a result, a need to lower the energy demands and the accompanying costs emerged. In order to lower the energy demand daylighting strategies have become increasingly important. These strategies have a dual purpose in terms of energy savings. Firstly, maximizing the amount of useful daylight entering the building to reduce the use of electrical lighting, while maintaining the benefits of non-image forming effects of light, such as performance and alertness [3]. Secondly, sunlight provides natural heating to the building. Although, an overabundance of solar irradiation during the summer, for example, could lead to overheating of the building and consequently increasing cooling demand [4]. To find an optimum balance between useful daylight and solar irradiation, and therefore the largest energy saving, the use of shading devices play an essential role. However, building users have individual preferences regarding daylight, which could undermine the effects from the optimization of the daylight control. Maintaining the comfort of these users to prevent them from overriding the optimized systems is therefore important.

Comfort for these users can vary from maintaining outside views, avoiding glare or having electrical lighting present at all times. It is therefore required to gain insight into the preferences, patterns and behavior of building users. The use of manual shading does not have clear patterns as opposed to systems based on sensors. For example, when multiple users are present, socio-psychological effects occur which could influence the manual shading use [5]. Potential effects of this aspect include reluctance to using the shades, this could be due to dominant or submissive traits present among the users or psychological traits called the "big five", as shown in Figure 1. These traits influence how users can be classified and potentially be modeled in their use of shading systems [6]. For example, Schweiker et al. [7] found users with a higher extraversion rating are quick to respond to strains, which results in extraverts being highly likely to interact with systems. In contrast, users with high neuroticism have a low tolerance for stress, are anxious and unassertive. This results in a low amount of expressed reactions to strains, therefore having a low probability to closing blinds. This low probability is likely to prevent confrontation with other users present in the surroundings, which would induce stress.

The use of manually controlled shading devices in a case study of an open office environment has been studied in this research. Manual systems were chosen as interactions with these are a direct result of building users maintaining their comfort. The results from this case study were analyzed using luminance distributions, to determine frequency of use and luminance thresholds for using the manually controlled shading system.

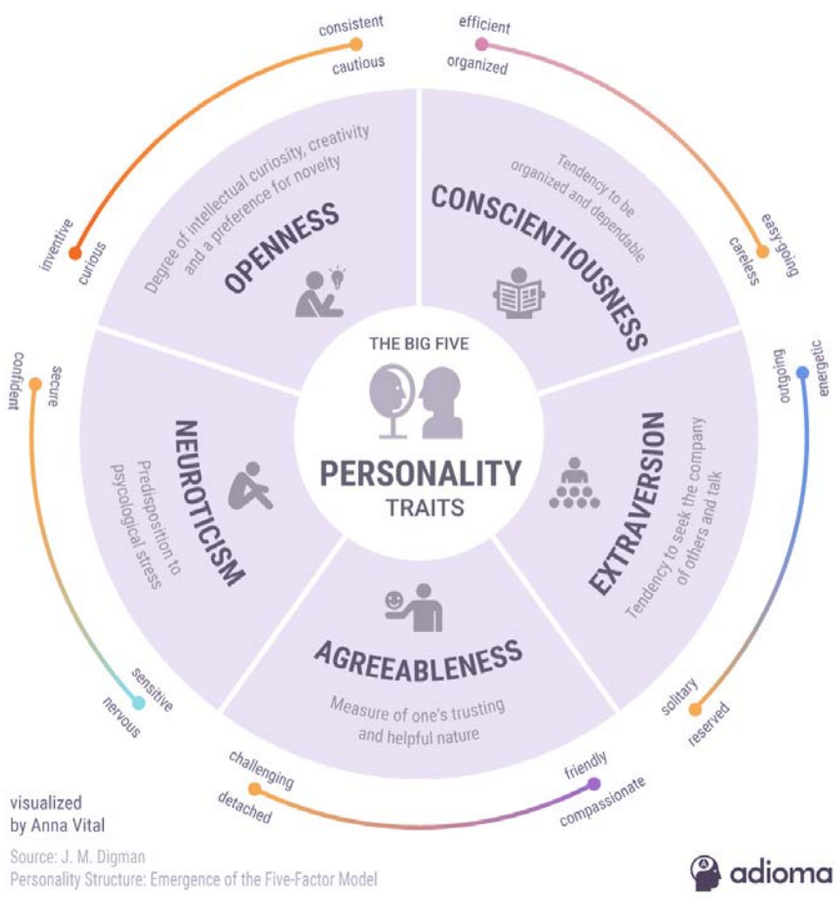

Figure 1. The big five personality traits. [11]

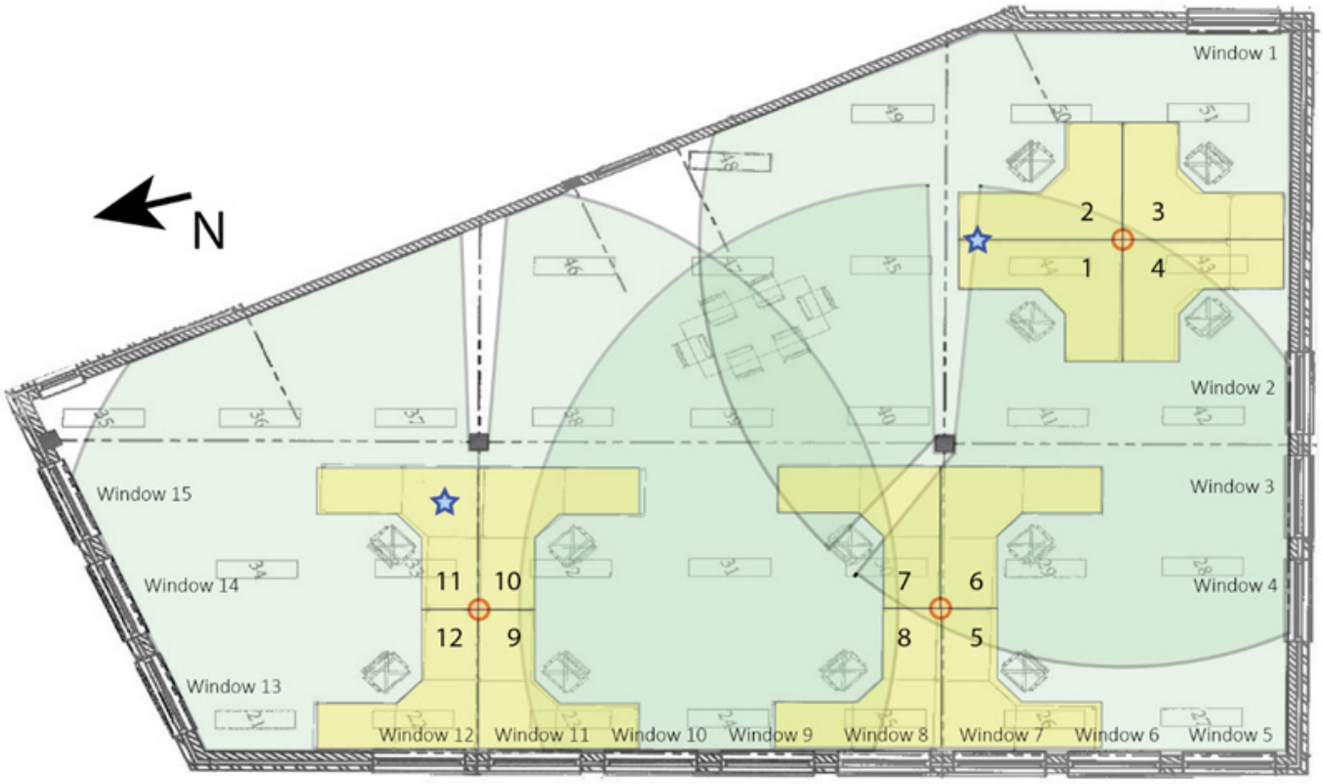

Figure 2. Layout of Office, with the cameras indicated by an orange circle.

METHOD

The use of manually controlled shading devices has been analyzed in an open environment office located in Breda, The Netherlands (Figure 1). The measurements to determine the use were done over three week periods, once during the summer and once during the winter. The office is approximately 195m2 and is located on a second floor. Within this office, 12 desks and 15 windows were investigated. The windows were equipped with external screens from green cloth. To determine the positions of the shading devices three Bee-Eye luminance cameras were used [8]. These cameras take HDR images on a 10 minute interval from within the office, which were then used to determine the position of the window shades.

To determine the position for each window shade for each image a detection algorithm was created. This algorithm is based on the Average Luminance values Per Window (ALPW) and the luminance average of the upper half of the window. In TABLE 1 a step by step process is described and in figure 2 this has been visualized. Additionally, the results from ALPW algorithm were compared to three existing algorithms called BlindSwitch-A, BlindSwitch-B and LightSwitch-2002 [9,10].

BLINDSWITCH-A

BlindSwitch-A (BS-A) [9] is an algorithm that uses exterior irradiance and penetration depth to determine the blind occlusion, for which occlusion starts at values above 120 W/m2. Afterwards, penetration depth raises the likelihood the blinds are closed as the depth increases. However, penetration depth could not be implemented and, therefore, BS-A only uses timeframes in which occlusion was likely to occur.

BLINDSWITCH-B

Blindswitch-B (BS-B) [9] uses vertical illuminance on the façade to determine the positions of the shades. To facilitate this algorithm data from a rooftop sensor was used to determine the illuminance for each orientation. This algorithm starts occlusion at 20klux and shades should be fully closed at 100klux. Additionally, a value-based hysteresis is applied to determine opening of the shades, the retraction starts at 50klux and all shades should be opened at 10klux.

LIGHTSWITCH 2002

Lightswitch 2002 (LS 2002) [10] is an algorithm that uses the irradiance on the desks to determine if the shades near the desk should be lowered. However, LS 2002 only differentiates between fully opened and fully close shades with an irradiance threshold of 50W/m¬2.. To facilitate this algorithm the luminance pictures from the Bee-Eye cameras were used to isolate each desk and determine the irradiance for each respective desk by transforming the luminance values to irradiances.

RESULTS

Figure 3 Total amount of shade closings
Figure 4 Duration of time shades closed
The general results for each of the algorithms can be seen in figure 3 and 4, which have been separated into winter and summer results. For the winter period ALPW detected 480 full shade closings and 306 partial closings. Additionally,

Table 1. Step process for the ALPW algorithm

Step 1.	Apply window masks to the images to create two separate images per timestamp for the full window and the upper half of the window.
Step 2.	Calculate the average luminance value for an entire window (avgwinL) and upper part of the window (avgwinLu).
Step 3.	Calculate a daily average luminance value over the course of a day.
Step 4.	Calculate upper and lower thresholds by multiplying the avgwinL by 70% and 30% respectively.
Step 5.	Compare avgwinL to daily average luminance, if avgwinL is lower than 25% of the daily average luminance the shade is considered fully closed.
Step 6.	If the shade is not considered fully closed and the avgwinLu value is between the range of the upper and lower threshold the shade is considered partially closed.
Step 7.	If the avgwinLu value is above the upper threshold the shade is considered opened.

the average partial closings per window shade is 20.4, with the highest value found being 56 closings and the lowest being 0. Furthermore, all windows show similar timeframes where full closings of the shades were registered. Each window showed 21 full closings with the exception of windows 3 to 9, showing only 19 full closings due to missing data. These closings all occurred at the end of the working day. During the summer period for ALPW a total number of 797 partial closings of the shades were found and 79 full closings.

