Academic year 2016 - 2017 #1 | December

MOLLIER

Study Association Building Physics and Services

INSIDE INFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

The 21st board of Mollier

Sound absorption of periodically spaced baffles

Niels Hoekstra, Maarten Hornikx, Constant Hak and Bert Blocken

Lungs of the city of Eindhoven

Rob Vervoort, Bert Blocken, Twan van Hooff and Roel Gijsbers (ENS)

EVEN THE SIMPLEST OF HOUSES
CAN BE A "ZERO ENERGY BUILDING"...

RICHARD

BY KOERT STAVENUITER

Foreword

Diyako Shadmanfar

Dear Mollier fanatics and admirers,

It is a great honour to write the foreword for the first edition of INSide Information of the academic year of 2016-2017. We present you the INSide information with great pride. I would like to thank you for picking up our magazine and showing interest in its content. My name is Diyako Shadmanfar and I am the chairman of the 21st board of Mollier. I like to look back at last year as an excellent and prosperous one with many successful activities.

As per usual, the INSide features many interesting articles. As most of you have noticed, the education structure on the TU/e has been updated the last couple of years. We have the director of the Graduate Program talking about the occurring changes regarding the transition to Graduate school. Also featured are articles of our own Mollier-members regarding the interesting research they have done for their graduation project. The featured topics this edition are: PV-cell performance, acoustics and air pollution in Eindhoven. This is only a small highlight of what we have in stock this edition.

In addition to our magazine, we will organize excursions, lectures, Meet&Greet with companies, study trips and other study related activities. Mollier has many committees you can join. As the year passes on, we will have to say goodbye to some of our beloved graduating Mollier members. This makes place for fresh new faces in the committees. Let us know if you have great ideas or are interested in joining a committee.

On behalf of the 21st board, we hope to continue to maintain and strengthen the relationships we have with our Mollier members, sponsors, bachelor students and PhD students. I personally want to thank Mollier members and sponsors for your input & support and along the way making Mollier such a lively study association.

Enjoy reading and I hope to see you around!

Yours sincerely,

Diyako Shadmanfar
Chairman 21st board s.v.b.p.s. Mollier.

EDITOR IN CHIEF Hester Thoen

EDITORS Wouter Karssies
Lotte Kooi
Jelle Reinders

COLOPHON

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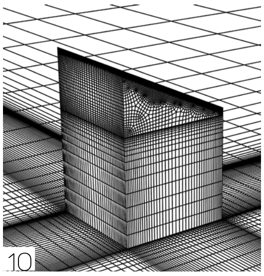
Post address
Postbus 513
p/a Secretariaat BPS
5600 MB Eindhoven
Tel: (040) 247 4406

Email: info@mollier.nl
Website : www.mollier.nl

This INSide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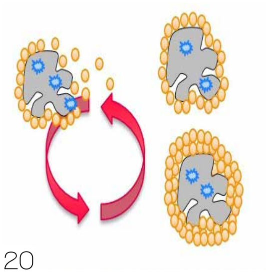
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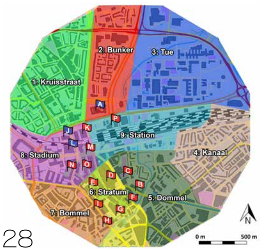

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The 21st board of Mollier

DIYAKO SHADMANFAR - CHAIRMAN

Hey everybody! My name is Diyako and I am 25 years old. I have lived in various places, but spent most time of my life in and around Rotterdam. You probably know this as the greatest city of the Netherlands. The people of Rotterdam are known for being very direct and not afraid to speak up. Those of you who are reading this, will probably recognise this in me as well. For the last year I have been living in Eindhoven now with a lot of pleasure. This probably has something to do with moving out and living on my own for the first time…

Rotterdam has many beautiful buildings and other forms of architectural sights. This got me interested to study Architectural Engineering. So I started off at the Rotterdam University of Applied Sciences, but discovered very soon that I wasn`t enjoying designing as I would have expected. I was more interested in analysing, investigating and solving the technical problems. Fast-forward a bit, I graduated in 2014. I signed up for the TU/e very quickly after that, but founded and landed a job as Planning Engineer for a contractor not soon after.

After working for a year, being 23 years old, I couldn`t help myself but thinking I wasn`t done yet with educating myself. It felt like I was missing out on something. Besides, I was always interested in building physics and building services. Therefore, I decided to go and pursue that desire of expanding my horizon. So far, I have been enjoying my time here at the TU/e a lot.

Besides study related things, I`m really into music. I am always on the lookout for new tunes to listen to. When I have the time, you can find me at concerts and parties on the right side at the front. In addition, I also play a little bit of guitar. Other than music, I like sports a lot. I used to play basketball during high-school and have picked up boxing some while ago. I am available Tuesdays at the Mollier compartment on Floor 2, so feel free to drop by for a chat or a drink.