A noteworthy occurrence is the high amount of short duration (10min) shade closings registered by the ALPW algorithm during both the summer and winter period. For this reason the duration might also be an important indicator for accuracy of the algorithm. For the winter period a total duration of 350 hours for the partial closings is found, while full closings have a duration of 323:40 hours. Which roughly translates to a duration of 69 minutes per partial closing and 40 minutes per full closing. For the summer period a total of 951 hours of partial closing were registered and 35:30 hours of full closing. Moreover, for the partial closings an average duration of 1:11 hours per closing was registered and for the full closings an average of 0:23 hours.
These low durations per closure are conflicting with findings of the literature study, which indicated approximately 1 interaction per shade per day for manual systems. For this reason the occurrences were filtered. When filtering through the data all short durations were either removed, or if multiple occurred in short succession, were combined. In general, the minimum duration threshold was 1 hour, with the exception of the end of workday occurrences. Although, this lead to losing distinction between partial and full closings of the shades. For the winter data this resulted in the 786 closings being lowered to 351 closings, while total duration was lowered from 673 hours to 649 hours. Furthermore, for the summer data this resulted in 886 closings being lowered to 258 closings, while total duration was raised from 986:30 hours to 1065:40 hours.

BLINDSWITCH-A

For BS-A a total of 80 timeframes occurred for the winter period where the shades might have been lowered according to this algorithm. For the summer period there were 324 timeframes registered. Additionally, the duration of the occurrences the winter period has a total of 36:40 hours, while summer has 175:40 hours.

BLINDSWITCH-B

BS-B uses the weather data to determine timeframes where shades are likely to be lowered by the building users. The 20 klux threshold has been passed for a total of 413 timeframes during the winter and 752 timeframes during the summer. However, during the measurements, the 100 klux threshold, which triggered a guaranteed closing, was not passed. The windows in the south façade had the highest occurrence rate, while the north façade has no occurrences. Furthermore, the winter has a total duration of 283:51 hours and the summer has 1109:12 hours.

LIGHTSWITCH 2002

In general, LS 2002 had to lowest amount of timeframes where closing of the shades might occur. The threshold of 50 W/m2 was passed 37 times during the winter and 79 times during the summer. Furthermore, the winter timeframes have a combined duration of 13 hours, while the summer timeframes have a duration of 50:20 hours.

DISCUSSION

When looking into the findings of the case study and comparing them to findings from literature, the high number of closings seems unlikely to have occurred during the study. This short duration period is still present in the filtered data, albeit in a lower number. This indicates either false openings or closings are registered by the ALPW algorithm. An example of this is the high amount of full closings found at the end of the workday during the winter period. This could be explained by the manner in which the ALPW method uses the daily luminance averages to detect full closings. A clarification could be that sunsets occur between 16:57 and 17:31 during the measurement period in the winter, which could make the luminance values decrease rapidly at the end of the working day. Although, these end of work day closings also occur in the summer period, albeit in a much lower degree and are mostly partial closings.

Another source of false registrations could be within the partial closings detection. Partial closings are based upon a difference between the average luminance of the entire window and the upper half of the window. However, there are other possible manners in which this difference might be influenced. Firstly, objects such as trees could cause natural external blockage on each window. This blockage could then disrupt the balance in such a manner that this could be detected as a false closing of the shade. Secondly, internal blockage could also occur. For example, movement or other actions by people inside the office could block the vision from the camera on the window. Lastly, sunlight reflections from, for example, windows or other similar surfaces from opposing buildings could cause bright spots on windows. These bright spots would then skew the average luminance and lead to a false registration. However, this might be counteracted by adding additional criterion to the ALPW algorithm.
All existing algorithms use the data from the Bee-Eye, except Blindswitch-B which uses independent data (roof sensor). Therefore, when the shading devices are being used the results from Lightswitch 2002 and Blindswitch-A might be influenced. Especially BS-A could be heavily influenced as this algorithm uses the image from the window to determine the irradiance on the window. Consequently, timeframes in which the full closure periods are registered by the ALPW algorithm, ideally should not overlap with closures from BS-A. However, overlapping partial closures could occur between the ALPW algorithm and BS-A. Instead, it could be assumed that when the threshold of BS-A is passed a closing from the ALPW algorithm would shortly follow afterwards. This, however, does not occur in most occasions. Users would want to adjust the shade positions according to BS-A when the threshold is passed, yet no actions were taken to bring the

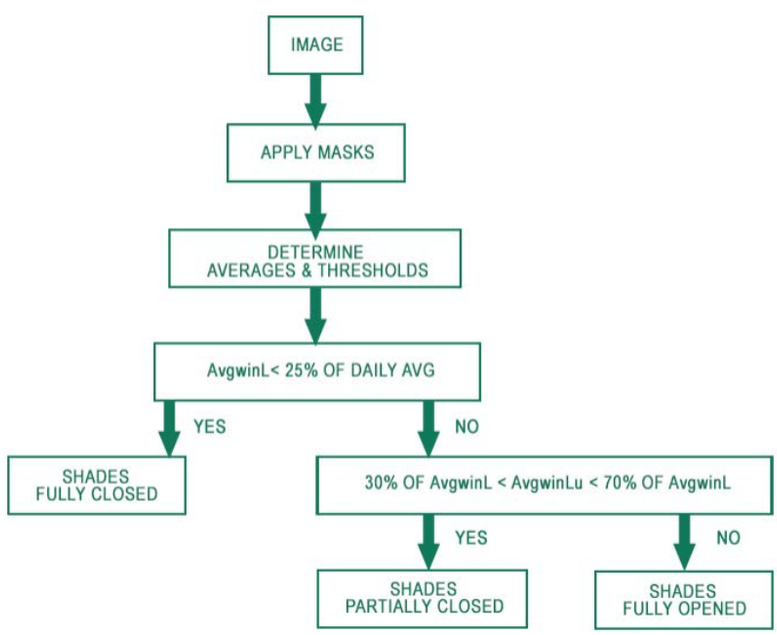

Figure 3. Flowchart ALPW algorithm.

values below the threshold. A reason for this might be that, in this study, BS-A misses the penetration depth to make a fully accurate calculation leading to an overestimation in duration.

Blindswitch-B has a high number of timeframes where closing of the shades might occur. This algorithm, however, uses minute data, which leads to a high number of data points. However, this type of data can instigate a high fluctuation rate in the shade positions, even with the built-in hysteresis. However, this hysteresis is value based and not time based. This can lead to the shades being lowered and raised within a timespan of a minute. Furthermore, this algorithm generalizes shade positions by façade. For example, BS-B indicated no shades in the north façade should be lowered during both measurement periods, however, the other algorithms had multiple registrations for windows in this façade. The building is not oriented perfectly to the North, which could account for some differences. Another possible explanation for this difference is that BS-B does not take surroundings into account. With the Netherlands being located in the Northern hemisphere, direct sunlight will not occur from a northern direction, for a building in a free-field. However, the chance of reflections from neighboring buildings or objects is high on the north façades.

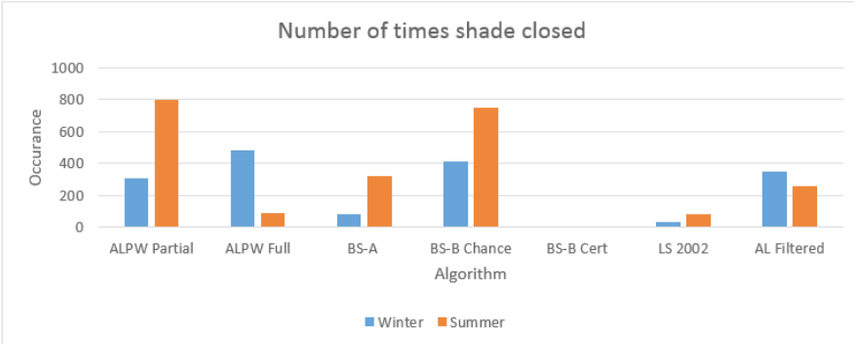

Figure 4. total amount of shade closings

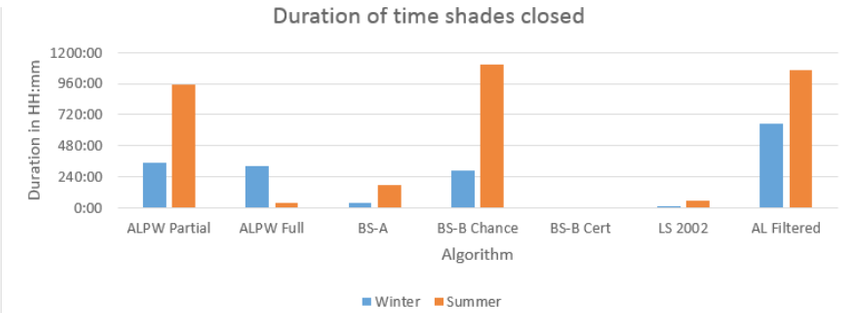

Figure 5. Duration of time shades closed

CONCLUSION AND RECOMMENDATIONS

Firstly, the goal was to determine what the luminance values were prior to closure of the shading devices or if there was a high amount of luminance fluctuation. Due to the noise and misidentifications it was difficult to determine in which range of luminance users interacted with the shading devices. A method to improve the ALPW algorithm could be using a different dataset created in a controlled environment in which the shade positions are pre-set over the course of the period. Using this dataset the thresholds used in the ALPW algorithm could be fine-tuned to decrease the amount of misidentifications. Furthermore, a correction, potentially based on the surroundings of the office, should also prevent cloud coverage or other external light blockage and sunset to be identified as closures.

Secondly, the timing and closing periods for Blindswitch-A, Blindswitch-B and Lightswitch 2002 all varied widely. It can be concluded that these algorithms could be improved as well, such as implementing a time based hysteresis for BS-B, as a consensus amongst the algorithms was to be expected for some periods. Although, Blindswitch-A is not implemented fully during this study, due to lack of implementation of sunlight penetration depth, some matching timeframes were expected. Therefore, it would be recommendable to do a comparative study between the existing algorithms to determine in which situations the three algorithms agree and disagree. Subsequently, the ALPW algorithm can be used to determine whether there is agreement amongst the existing algorithms and the case study.

Finally, the main limitation of this study is the lack of a baseline. For this reason it was difficult to determine whether the findings were accurate or were over- or underestimating the amount of closings of the shades. A possibility to solve this issue is to manually check the images for a number of representative situation or the entire data set. Although, this is a labor intensive method it would greatly increase the ability to draw quantitative conclusions from the data. It would, therefore, be recommended to do so in future studies.

As a conclusion, the ALPW method needs improvement to correctly identify shade positions. After which the luminance values and fluctuations on the windows can be analyzed to determine the influence on the usage of the shading devices. ■

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Convective Heat Transfer at Ground Surfaces in Urban Areas

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Urban areas have their own unique microclimate and differ significantly compared to their rural surroundings. This phenomenon is called the urban heat island. Urban buildings shape airflow in the urban sublayer and the resulting aerodynamic conditions strongly affect pedestrian comfort, ventilation potential of urban spaces and building energy demand [1]. This project aims to analyze convective heat transfer at ground surfaces for different building configurations.

BUILDING CONFIGURATIONS

The configurations chosen are based on a reference case which consists of 16 cubic buildings, whose side (L) and the distance (D) between buildings is 32mm. In order to investigate how flow changes in different configurations, the array has been modified on three different parameters: distance, orientation and height. The distance between buildings was both halved and doubled. For the orientation, the array is rotated by 30° and 45°. For the height parameter, all the buildings are doubled in height.

WIND-TUNNEL MEASUREMENTS

Flows through the buildings are analyzed according to two different criteria. The first is wind speed, measured with a Cobra Probe only performed on the reference configuration and the second is temperature, taken with an infrared camera. All the measurements were performed in a wind-tunnel at a wind speed of 7m/s. Figure 1 shows the results of the Cobra Probe measurements. The lines in between the buildings parallel to the wind flow have a similar behavior. Wind acquires speed as it enters the cube array. Right before exiting the array, the flow accelerates and decelerates after exiting. It is also visible from the graphs that the velocity is unsteady near the ground and along the height of the buildings, while it becomes constant as the height increases when the flow is not influenced by the buildings. Overall, the wind speed is higher outside the configuration (blue line). The se configurations have also been compared with the reference configuration for the thermal imaging.

In the windward direction, the flow between the buildings varies in Configuration 1 and 2. In the latter, there is a so-called interaction flow, which indicates that two corner streams originating and separating at the passage-entrance corners interact and merge together in a single wide passage jet causing higher wind speed – hence lower temperature – than those in a single corner stream [2]. On the other hand, Configuration 3 has an isolated flow, which means that there is no interaction between the corner streams in the passage [2]. Standing vortices and low wind speed are present downwind and upwind of every building.

The stagnation area of Configuration 4 both upwind and downwind is significantly bigger than the one in the base case. The most critical areas are in the corner stream at the side of the buildings, since increasing the height of buildings causes higher speeds.

In the 30° rotated configuration, the wind speed in the area downwind greatly increases. There are many critical areas where the wind speed is high, both between the buildings and around the configuration.

In the 45° rotated configuration, the wind flow has the most influence on the heat transfer. There are no standing vortices upwind because the wind hit the edges of the building, hence the corner streams do not reach high speeds. Nevertheless, the corner streams join downstream of the building, increasing the overall wind speed.

CONCLUSIONS

The change of parameters in building configurations has a big impact on the thermal convective heat transfer at the ground level. Every configuration creates different patterns and each of them has advantages and drawbacks.

Wind speed and thermal images can be used effectively at an early stage of the design phase, when the building's cross section or the arrangement of buildings are examined from the viewpoint of the pedestrian-level wind environment. However, the application of this system is limited to simple arrangements. ■

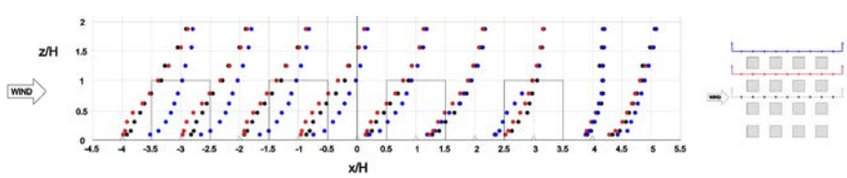

Figure 1. Measurements with the Cobra Probe. Comparison of wind speeds.

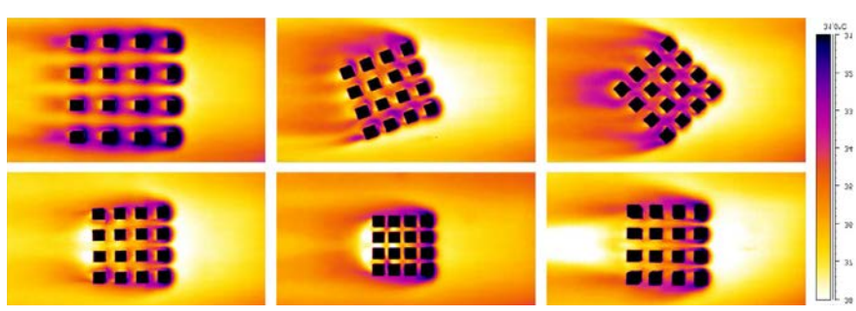

Figure 2. Thermal imaging during the wind tunnel measurements.

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"If you want to make a difference, you have to dare to think differently"

Author
Bilim Atli, TNO

Bilim Atli is a research scientist within the Buildings, Infrastructure & Maritime unit of TNO. In these times of automation, she believes the scientist's human view of the future is becoming more important than ever – it's a view that TNO backs.

"My department focuses on reliable, sustainable and safe solutions for the maritime & offshore, buildings & infrastructure, energy and defence sectors. I work in the Structural Dynamics expertise group, where we contribute to the development of sustainable ships built with composites, among other things. These materials have been used for years by aircraft builders for whom the main goal is to save weight, and therefore fuel.

For marine and offshore applications, composites have even more advantages: you can create more complex geometric shapes and embed sensors into the hull, allowing you to monitor the vessel's behaviour throughout its entire life cycle. A ship like that is rightly called a 'smart megastructure'. We are currently in an EU project to build such composite ships. My job is to develop and carry out experiments with colleagues to demonstrate clearly how structures behave under extreme conditions. It is about pilot setups of many metres in height, so very challenging. Last year, for my research into cryogenic storage tanks I was elected Young Researcher of the Year at TNO out of four nominations. These can be found on ships powered by LNG, or liquefied natural gas, because LNG must be stored at a temperature of 163 degrees below zero. Which materials are resilient to such low temperatures? And can they withstand an impact or collision? In addition, we are seeing the world take its first steps towards a hydrogen economy. Also with hydrogen it is more efficient for many applications if it is stored in liquid form. And that requires even lower temperatures. A next goal may be to develop cryogenic tanks for this purpose. "

Figure 1. Bilim Atli

THANKFUL WORK

"I obtained my PhD at Penn State University with a thesis on aerospace engineering. At a career fair in Boston I ran into TNO for the first time. I was attracted by the position of TNO between business and university. In business, the focus is often on a single product. At TNO you can take a broader view: very nice if you have an inquisitive mind. Moreover, you are working on a product that will become reality in the near future. Its feasibility has already been proven at university level and it is TNO's task to demonstrate the reliability, sustainability and safety of the application. Both pragmatic and challenging, and therefore thankful work. The breadth of my work itself is also attractive. I am both a scientist and a scientific leader of a product-market combination within our unit. On the one hand, I must design and carry out tests, report on them and make suggestions for follow-up projects. On the other hand, I have to set up a project portfolio and make it fit in with our roadmap."

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"TNO is actually a collection of more than 3000 very smart people from all backgrounds and with different areas of expertise. At the same time TNO has an eye for each individual. You can follow different career lines, and the HR department will guide you from the very beginning. At the start you also get a mentor. And you can always ask for what you need, whether it's coaching or training. What I like about starting at TNO is the traineeship. This enables you to quickly get to know the various departments and see how varied and interesting TNO's work is. Furthermore, the balance between work and private life is very good. You determine your own agenda. Flexible working hours and working from home are among the possibilities. And a mummy- or daddy day is very common here."

HUMAN VIEW

"My ideal working day? It starts with coffee! After that, I am happy when a day offers the combination of experiments, analyses, reports and customer dialogue. I have been working on the structural dynamics of maritime structures for about seven years now. As a research scientist, you can develop from junior to principal at TNO. I want to reach that highest level ever. In the meantime, your team grows and your portfolio changes, so there are constant challenges. And you always have to keep an eye on the future.
Especially at a time when automation is booming and machines are taking over the repetitive tasks of the scientist. Your added value is your human view. If you want to make a difference, you have to think differently, be creative, see how you as a scientist can make the world a better place." ■

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Sustainable Building Materials Conference 2019

Authors
dr. F. (Florent) Gauvin

The building sector is by far the largest consumer of raw materials and producer of human-made materials. From a sustainability and circularity point of view, the effects of this demand can among others be mitigated using biogenic resources, smart material design, enhanced durability, functionalization, reuse and recycling, and the use of side streams (e.g. waste materials). Following the success of a previous conference in Wuhan in 2015, the building materials group of the built environment organized the 2nd edition of the International Conference on Sustainable Building Materials, ICSBM 2019, in Eindhoven last summer between the 12th and 15th of August.

During these four days, the conference addressed this challenge from a scientific approach, thanks to researchers coming from many different countries. Different themes were explored, since building materials science is a syncretic discipline hybridizing mineralogy, ceramics, solid-state physics, chemistry, metallurgy and biology. Advanced characterization and treatment methods, together with novel technologies and modelling tools, are vital for the study and improvement of the complete life cycle of building materials, from raw materials, to production, use and recycling.

The conference was split in different types of activities. First, the keynote speeches, where every morning from 9 to 12:30 am, lectures were given by 16 of the world most well-known researchers in the field of building materials.

Then, the traditional parallel session took place during afternoon. On Monday and Wednesday, 4 sessions were taking place, each focusing on a different topic such as new cementitious binders, Waste recovery treatments and valorization, Biogenic materials and Functionalized materials and Greened materials. This was a great opportunity for researchers and students from different horizon to present their work and debate on very specific topics. Of course, longer discussions happened during coffee and lunch breaks! It was also the opportunity for students to learn more from specialists in building materials, in order to get more knowledge about this topic.

Figure 1. Prof. T.A.M Salet, dean of the Department of the Built Environment and Full Professor of Structural Design/Concrete Structures during the introductive speech, Monday 12th August.

Another great event during this conference was the organization of 3 different workshops that happened the Wednesday afternoon. The first one was about the modelling cement chemistry using a specific software named PHREEQC, organized by Prof. M. Tyrer, Prof. A. Watson and Prof. A. West from Coventry University. The second one was about the 3D Concrete Printing technology, by Prof. T.A.M Salet and Prof. C. Gehlen (Technical University of Munich), showing the principle of different 3D printing technologies, approaching both extrusion printing and particle bed printing. The last workshop was about the microstructure of cementitious system, led by Prof. H. Poellmann (Martin-Luther-Universität Halle-Wittenberg) and Prof. S. van der Laan (Eindhoven University of Technology), showing how microscopic observations can be quantified and related to the bulk material characteristics thanks to various complementary analytical techniques.