MARISSA VOS - SECRETARY AND COMMISSIONER OF EDUCATION

Hi, my name is Marissa (obviously, as it is mentioned in the header) and I am 22 years old. I live in Eindhoven for almost 4,5 years, but grew up in Grijpskerke in Zeeland. Of course the most beautiful, picturesque and idyllic town in the whole Netherlands. Despites the fact that life isn't really fascinating in Zeeland, I can't really complain with living a few kilometers from the beach. When I graduated from high-school I mostly doubted between civil engineering at TU Delft and building engineering at TU/e, but I liked the atmosphere in Eindhoven too much and decided to start my study in the big green Vertigo building in 2012. In contrast to a lot of bachelor students, I never wanted to become an architect and was convinced to choose the technical side of the building engineering. So eventually I chose the track for building physics and services and after 3 years of studying I started my master BPS in 2015.

Before I lived in Eindhoven I played soccer for almost 6 years. When I came here, I started dancing but it took too much time and my biggest sport during my studies unfortunately became drinking beer. Although I often try to do some group lessons at the sport center and sometimes go running in the morning, my bed is way too nice and sports aren't really my piece of cake anymore. Next to sports, I like to paint and be creative. Often, I just get inspiration as I'm walking around and start to make a painting or drawing. I also like to create analog pictures, better known as Lomography, as the surprising effect of film rolls really fascinates me. Next to creative things, I just like to be busy. I do some committees at my student association and I have a lot of part time jobs. I'm always in for a drink or some socializing, but as I'm doing an internship at Deerns until February I'm only at the university on Wednesday. But, as this is the best day of the week to get a free tea or coffee (Richard's tea table red.) you probably see me around!

STEFAN KOENDERS - TREASURER AND VICE-CHAIRMAN

My name is Stefan Koenders and I am 24 years old. I'm born in Nijmegen, but lived for the last 23 years in Millingen aan de Rijn. This is a real small village near the border with Germany. The German border is so close that I could see it from my window. My primary school was in this small village, but when I went to high school I had to go to Nijmegen. Every day I cycled over 18 km, because my parents like to live in the middle of nowhere. After my high school I went to the HAN (University of Applied Science) to study 'Bouwkunde'. In 2015 I started with the premaster program for the BPS Graduate School and in February of 2016 I started with my master. This was also the moment to move out of House, into the big city of Eindhoven!

At the beginning of my school carrier I wanted to become an Architect. Already in one of the first months I got really bored by the subject and didn't like all the explaining why I designed things the way I did. In the end, I focused more on building physics and that was also the reason to do this master. Now, doing the master, I am focusing on the combination of comfort and energy. My current project at the Building Performance chair is analyzing and optimizing a new Building Integrated Photovoltaic System, namely the ZigZagSolar Energy Harvesting Façade.

Besides all the school stuff and learning, I also have some hobbies. First of all I am a bass player in two rock bands. Both bands consist of good friends of mine and we just like to have fun playing music. I also like to sport, but I have some motivational problems. So currently I am not sporting at all, but I am going to start again with running and spinning. So if you ever want to talk to me, drink coffee or something else, I am at the Mollier desk on Thursdays.

WOUTER KARSSIES - COMMISIONER EXTERNAL RELATIONS

Dear friends and colleagues, my name is Wouter Karssies, 24 years old. I will strengthen the board this year as commissioner of public relations. I'd come a long way, literally. I was raised in the most beautiful village, Peize, just below Groningen. After achieving my 'VWO'-diploma, I was not quite ready to leave the best student city in the world just yet. I applied at the Hanze University of Applied Sciences to become an architect. After one year I switched towards Building Technology and another 2,5 years later I graduated.

Now I had the choice to do a masters or look for a job. The choice was easy. I went to Eindhoven starting the premaster Building Physics and Services. I finished my premaster. Started September 2015 with the master doing a master project with big data, occupant behavior, energy and a measurement project with lighting. Right now I'm busy with my graduation project about the optimization of semi-transparent Photovoltaics.

In my spare time, I'd like to volleyball. It's my way of getting rid of all day frustrations and keep my head straight. I trained a girls team here in Eindhoven, for one-and-a-half year. Unfortunately I cannot combine this with Mollier. Besides volleyball, I like to travel, see new things, places, buildings. And last but not least I have a large group of friends spread around the whole country, who I see on several occasions and have a good time with.

My graduation project together with the board of Mollier will keep my agenda full. But I hope this will be a great experience and it will certainly upgrade my personal skills.