The last organized activity in this conference was the poster session, which took place in Auditorium during Wednesday's lunch break, in order to maximize the discussion between the participants and the spectators.

However, conferences are not just about presentations and lectures. It is also a great social event, where people from different countries can discuss and share their experiences. On Wednesday evening, the conference dinner was organized, in Metaforum, with a great barbecue under the courtyard!

Eventually, Prof. H.J.H. Brouwers closed the conference on Thursday 15th August after the 4 last keynote speeches, introducing already the 3rd edition of this conference, which will take place in Wuhan, China in 2021. ■

Figure 2. Prof. Shinichi Igarashi from Kanazawa University in Japan, giving his keynote speech in Blauwe zaal, Auditorium.

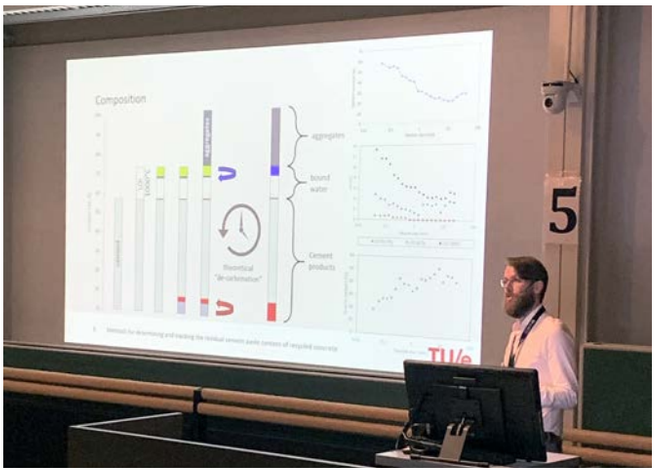

Figure 4. Perry van de Wouw, PhD candidate in the building materials group, during his presentation named "Methods for determining and tracking the residual cement paste content of recycled concrete" in the Waste recovery treatments and valorization session

Figure 5.: Prof. H.J.H. Brouwers, chair of the Building Materials group during the closing ceremony of the conference

Figure 3. PhD candidate and master students from TUe during one of the parallel session

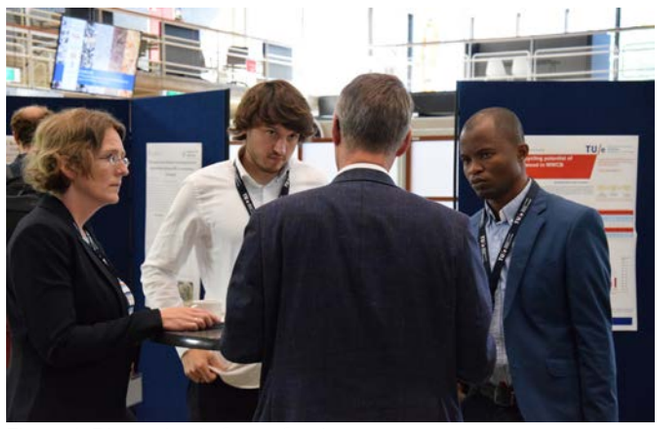

Figure 6. Discussion in front of various posters.

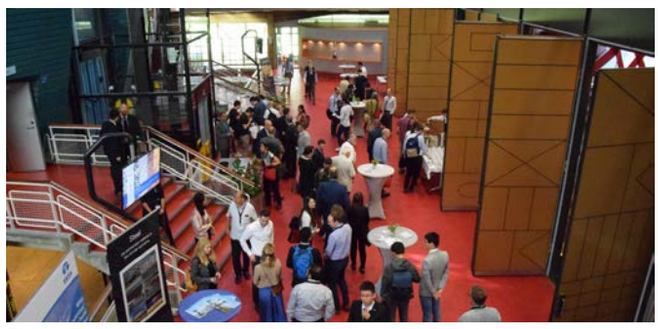

Figure 7. Coffee break between two keynote speeches

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Robert Snoeren, trainee Kuijpers
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Energy saving opportunities in operating theatres

Supervisors
ir. W.H. (Wim) Maassen, PDEng
prof. ir. W. (Wim) Zeiler

Author
A. (Aleksandra) Zarzycka

The need for (nearly) Zero Energy Buildings (nZEBs) in the Netherlands is becoming one of the focus points for the building sector. Factors such as climate change, increasing energy prices and scarcity of fossil fuels have contributed to the decision of the European Union to issue the Energy Performance Building Directive which gives a general definition for nZEBs [1]. Each Member State is obliged to propose a plan on how the following two requirements will be achieved, differentiating between building types. In the Netherlands, the government has published the National Plan to promote nZEBs [2], describing a plan to reduce energy consumption in the built environment. The health care sector, being responsible for 1.64% of total energy consumption in the Netherlands [3], is a very energy intensive industry and therefore action needs to be taken to reduce its impact. Previous study [4] has investigated energy consumptions of various spaces within a hospital and concluded that for Dutch hospitals the energy reduction potential seems to be the highest in isolation rooms and operating theatres. For this reason, in this project it will be investigated which concepts and solutions can contribute to the optimization of energy consumption in the Operating Theatres (OTs), maintaining highest levels of infection prevention and indoor comfort. In order to do so, it is crucial to understand the importance of the ventilation system and its impact on infection rates. This will be done through series of measurements in the OT, aiming to provide insight into bacteria transmission paths and the role of the ventilation system in preventing infections.

METHODOLOGY

In this study the possibility to reduce energy consumption in the ORs is investigated, using an approach that puts the human and his safety in the center of attention. Therefore, the analysis begins with understanding the ways of pathogen transmission and routes of infection acquisition. Secondly, human factors such as thermal comfort of the operating staff and characteristics of the patient are studied and related to healthcare-associated infections. In the third step the impact of ways of working, hygiene, discipline and regulations is analyzed. Last part of the literature study focuses on the operating room itself and various factors that influence its performance, such as the choice of a ventilation system.Most important factors in infection prevention are therefore categorized into four groups, the so called 'four Ps': pathogens, people, practice and place.

By approaching the problem from this perspective it was possible to distinguish new strategies for energy reduction and process improvement. Traditionally the design of the operating theatres is based on many steady-state parameters, while in practice these values vary greatly. Aspects such as hand hygiene, skin shedding of the staff, parameters of the clothing (in case multi-use attire is used), movement of the staff etc. cannot be approximated with one number since they differ everyday depending on the team. Moreover, environmental factors such as relative humidity and indoor temperature can play a role in the spread of pathogens. When it comes to the systems themselves, their design parameters such as the location of inlets/outlets or location of heat sources in the room can greatly alter the way bacteria istransported within the OR. However, those are values that affect the risk of surgical site infections (SSIs) most, assuming proper functioning of the ventilation system that does not allow ingress of particles from a non-sterile to sterile zone.

For this reason, it has been decided to conduct in-use mesurements in the one of Amsterdam's OTs. Eight different situations were simulated, for three different airflows. Each

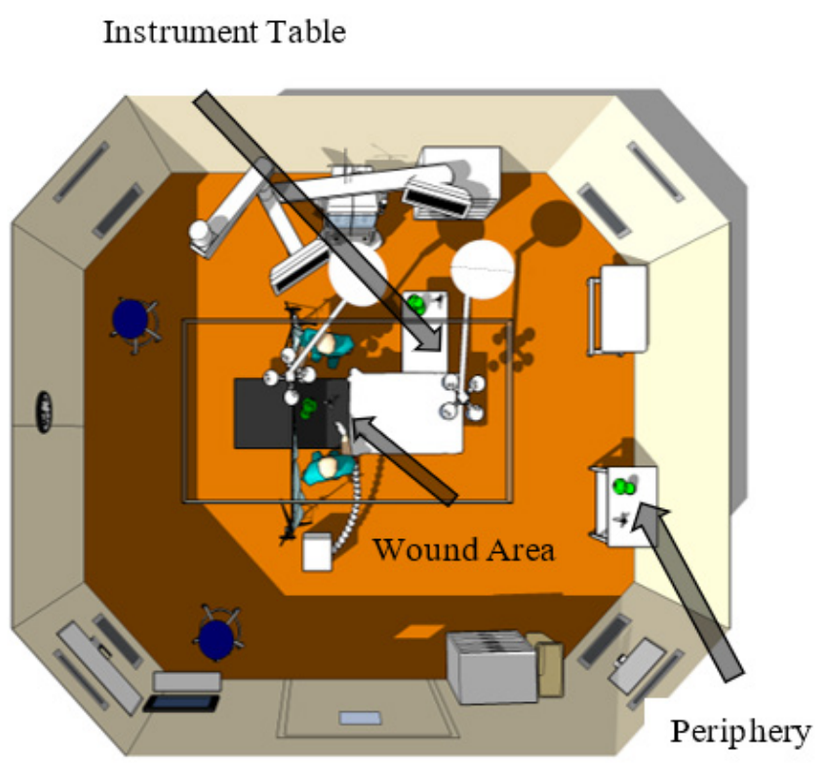

Figure 1. Top view of a 3D model representing the Operating Theatre. Model is not to-scale.

Table 1. Overview of measurements

Measurement number	2 people in the clean zone	5 people in the clean zone	2 people in the clean zone +3 people in the periphery	Surgical attire	Cleanroom clothing	Door openings
M0						
M1	✓			✓		
M2		✓		✓		
M3			✓	✓		
M4	✓				✓	
M5		✓			✓	
M6			✓		✓	
M7			✓		✓	✓

measurement lasted 10min, due to the recommendation in RL8: a measurement series should preferably consist of continuous measurement with data collection every 1 minute and lasting at least 10 minutes. For each measurement two things were recorded: number of particles in the air and number of bacteria. Three parallel samplings are performed at the predefined measuring points according to the points for particle measurements of DIN 1946-4 2008. These measurement points are located directly on the operating table (≤0.5m from the operating site), on the instrument table and in the periphery of the room near an exhaust opening. The exact locations of the measurement points are presented on Figure 1.

In order to simulate a real operation as close to reality as possible, all the hygiene procedures have been followed. The equipment inside the OR was on, as well as the lamps and the heated blanket that would be covering the body of patient. To simulate the operation itself, small objects are handed over to one another in a random sequence, conversations are carried out under normal volume and in one scenario, door openings are made. The overview of the measurements is presented in Table 1.