CONSTITUTION DRINK

September 14th. The moment was there to for the 20th board to pass the baton to the 21st board. The general meeting of members was scheduled in the afternoon, during which the inauguration took place. The highlight of that afternoon was the knotting of the tie. As everyone knows, there is no board better in knotting a tie than the 20th board, but for now I am pleased to say that the 21st board is capable enough. Time to celebrate! The constitution drink was the next item on the program which proceeded in the Skybar. Many boards from other study associations, old Mollier boards and Mollier members came to congratulate the new and fresh board of Mollier. Thanks to all our volunteers the constitution drink went off quietly, besides the occasional attempt to revel our guestbook. It is a night to never forget (if you still remember). As a tradition, we continued the night with all Mollier members and alumni in the city center. A well-cared for buffet was waiting for us at restaurant 'Ons'. So, most of us had a delicious dinner. After everybody was fed-up the party started and even a little bit of dancing was performed on the dance floor. Thanks to our many active members, alumni and our new board we had a great academic year kick-off. Thank you all for a great evening and let this be a great year again!

Excursion to SUM 2016

Author
M. (Marius) Lazauskas

Stabiplan organized SUM 2016 in the van Nelle Factory. The outcomes indicate a bright future for BIM. The adoption of BIM workflow in construction industry is moving forward and the Netherlands is leading this race in Europe (Followed by United Kingdom in second and Germany in third place). Historically BIM is nothing new – the theoretical framework was already in place in the late 80's, but it took 3 decades for it to take off and become the new standard. More and more companies are recognizing the cost saving benefits of using BIM. Furthermore the current Virtual and Augmented Reality trends allow BIM to be also used as an easier tool for communication of designs to clients and among multidisciplinary team members. Besides engineer and advisor meeting rooms BIM coupling with Augmented Reality has implications in field work. It increases onsite quality of work and eases troubleshooting in cases of errors.

Currently virtual reality graphics generated from BIM models are not photorealistic. Wide spread adoption of cloud computing is changing that. Massive cloud computing resources available at low usage times, due to time zones around the globe, allow to utilization of this resource for creation of photorealistic Virtual Reality environments. This makes communication with clients a lot smoother.

Moreover Stabicad plugin for Revit allow multidisciplinary teams to execute their tasks in a timely fashion and, on top of that, deliver better quality products. What furthermore makes BIM adoption attractive is BIM component libraries, which include a broad range of products and eases search for technical product specifications. The BIM library specifically tailored for MEP engineer needs is Stabiplan MEPcontent. Less time spent looking for MEP component datasheets – more time spent designing modular solutions. This accounts for tremendous time savings on construction site, when installing modular products, and smoother design processes in the long run. BIM library coupling with Augmented Reality also revealed benefits of such innovations for work in the field.

As the Dutch construction industry is leading in BIM adoption in Europe the experience gained here can ease the transition to BIM in the rest of Europe. End goal of Stabiplan seems to be the market leader in MEP BIM solutions in Europe and it seems they are on the right track. Stabiplan is increasing its pan European market presence with pushes into French, German and Romanian markets. This makes it unique among European software solution developers for the construction industry market – other players tend to stay regional. Who knows, maybe the upcoming MEP 2018 is not going to be held in the Netherlands at all, I was informed that Bucharest is a nice place. ■

Cavity Airflow in Building Integrated Photovoltaic Systems

Author
M. (Michiel) Klep

Supervisors
prof. dr. ir. B. (Bert) Blocken
dr. ir. T. (Twan) van Hooff
prof. dr. ir. arch. D. (Dirk) Saelens

INTRODUCTION

Due to climate- and energy regulations for buildings, the use of building-integrated renewable energy technologies is becoming increasingly important in the built environment. Therefore, Building Integrated PV (BIPV) systems are becoming a popular technology for improving building energy consumption.

The Swiss BIPV Competence Center identifies two main criteria that a PV composition must adhere to in order to qualify for a BIPV product:

- A double function of the building element including energy generation and/ or weather-proofing, noise reduction, seamless integration etc;
- Homogeneous coverage of the surface. [1]

The overall composition for all BIPV roof systems, shown in Figure 1, can be characterized as a partitioning structure with an insulation layer, construction components, an air gap and a watertight layer with integrated PV elements.

However, the integration of PV cells into building roofs and façades, increases PV cell operating temperatures, consequently decreasing the energy conversion efficiency and adding to heat generation in urban environments. [2]