In M1, two surgeons are simulating an operation. Sterile coat and gloves are worn. Surgeons lean above the wound area, talk and pass on imaginary objects from the instrument table. For the second measurement, M2, the two surgeons remain at the same spots as in M1 and are joined in the clean zone by three assistants. The clothing types are presented on Figure 2. In M3 two surgeons remain at the same spots as in M1, and three assistants are situated in the periphery of the room. One is fulfilling a function of an anesthesiologist, sitting behind the blue curtain at the head of the operating table. Two assistants are moving around the right side of the room, passing objects towards the instrument table. Measurements M4, M5 and M6 were analogical to the first three, the only difference being the clothing type used.

M7 measurement was identical to M6, however the door was opened 10 times. The door in the OT was a sliding door, which was opened to its full opening position, allowing the person to pass and then sliding back to its closing position. One assistant has been leaving the room every time the door was opened. He then stayed in the lock just outside the operating theatre and returned, walking directly in the direction of an instrument table, pretending to be passing the equipment to the surgeons.

All the measurements have been conducted for a 100% (4354 m3/h), 71% (3088 m3/h) and 32% (1377 m3/h) of the standard airflow used by the hospital. The room is class 1 performance level 1 OT, with ISO5 performance in the steady state under the UDF system and ISO7 performance in the steady state in the periphery. The size of the UDF surface is 4.32m2. The area of the periphery is 17.8m2. The airflow is adjusted by a frequency-controlled fan. During the 72% airflow scenario, it was noticed that only two out of four outlets were working. This is because two exhausts are connected to the recirculation loop and two exhausts are discharging the air to the outside.

RESULTS AND DISCUSSION

In the following section the results of the measurements will be presented. During a thorough analysis of the results it was concluded that increased values of particle concentrations or CFUs in the periphery have little impact on the conditions inside the clean zone (wound and instrument table). The ventilation system creates a protective barrier around these clean spaces and the ingress of particles from the periphery is limited. Therefore, in this paper only the wound area and instrument table will be discussed. These are represented on the graphs with two colors: blue lines refer to the instrument table and green lines to the wound area.

INFLUENCE OF THE AIRFLOW

Looking at the values of particle concentrations for 100% and 71% airflow and at the CFUs for all the measurements it was concluded that the performance of the lower ventilation setting is as good as of the 100% airflow. For different situations and measurement scenarios the system works in a similar way, maintaining comparable conditions in the OT. Lowering the airflow to 32% resulted in significant increase in both measured values. High quality of air was no longer possible to be achieved. In the

Figure 2. Surgical clothing of people standing in the clean zone (top) and assistant's clothing worn in the OR (bottom)

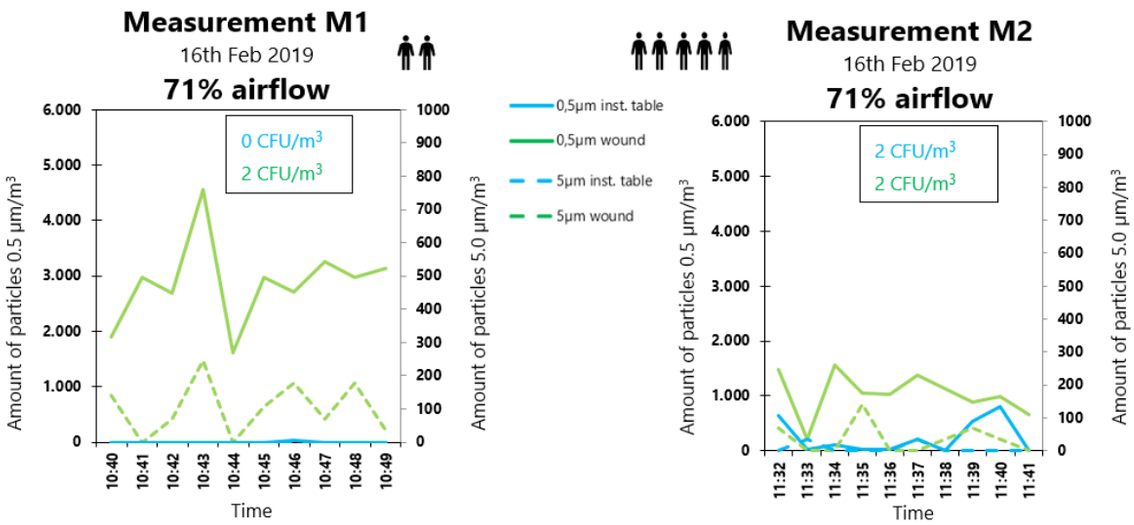

Figure 3. Results of M1 and M2 measurements for 71% airflow

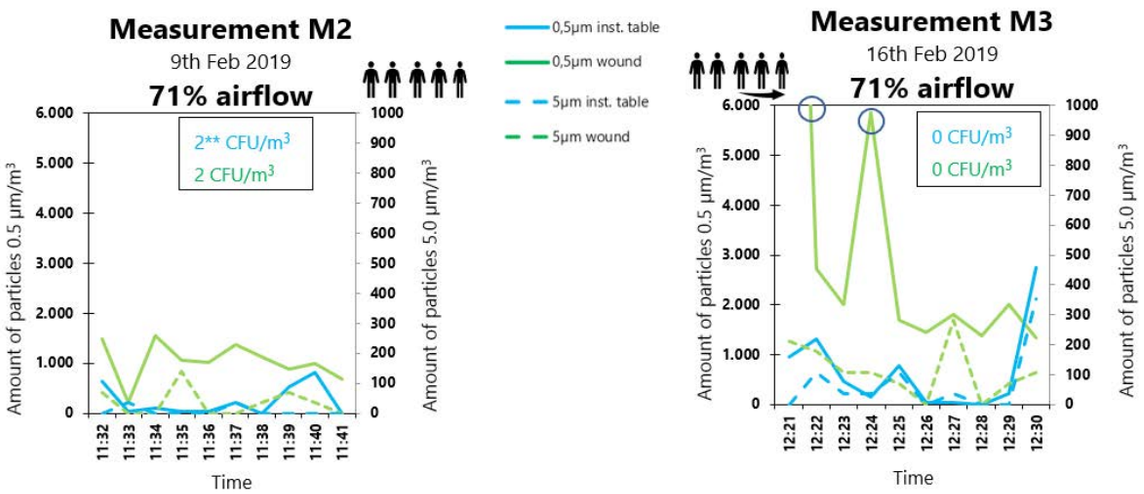

Figure 4. Results of M2 and M3 measurements for 71% airflow

following sections only 71% scenario will be discussed, as the most promising case for energy reduction.

NUMBER OF PEOPLE PRESENT

Figure 3 presents the same comparison between M1 and M2, for the decreased airflow of 71%. It can be observed that the concentration of smaller particles decreased at the wound area and increased at the instrument table. Bacteria and skin particles are however mostly shed during movement.

For this reason, M2 is compared with M3, where the same amount of people is present in the room, but there is increased movement in the periphery. Figure 4 presents this comparison. Two points encircled during M3 measurement are points where values of ISO5 class were exceeded for the particles of 0.5µm/m3 in the wound area. However, no bacteria were found at this location. It can be concluded that the movement of people introduced certain peak events in particle concentrations, at the moment when a person passed right next to the measuring equipment, however it did not disturb the functioning of the ventilation system which continuously maintained the wound area sterile.

CLOTHING TYPE

As it has been mentioned before, the most dynamic situation in the measurement M6 is the one where the reduction in shed particles due to change in clothing is the highest (Figure 5). Cleanroom clothing covers larger skin area than surgical clothing, therefore attributing to the reduced particle concentrations in the air. The differences in particles observed are bigger than for the changing amount of people, meaning that proper clothing in the OT is a critical parameter contributing to indoor air quality during an operation.

OPENING THE DOORS

As it has been mentioned before, the most dynamic situation in the measurement M6 is the one where the reduction in shed particles due to change in clothing is the highest (Figure 5). Cleanroom clothing covers larger skin area than surgical clothing, therefore attributing to the reduced particle concentrations in the air. The differences in particles observed are bigger than for the changing amount of people, meaning that proper clothing in the OT is a critical parameter contributing to indoor air quality during an operation.

CONCLUSIONS AND RECOMMENDATIONS

In operating theatres, many factors including the number of staff, clothing, different airflow supply rates, movement of the people and their number and amount of door openings may influence the indoor air quality in the operating microenvironment and occurrence of surgical site infections. These have been studied during a simulated operation and the following conclusions have been drawn. The amount of people present in the OT is not a factor that influences the infection risk significantly. Moreover, the system seems to be removing the pollution more effectively with the lower airflow of 71%, maintaining a more controlled situation than at 100% flow. When it comes to the impact of clothing, changing the attire from surgical to cleanroom suits resulted in the reduction of particles present. For the wound area and the instrument table, this reduction wasn't significant in cases when there was little movement. The biggest difference was observed when there was movement of people in the periphery, comparing scenarios M3 and M6. In M7 the influence of door opening was tested. It was concluded that for this situation that was simulated, opening the