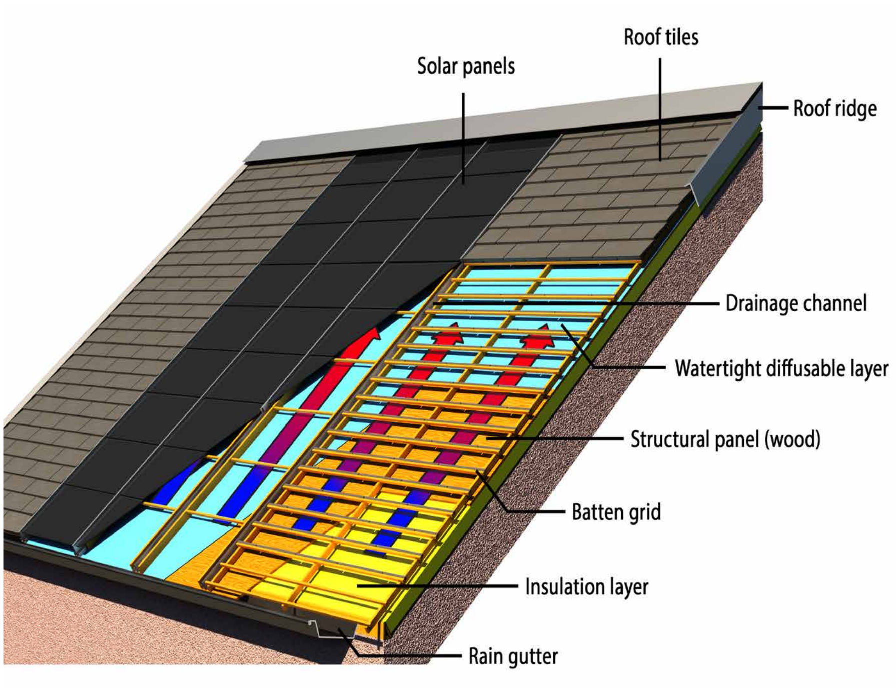

Figure 1. Three dimensional representation of a typical BIPV in- roof construction

The maximum power output and electrical efficiency achievable by a PV panel, are highly dependent on the temperature of the silicon (c-Si) modules, used in 90% the PV systems [3]. This temperature related coefficient is different for each PV material, as is shown in Figure 2.

The addition of a cavity behind the PV - surface, allowing air to cool the PV-surface from the back, is a well-known method to passively counteract these increased temperatures.

OBJECTIVES

The study aimed to identify efficient geometries for the BIPV air

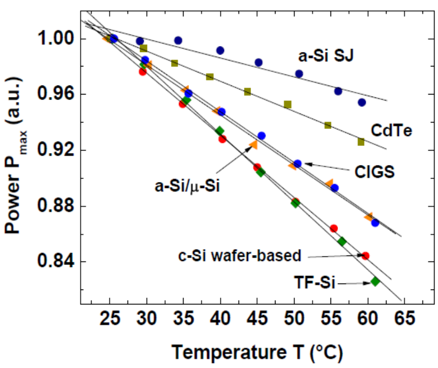

Figure 2. Relation between maximum power output (Pmax) and cell temperature [3]