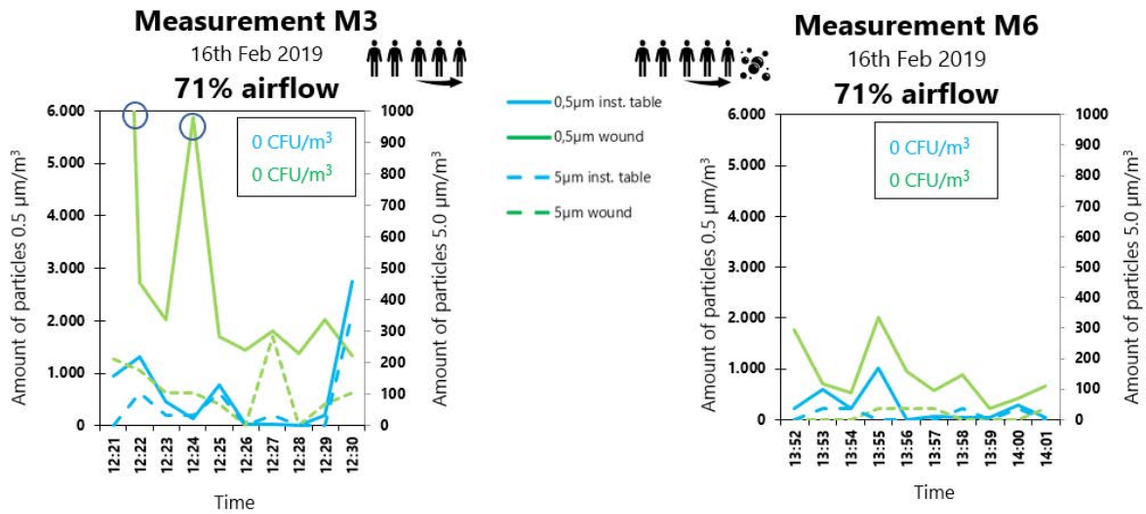

Figure 5. Results of M3 and M6 measurements for 71% airflow

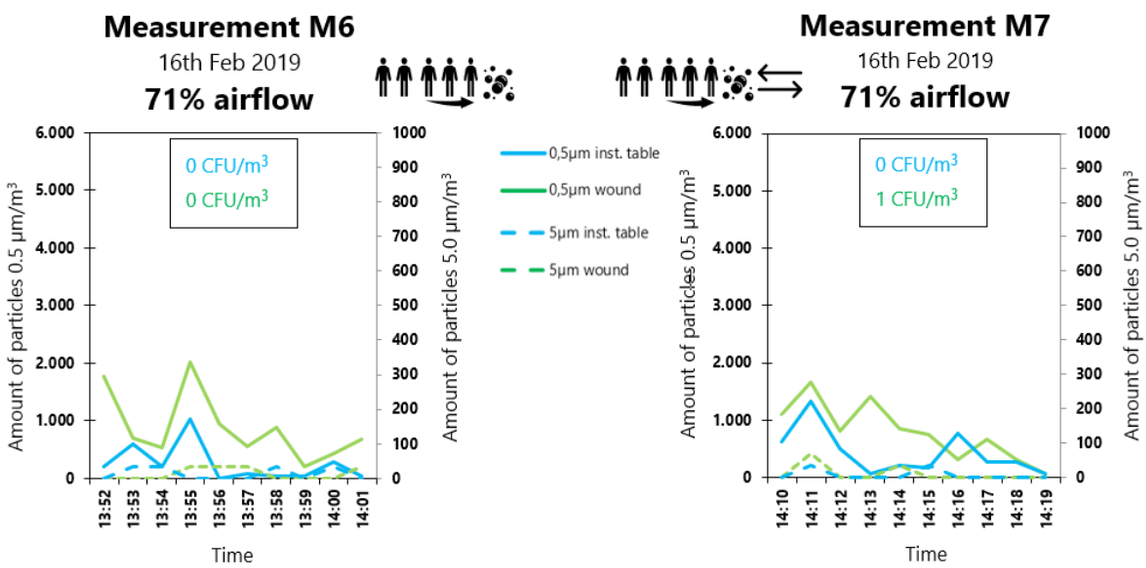

Figure 6. Results of M6 and M7 measurements for 71% airflow

doors and multiple re-entering the room during an operation did not influence the air quality in the wound area and instrument table.

The results suggest that it is possible to reduce energy usage in the operating theatre while assuring high level of surgical site infection prevention. It has been proven in this project that lowering the airflow to 71% assured proper functioning of the ventilation system and did not contribute to worsening the indoor air quality based on number of particles and colony forming units measured. However, it is crucial to keep in mind that all the conclusions drawn in this research are relevant for one specific room type and ventilation system. Therefore, they cannot be directly translated to all the UDF systems across various hospitals.

The result from this study should act as an incentive for policy makers, to reconsider the regulations regarding minimal required air flows in the operating theatres and strive for more research-based evidence on this topic. The newest concept Dutch regulation RL8 provides information on in-use measurements in the OR. This is believed to be the best possible way to understand the actual performance of such a sensitive environment and to assess its quality. As it has been shown, measured parameters are easily influenced by changes inside the room and it is critical to be able to understand the quality of the air during an operation. ■

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Alumni at Work

Author
ir. C (Christina) Randjiet-Singh

Hi there, my name is Christina Randjiet-Singh. I was born and raised in Uden, Noord-Brabant. Currently I live in Arnhem.

In 2008, I started studying building engineering at Avans Den Bosch. Here I graduated in 2012 and started with the pre-master Building Physics and Services. The courses in building services interested me the most.

The pre-master was a lot of fun. I met a lot of people during the start activity to Warsaw and made some great friends. During this time, I was a member of the study trip committee. After that I decided to join the 18th board. This is how I met my boyfriend – he was the chairman of the 17th board.

In September 2015, I proudly received my diploma building physics and services and after a four-week holiday, I started at Schrijvers Technische Installaties as a trainee. In this position, I had the opportunity to discover every department of the company. I first started at the construction site and it was very interesting to see how more than 200 people worked on the site. The organization and planning was the most challenging. I also learned a lot about materials and their purpose and application.

After my adventures outside, I started at the calculation department. I didn't expect much of it, because I didn't care about costs. It was a big surprise that calculation is more than the costs. It is about making choices, making a good design that can also be made within budget.

The next department was the engineering and "werkvoorbereiding". This was interesting since I started to work out the project for which I made calculations. I did all the preparations, detail engineering, orders and communicated with the mechanics on site. This was the time I realized it wasn't the right department for me. I didn't like the details and it was also too much to handle all the questions of the mechanics and subcontractors. Above all, I missed a lot of practical knowledge about materials to answer their questions. I preferred the calculation department more because I had the possibility to engineer the installations and make decisions in a more abstract way.

Thus, I ended up working as a pre-engineer. My work consists of creating installation concepts, informing and advising the customers. This varies from completely residential projects and tenders for small utility projects to large-scale renovations of homes. Here, I can usually also deal with topics that are new to our company. For example, the engineering of our first seasonal thermal storage system (WKO) with which we become an energy supplier for 30 years. Becoming an energy supplier means a lot more than our usually business. Permits are needed, but also a business case, financial model and a completely new administration needs to be developed. It was my job to handle all these things. A very exciting task with lots of challenges.

In addition to my technical work, I am also involved in process improvement with Lean Six Sigma and I expect to get my Green Belt by the end of this year. I also love to travel and together with my boyfriend, we love to discover the world together.
Long story short: I have been able to do many different things within the company because a lot is possible and I can draw my own plan, I have had four very nice years so far. Of course, this is also because of my colleagues who always help me, but mainly because we have a lot of fun together every day.■

Figure 1. Me with my 18th board

Figure 2. Travelling with my boyfriend. Here at the Macchu Picchu

"The best way to predict the future is to create it"[1]

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

This quote seems very fitting for the TU/e because as a university we aim to "create" engineers who will be able to "create" innovative solutions for societal challenges such as achieving a zero-carbon built environment that ensures wellbeing of people. These innovative solutions must be thoroughly tested before large-scale implementation in order to understand how they can best be integrated into existing buildings or combined and optimized in new designs. This could be done by (trial and error) experiments in real buildings, but that will be risky, costly and take a very long time. It will be more efficient – and likely more effective – to predict and analyze future behavior in advance. This is the main aim of computational building performance modeling and simulation, or building performance simulation in short.

Building performance simulation is arguable one of the most powerful analysis techniques for optimizing product development, design and operation of buildings. Nevertheless, it is very important to recognize that (1) simulation does not directly generate solutions or answers – its main purpose is to increase understanding, (2) existing tools may not yet be able to simulate innovative solutions - model and simulation method development will often be necessary, and (3) most of the time it is quite difficult to ensure the quality of simulation results.[2]

In practice there is a growing acceptance that building performance simulation may have an important role in the development of high performance buildings. However until now, in most countries there is a rather surprisingly low uptake and building performance simulation is still generally restricted to a relatively small number of tasks: such as the design of building envelopes, or the prediction of the risk of overheating during the summer or the calculation of maximum cooling loads. As indicated in Figure 1. the majority of new buildings comply with minimum requirements. The corresponding design evaluation tools must be rather simple to use. (By the way, building simulation is often necessary for the development of such tools.) There are only few buildings with a much higher ambition level. Such buildings typically rely on innovative systems and components, and in order to reduce future performance risks building performance simulation is commonly applied.

We think that there is much more potential for better design support by use of building performance simulation. There are however several issues (or research opportunities) that must be addressed such as early phase design support; multi-scale approaches (from construction detail to district level); uncertainty and sensitivity analysis; robustness analysis (employing use and environmental change scenarios); optimization under uncertainty; inverse approach, to address "how to" instead of being able to answer "what if" questions; multi-physics, particularly inclusion of electrical power flow modeling; and, integration in the construction process, using building information modeling (BIM); construction process modeling, etc.

Another research area, which is not directly related to design of a particular building but serves more general objectives, is policy support. Examples of where we have been involved include heat wave vulnerability classification of existing houses, integration of urban heat islands in building energy simulations, and clustering of existing house types that would benefit from similar construction and building services renovation packages.

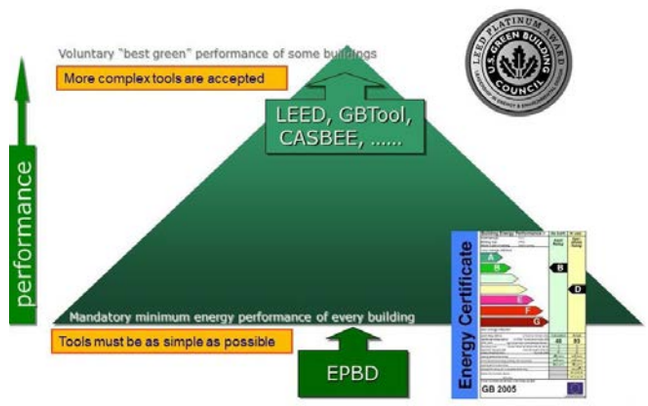

Figure 1. Building performance simulation (and derived tools) in the context of design guidance

Modeling and simulation also has an important role in the development of novel building systems and components. In our case, in particular for moving innovations across the "Valley of Death". The latter is a metaphor for the lack of resources and expertise that impedes new ideas in their transition from lab to market. This gap is indicated as technology readiness levels 4 – 7 in Figure 2. This gap also hinders innovation and adoption of new technologies for improved energy efficiency and environmental quality in buildings.

Building performance simulations allows iterative evaluation of multiple product variants, in order to provide information for strategic decisions that acknowledge high-potential directions in the development process. What-if-analyses can be performed to evaluate the robustness of a new technology in many different usage scenarios and operating conditions. Moreover, building performance simulation can act as a virtual test bed to assess the potential of materials with not-yet-existing properties. All these analyses can be done on the basis of relevant performance indicators, and as such, the method may help creating competitive advantage by improving product performance or time-to-market in a cost-effective way. Examples of products for which we have done this are smart energy glass, façade cladding systems, shading systems and various building integrated photovoltaic systems.

There also exists a considerable and rapidly increasing interest - in practice and (our) research - in the use of simulation for

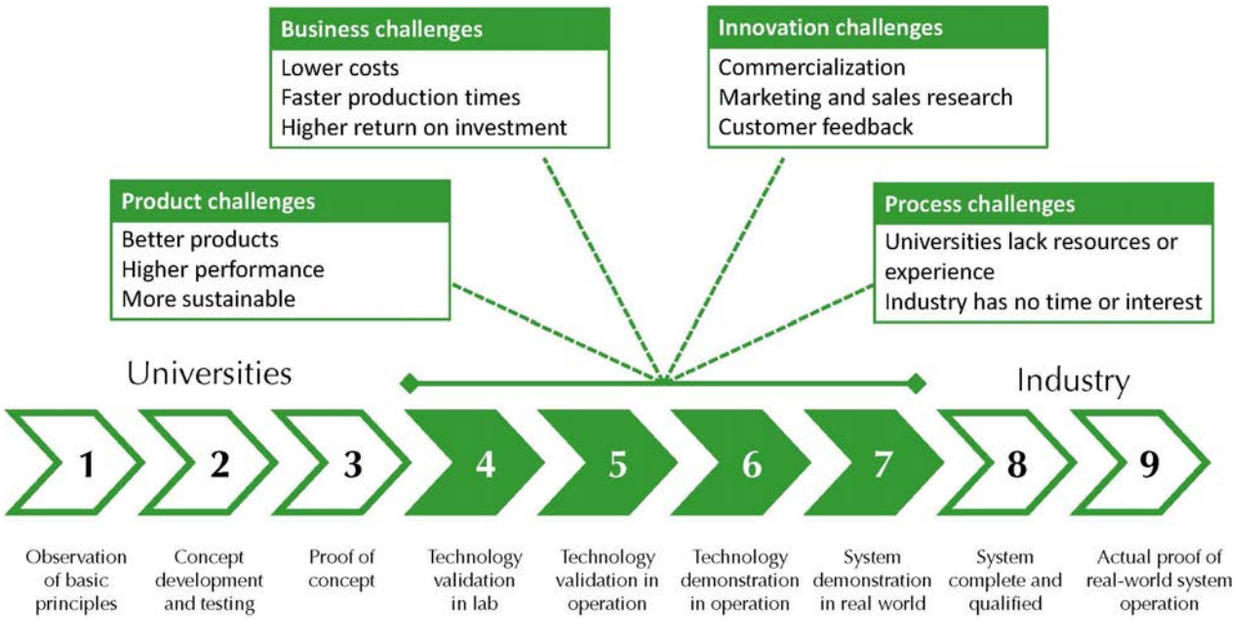

Figure 2 Overview of activities at different technology readiness levels (TRL). Details are given for some of the challenges at TRL 4 to 7.

post-construction activities such as commissioning, operation, maintenance and management. The uptake in current practice is still limited, but we expect that the next decade will see strong growth in the application of building performance simulation for such activities. The two main reasons for this are (1) the current (considerable) discrepancy between predicted and actual energy consumption in buildings, and (2) the emergence of new business models driven by whole life time building (energy) performance.

An interesting example exiting research topic in this context would be digital twins, e.g. as in Figure 3. Predictions based on the virtual digital twin can be used for control optimization, fault detection and diagnosis of controls, as well as for analyzing/predicting the building's dynamic response to changes in construction, usage, occupation or energy supply.

If you want to be a (future) simulator, you first and foremost need sufficient domain knowledge – otherwise simulation reduces to playing a (non-serious) game. In addition you will need knowledge and skills relating to principles, assumptions and limitations of modeling and simulation. Only with this combined domain and simulation background will it be possible to assure the quality of your simulation outcomes and have confidence in the information (and the advice to clients) that you derive from it. ■

Figure 3 Example digital twin of a building. Source: https://www.bau.fraunhofer.de/en/fieldsofresearch/smartbuilding/digital-twin.html

[1]Quote widely attributed to President Abraham Lincoln, but apparently there is no concrete evidence Lincoln ever uttered those words.

[2]For discussion of quality assurance in building performance simulation, see Chapter 1 in Hensen, J. L. M. and Lamberts, R. (Eds.) (2019) "Building Performance Simulation for Design and Operation; Expanded second edition", Routledge, London and New York.

Comfort
Pay-back time!

Author
M.P.A. (Mike) van Osta, MSc.

Buildings and interiors are always around us. They influence our state of mind and in some cases, even influence people's health. Designing a healthy and comfortable office building has several advantages. People are more satisfied with their workplace, productivity is higher and sick leaves are reduced. What hold investors back in investments in comfort is that in general, higher costs are involved to create better comfort. For the building owner, this can often be seen as extra investments from which an immediate positive effect can be seen. However, several studies have shown that investments in comfort can be earned back in a short time. A higher productivity and lesser sick leaves can directly be translated into cost savings.

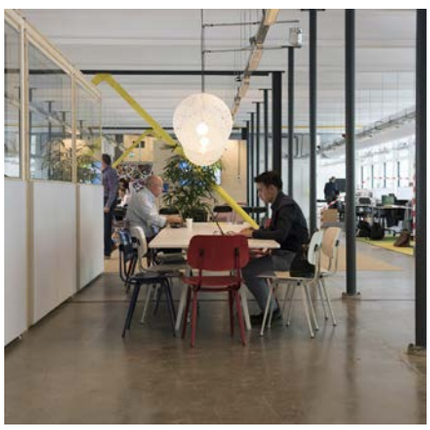

Figure 1. Royal Haskoning office in Amsterdam

The (Dutch) Building Decree sets requirements for health in buildings. These concern minimum requirements and they do not cover all aspects that are important for a healthy building. However, in practice we still see, unfortunately, that the Dutch construction industry considers the minimum requirement from the Building Decree as the maximum.

For every design, a question that should be asked is, "What do users really benefit from?" With a good foundation from human psychology and physiology, it is possible to set better demands and thus prevent us from over dimensioning or under dimensioning building systems. In an early design phase, Royal HaskoningDHV assists the design team with studies in building physics to advise on various comfort parameters. This advice includes dynamic building simulations to predict thermal comfort in buildings and room acoustics simulations to assist architects with the room layout design and material finishes.

VISUAL COMFORT

Research shows that people prefer working in daylight. Employees sitting close to a window are significantly more satisfied compared to employees who are further away from a window [1], (research based on distance larger and smaller than 4.6 meters from the facade). Light suppresses the production of the sleep hormone melatonin, which keeps us awake and alert. Due to a lack of natural daylight, our day and night rhythm is disrupted. The best way to restore the balance is to use as much natural daylight as possible in our buildings [2].

In addition, view plays an important role in the perception of visual comfort. A connection with the outside world is important. It provides a dynamic experience and provides relaxation. A study at the administration offices of Northwest University Campus showed that companies reported fewer sick leave at offices with a view of a green environment with sufficient daylight, in comparison to rooms facing a façade without windows [3]. A study in a call center in California has shown that their employees process telephone calls 7-12% faster in rooms with window openings with a view of greenery [4].

AIR QUALITY

Fresh air is essential for a healthy indoor climate. Due to stricter energy requirements, buildings are increasingly designed to be airtight. Air-tightness successfully helps manage heat, moisture and noise, but limits the natural infiltration of outside air. This puts the emphasis on the operation of the ventilation system. From an energy point of view, an attempt is made to keep the ventilation rate in a building as low as possible.
Many buildings are contaminated by poor flushing of fresh air. As a result, the indoor climate is often up to 4-5 times worse than the air quality outside. The air is polluted by all kinds of substances that are released into the indoor environment, such as moisture, particulate matter, micro-organisms and chemical components. This can lead to health problems such as irritated airways and fatigue.
To improve air quality, adequate ventilation is essential. Scientific research combines a higher ventilation rate with productivity gains of up to 11% [5]. Doubling fresh air intake rates reduces absenteeism and other sickness symptoms by around 10% [6].

THERMAL COMFORT

Office employees consider thermal comfort as one of the most important parameters for a comfortable

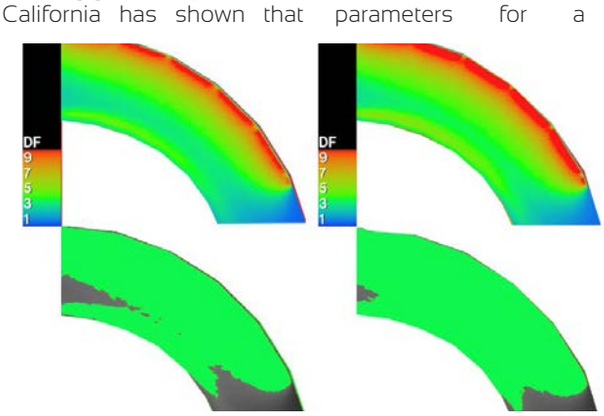

Figure 1. Daylight quality in open plan office expressed in daylight factor

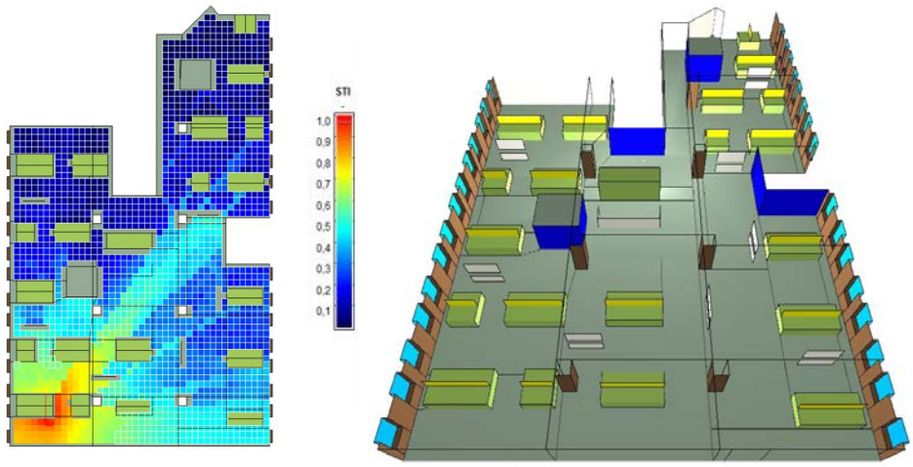

Figure 2. Room acoustics parameter speech transmission index (STI) simulated in open plan office

experience. Due to high temperatures, productivity can decrease by 6%. When the temperature is too low, productivity decreases by 4% [7], (on average based on 24 studies.)

Complaints on thermal comfort can often be found in offices. Based on an indoor climate survey in 215 office buildings in the US, Canada and Finland with 34,000 respondents, most people experience discomfort because of temperature differences between their workplace and other locations in the building. The second point of complaint is that people have no influence on temperature control or can only be carried out by a colleague. Third, the building services respond too slowly to the setpoint changes [8]. When building users have the option to open windows and the setpoints can be controlled, wider temperature ranges in temperature are accepted. [9]. A study in an office environment has shown an increase in productivity of 2.7 to 7%.

ACOUSTICS

In an open plan office, acoustics play a prominent role. From an ergonomic perspective, in a quiet (silent) environment, employees can perform their duties with sufficient concentration. Besides, it is important that employees feel comfortable in their office environment and will not be distracted by each other. Although 'The New Way of Working' – together with the introduction of open plan offices that offer important advantages in terms of the flexibility in organization and its finances, it has been frequently demonstrated that work processes in the open plan office are subject to a greater risk of distraction and reduced job satisfaction.