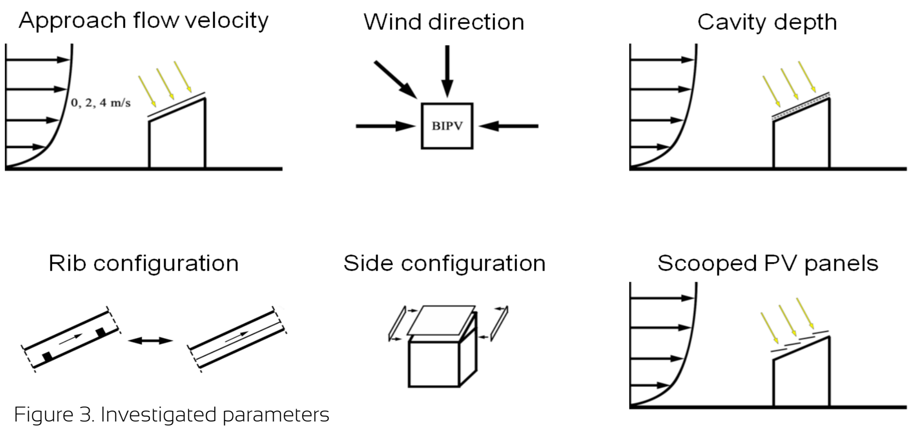

Figure 3. Investigated parameters

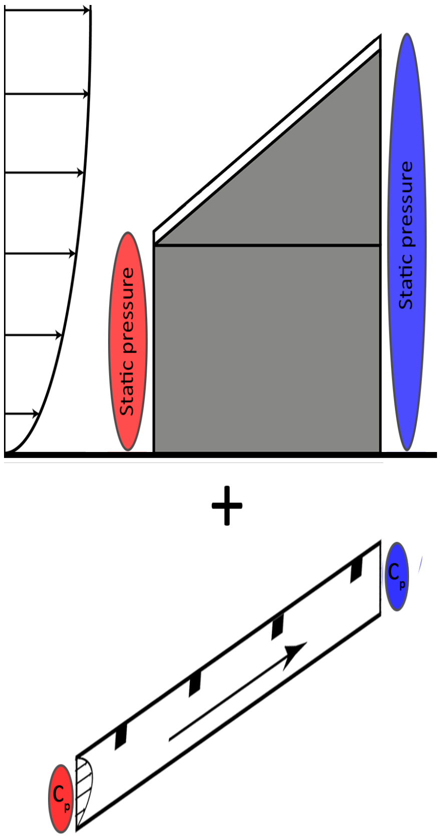

Figure 4. Representation of the decoupled approach

cavity. Therefore, this investigation evaluated the effiect of different design parameters on the airflow and heat transfer throughout building cavities. The present work consists of a literature study, an experimental study and a Computational Fluid Dynamics (CFD) model, used to analyze different cavity design configurations. The evaluated parameters, shown in Figure 3. included: the reference wind velocity, the wind direction, the configuration of the cavity sides, the placement of ribs inside the cavity, the cavity depth and the effect of a scooped panel configuration.

METHODOLOGY

A very computationally demanding grid is required for the parameter study. This is caused by the large difference in length scales for the model (0.01 m to 100 m), resulting in a large amount of cells. In order to counter this problem, an approach is proposed by Nore et al. [4]. This "decoupled" approach consists of splitting the model into two separate models. The first model computes the mean pressures at the cavity inlets, induced by the wind pattern around the building. Afterwards, the pressure coefficients (Cp) and turbulence characteristics are transferred to the second model, which consists of a detailed representation of the cavity.

VALIDATION STUDY

The ability of the numerical model to provide accurate predictions for buoyant airflows was imperative for the study, due to two main reasons:
1) Buoyant flow is generally considered more difficult to model than forced flow when using CFD, 2) the effect of buoyant channel flow on PV module temperatures is most pronounced in a worst case situation, when temperatures are high and wind velocities are low.
A Reynolds-Averaged Navier Stokes (RANS) CFD model was validated for buoyant and forced convection in ducts, using experimental from a laboratory wind-tunnel setup, which was created at the department of the Built Environment at the TU/e Figure 5.

The 6.3 m long wind-tunnel consisted of a 5 m development section, a 1.3 m test section and had a squared 0.5 x 0.5 m2 cross section. A heated panel of 1.3 x 0.5 m2 represented a solar panel and consisted of two aluminum plates with a heating-resistance foil glued to the back. The resistance foil provides a constant and uniformly distributed heat flux across the aluminum. In total, four Styrofoam ribs were installed in the cavity: one in the test section and three in the development section, as shown in Figure 6. The region of interest for measurements is the before and after rib area of the fourth rib.

The air (at atmospheric pressure) is aspirated through the duct, driven by the fan, setting the mass flow to achieve a representative bulk-flow

Figure 5. The wind-tunnel at the department of the Built Environment

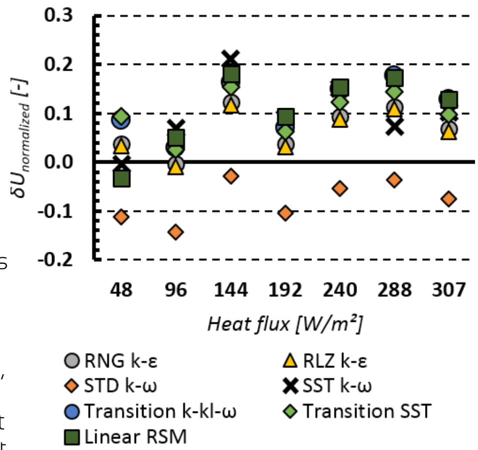

Figure 7. The normalized inlet velocity error values($(T_{modeled} - U_{measured})/ U_{measured}$) for different turbulence models at increasing heat fluxes

velocity. Two reference velocities of 1.0 and 2.0 m/s were selected for the investigation. The measurements for the inlet profile were taken at the start of the test section. Measurements were taken when a steady state situation, indicated by a constant panel temperature, was reached. A FLIR thermal camera was installed above the measurement section, imaging the entire heated panel. In addition, a hot-bulb anemometer was installed inside the cavity in order to obtain vertical velocity profiles.

The measured velocities and temperatures at different heat-fluxes were compared with the modeled velocities for different simulation input

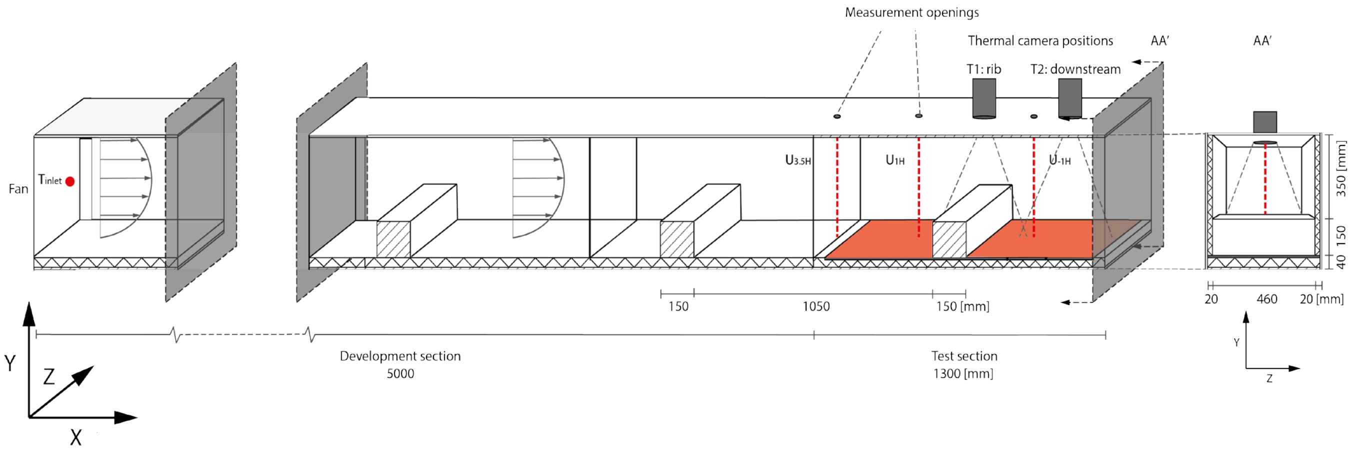

Figure 6. Schematic representation of the ribbed wind tunnel test section

parameters, such as turbulence models, radiation models, turbulence intensity, emissivity values and heat-losses. The normalized error values for the velocity target variables are provided for different turbulence models in Figure 7.

The validation cases were investigated in order to obtain CFD modeling strategies, input parameters, limitations and error estimations. From the validation study it was concluded that the Boussinesq approach provided reasonable accuracy for coping with buoyant flow.

PARAMETER STUDY

A full-scale simulation on heat and mass-transfer, was performed for a typical generic case study building. The computational grid was created using ANSYS Gambit 2.4.6. A base-case building was modeled as a simple typical two-story Dutch dwelling with a roof-based BIPV configuration. The building, shown in Figure 8, has dimensions of 5.0 x 5.0 x 7.4 m3 (L x W x H), with a typical 35o sloped roof. The cavity was modeled as a 0.1 m opening in the sloped roof, bounded by the roof slope and a two-dimensional cover plane, representing the PV area.

In reality, it is likely that multiple building geometries are present near a BIPV configuration. However, no surrounding buildings were modeled in order to find a generic result, independent of the exact location. To still account for the representative aerodynamic characteristics present in an urban environment, a representative roughness was imposed on the ground surface.

BOUNDARY CONDITIONS

For the radiative heat flux, a worst case scenario for a summer day with qrad = 1000 W/m2 in-plane irradiation was assumed. This heat flux was corrected for the absorption coefficient (5%) and for the conversion of light into electricity (15%), yielding a representative qsolar of 800 W/m2. (15%), yielding a representative qsolar of 800 W/m2. The outdoor air was set at 20oC, using the associated air properties This temperature was also used as the Tsky for radiative transfer from the panel to the sky. The emissivity of the panel was set to 0.85 to represent typical solar cells [5]. Different parameter scenarios (Table 1) were investigated using the derived computational model.

Table 1. Parameters with associated scenarios investigated using the coupled model

Parameter	Scenarios	Unit
U_{ABL} (U_{ref})	0, 2, 4	[m/s]
Wind direction (ϕ)	0, 45, 90, 180	[°]
Air gap depth (D_{cavity})	0.05, 0.1, 0.15, 0.2	[m]
Side configuration	open, closed	[-]
Panel configuration	flat, scooped	[-]