Distraction is one of the biggest reasons for reduced productivity and well-being among employees who regularly work in an open plan office. In particular, irrelevant speech sounds can be very disturbing. When employees are exposed to intelligible speech that is not relevant to the work to be performed, a part of the mental capacity is required to block these sounds. This reduces the concentration for the task, and one is also exhausted faster. In an open plan office, speech sounds are perceived as uncontrollable. This reduces job satisfaction, but also job performance [10].

It is therefore important that (intelligible) speech cannot reach too far on the office floor. One must realize that it should not be too quiet! The measures to be taken to achieve a pleasant acoustic work environment depend on the desired use and (thus) the intended work processes.

In office buildings it is necessary to realize sufficient acoustic privacy between enclosed spaces. This is achieved by selecting sound-proofing barriers depending on the function and privacy requirement. Nuisance from contact and walking noise can be prevented by selecting sufficiently heavy floor structures and soft floor finishes. Open plan offices can offer a good work environment, as long as noise distraction is limited as much as possible. This requires a combination of architectural and interior facilities, in line with work processes.

COMFORT PAYBACK TIME!

As discussed, comfort leads to higher productivity and therefore cost savings. We have seen that a lower indoor temperature in the summer increases productivity by 6%. The costs of outdoor sun blinds is estimated at € 300,000. This can be earned back within two months for an average office. Acoustic dividers in an open plan office costs around € 90,500 and the return on investment is estimated at one month.

Results from the studies are work and location dependent and cannot be summarized. Different measures naturally reinforce each other. To get seriously started, and to be able to achieve real results, it is important to apply the subject integrally. With only a plant on the desk, you are not there yet. But if you are willing to make some investments, an increased productivity of 5% to 10% is not an unrealistic at all! Even with 1% increased productivity, you have already earned back the investment. ■

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Sprinkler Protection for Personal Safety

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Claudia Rojas Garces MSc., Nieman Consultants

INTRODUCTION

Sprinkler protection is gaining popularity. In stead of creating fire compartments with fire resistant separation constructions and a fire resistant load bearing structure it is possible to prevent fire spread by a sprinkler protection. In fact, this is much more effective than fire compartmentation, because a sprinklered fire is only a localized fire with a low thermal load on building elements.

When a sprinkler protection is succesful in reducing the thermal load on building elements, then it might be also succesful in reducing the personal risk of building occupants, caused by thermal and toxic pollution of the smoke. This is exactly the topic of the research project 'Benefits of sprinkler protection for personal safety'. The goal of this research project is to determine whether or not sprinkler protection influences evacuation safety.

Sprinkler protection limits the spread of fire but not necessarily the spread of smoke. Nevertheless a sprinkler protection might have a positive influence on evacuation safety, because limiting fire development means also limiting smoke production. Besides, a sprinklered fire decreases the temperature development in the fire room compared to an unsprinklered fire. That means a reduction in the overpressure in the fire room, the driving force for smoke propagation in a building. Escape routes can be kept free of smoke for a long time in case of a sprinklered fire.

The research was carried out with Cfast multizone simulations for three different cases. All cases were simulated with and without a sprinkler protection:

1. Evacuation safety in a large compartment with a stratified smokelayer
2. Evacuation safety in a large compartment with smoke mixed in the compart-ment volume
3. Evacuation safety in a small room connected to a corridor

In this article only the results of the small room connected to a corridor are discussed, see figure below. This case is especially interesting because in both health care and residential functions for elderly people this is a frequently used lay-out. For this kind of less self-reliant building occupants long evacuation times will be needed. The more evacuation time available, the safer the situation is for building occupants.

ASSESSMENT CRITERIA

The assessment criteria for personal safety depend on the definition of evacuation safety. In most building codes the building occupants are supposed to be self reliant. This means that safe evacuation is implicitly defined as reaching a safe area without serious health damage. This corresponds to the following assessment criteria:

- Radiative flux < 2.5 kW/m²
- Convective heat < 70 oC
- Visibility > 5 m

In small rooms the sprinkler is activated too late to improve visibility, compared to a non-sprinklered fire. However, the sprinkler protection can be of value when instead of an assessment on health damage an assessment on lethality is applied:

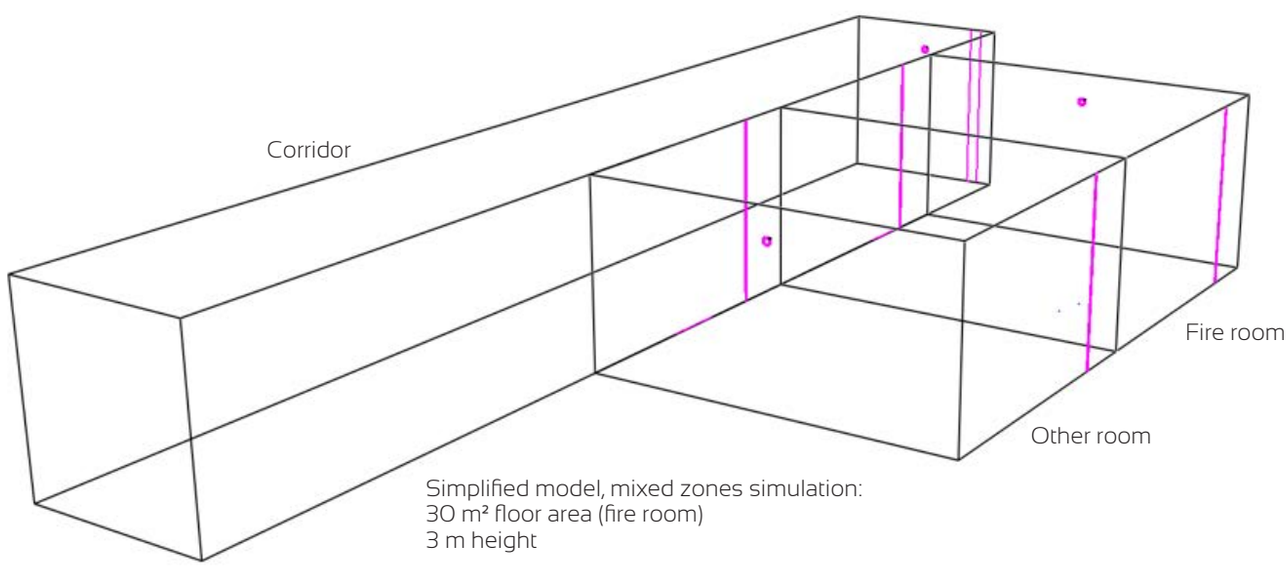

Figure 1. Isometric wire model of the corridor, connected to small compartments

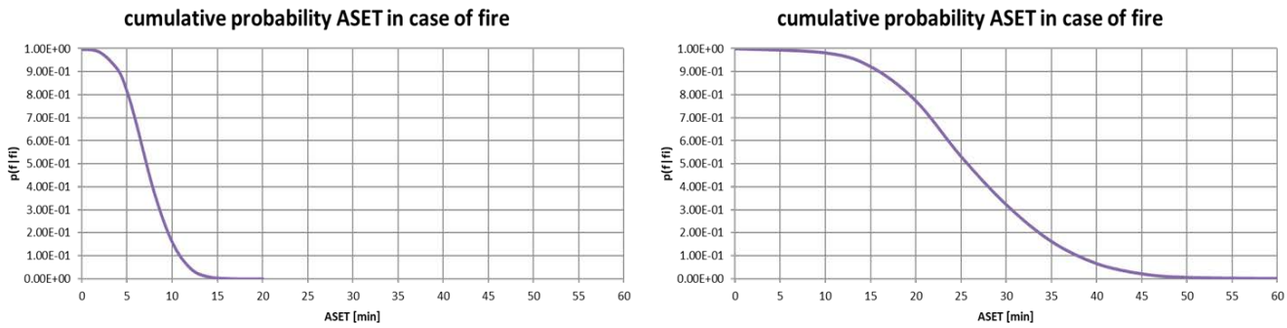

Figure 2. Cumulative distribution functions of ASET in the small fire room, CO-dose criterion (lethality). The left graph shows the cumulative distribution without fire protection; the right graph shows the cumulative distribution with sprinkler protection.

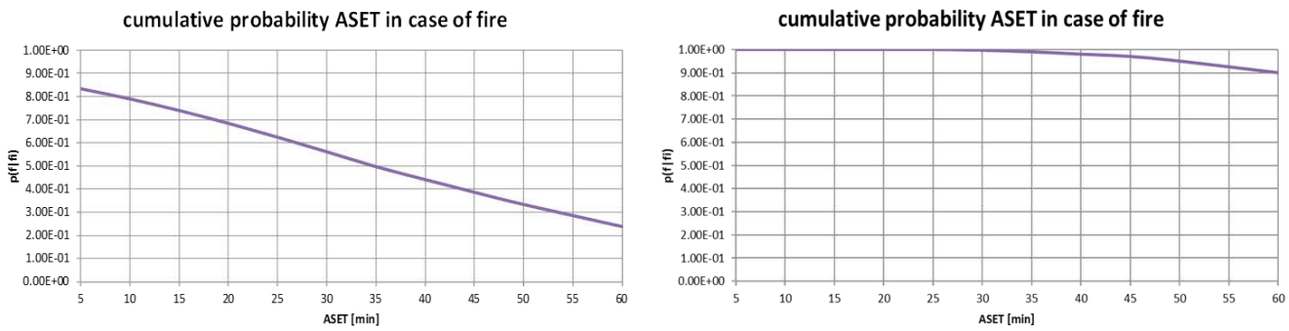

Figure 3. Cumulative distribution functions of ASET in corridor, visibility criterion (health damage). The door to the fire room is opened at t = 5 min. after fire start. The left graph shows the cumulative distribution without fire protection; the right graph shows the cumulative distribution with sprinkler protection

- CO-dose < 35,000 ppm.min.
- O2 concentration > 60,000 ppm

The available safe egress time (ASET) is defined as the time during which all assessment criteria are fulfilled.

RESULTS

The results for large compartments are clear: sprinkler protection improves the reliability for evacuation safety by improving the available safe egress time ASET.

In small compartments the influence of sprinkler protection seems to be negligible when the ASET is assessed on health damage criteria. However, when the ASET is assessed on lethality criteria the influence of sprinkler protection is obvious, even in small compartments. (Fig. 2)

For the corridor, being the escape route out of the connected fire compartments, personal safety is related to health damage criteria. The ASET in the corridor appeared to be much longer in a sprinklered situation than in the non-sprinklered situation. (Fig. 3)

CONCLUSION

Sprinkler protection influences the available safe egress time in a positive way. In small compartments the benefit for self-reliant building occupants is less than in large compartments. However, the smoke propagation to escape routes and to other compartments is delayed by a sprinkler protection. And maybe more important: the probability of surviving a fire increases a lot when a sprinkler protection is applied.

So sprinkler protection is not only valuable for damagecontrol and protecting the separation constructions and load bearing structure, but also valuable for personal safety of building occupants. ■

The research report is available on www.sprinkler.nl

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