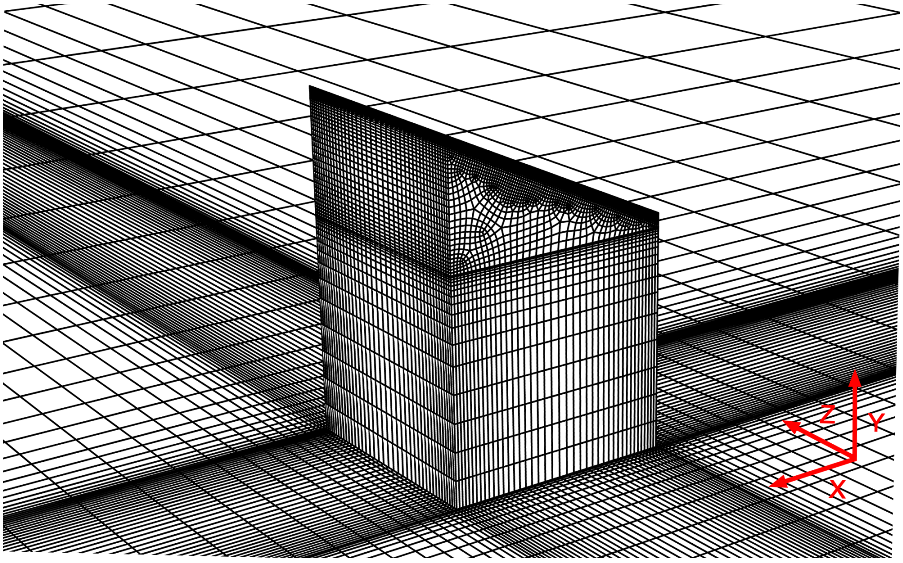

Figure 8. The mesh resolution close to the case-study building

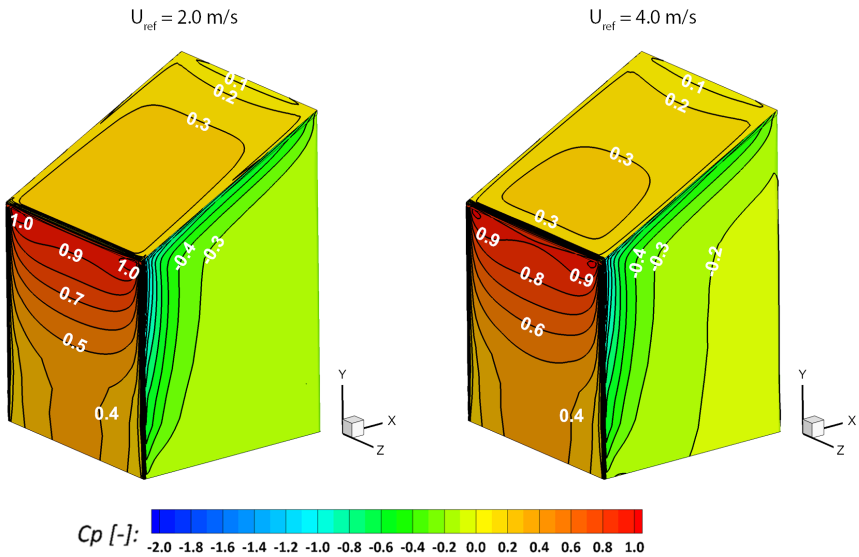

Figure 9. The surface pressure coefficient distribution for both reference velocities

The different simulation results were compared to a base case. The base case was defined as a wind environment with Uref = 2 m/s, Texterior = 293.15 K, Dcavity = 0.1 m, a wind direction parallel to the cavity and closed cavity sides.

PRESSURE DISTRIBUTION

The simulation results for the coupled and decoupled approach were compared. The building pressure model was used to derive the static pressures at the cavity opening surfaces. An average ΔP of 4.44 Pa was found across the cavity for Uref = 2 m/s and 15.10 Pa for Uref = 4 m/s. The building pressure contours are shown in Figure 9 for Uref = 2 m/s and Uref = 4 m/s. The derived pressures at the cavity inlet and outlet were used as input conditions for the detailed cavity model.

The mass-flow rate through the cavity was compared for Uref = 2 m/s and for Uref = 4 m/s. As anticipated, the decoupled model overestimated the mass flow through the cavity, due to the lack of local pressure losses at the cavity inlet. However, when an estimation of the local losses was provided, it was observed that the simulation results improved, yielding errors < 4% compared to the coupled model.

RESULTS

The main target variable that was investigated, is the Heat Transfer coefficient (HTC) at the PV panel surface, because the surface averaged temperature and therefore the cell efficiency (Δη) can be directly attributed to the HTC. For this article the results for one of the investigated parameters are shown. The influence of the governing wind-direction was investigated for Uref = 2 m/s. Four wind directions were investigated: φ = 0o, 45o, 90o and 180o. The wind direction has a large influence on the HTC distribution on both panel surfaces as shown in Figure 10.

The collection of target variables for the wind direction scenarios is shown in Table 2. The surface averaged temperature is also translated to the loss in energy conversion compared to the standard test condition (STC) due

Figure 11. Representation of parameter importance for $\Delta T_{scenariorange}/\Delta T_{scenariorange,max}$

Table 2. Target variable comparison between the wind directions

Parameter	T_{avg} [K]	T_{max} [K]	$\Delta\eta$ [%]
$\phi = 0^o$	318.8	322.6	-9.4
$\phi = 45^o$	320.8	325.1	-10.4
$\phi = 90^o$	325.8	330.2	-12.6
$\phi = 180^o$	326.8	338.7	-13.1
Parameter	$\overline{U}_{cavity}$ [m/s]	Q_{flow} [kg/s]	$T_{air,cavity}$ [K]
$\phi = 0^o$	1.55	0.76	297.4
$\phi = 45^o$	1.37	0.69	299.3
$\phi = 90^o$	0.56	0.18	306.6
$\phi = 180^o$	-0.78	-0.42	301.1

to increased surface temperatures. A representative crystalline silicon cell was used as a reference. The conversion loss (Δη) is displayed as a percentage decrease from the STC condition (Tref = 25oC).

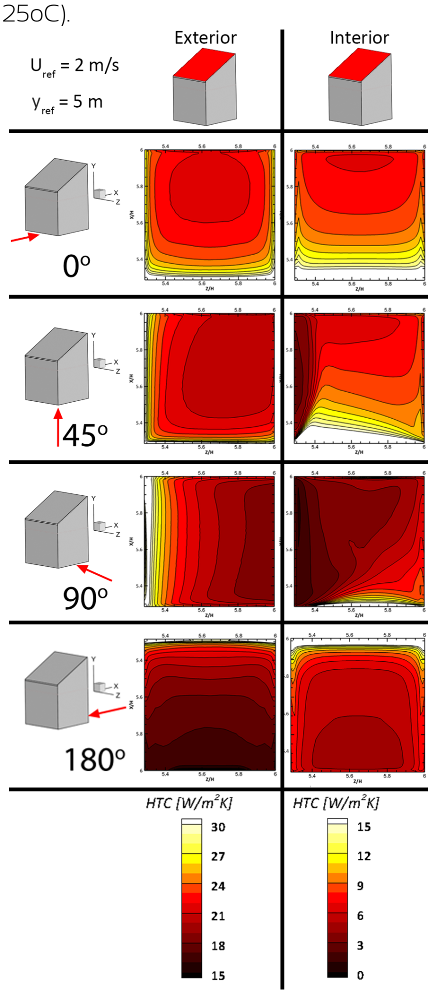

Figure 10. HTC distribution at the panel surfaces for different wind directions

The wind direction parallel to the cavity is the most favorable, when the air flows over the front of the building. However, for the reversed wind direction, the operating temperatures and conversion efficiency are worse. This is presumably due to the solar panel, being located in the recirculation region. The 45o and 90o directions mainly lower the interior heat transfer, leading to increased operating temperatures. A similar target variable comparison was performed for all the investigated parameters.

CONCLUSION

The results for both approaches were compared, in order to evaluate the validity of the decoupled approach. It was concluded that results from the decoupled approach deviated from the coupled approach and induced additional errors of ≈ 12-15% for the mass flow rate. After providing corrections for local pressure losses, errors for the mass flow rate were reduced to < 4%. However, no clear trend in the error was found for different reference velocities, making the coupling heavily dependent on the correct estimation of local pressure losses and exterior heat losses.

DESIGN RECOMMENDATIONS

The research findings for the parameters were used to propose design recommendations for further improvement of BIPV geometries and cavity configurations utilizing passive cooling. The importance of the investigated parameters is presented in Figure 11. It should be noted that the presented parameter influence is highly dependent on the selected input ranges. The reference velocity and wind directions were found to have a much larger influence on the CHTC's than the cavity design parameters, except for the cavity inlet and outlet configuration (which was varied between a 100% and a 0% opening).

An optimal depth of approximately 0.15 m was found for the cavity. The configuration of the cavity sides was found to have negligible influence for perpendicular wind-directions. However, for sideways wind directions the open configuration showed an improved performance.

The "scooped" arrangement was found to perform just slightly better than the straight configuration for U = 2 m/s, contradicting the velocity increasing "Venturi effect". For U = 0 m/s the straight cavity outperformed the scooped cavity. This is most likely caused by the steady buoyant flow velocity resulting from the straight cavity. Components inside the cavity were found to significantly decrease velocities, while increasing flow turbulence, resulting in higher temperatures for high blockage ratios (>20%) but slightly lower overall temperatures for low blockage ratios. From the investigation it was also concluded for the vertical rib configuration that HTC's were higher compared to the horizontal rib configuration for buoyant flow. ■

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Building your future

Author
prof. doc. H.J.P. (Harry) Timmermans
Program Director ABP-GS

Times, they are a-changing. Just ten years ago, when I submitted a research proposal, I knew the competition would come only from other groups in Architecture and Urban Planning or Civil Engineering. At the last European call, I additionally found myself in competition with proposals from Institutes of Applied Physics, Electric Engineering, Computer Science, Operations Research, Industrial Engineering, Innovation Sciences and Economics. Boundaries of traditional disciplines are rapidly fading, while solutions for emerging societal problems require the collaboration of different disciplines.

In response to such trends in industry and society, the vision of the Graduate School is to create opportunities for Master Students for their personal development on the boundaries of disciplines, creating profiles and skills sets that are scarce in their combination and that create appealing profiles for jobs of the future.

Interestingly, the Research Assessment Committee argued that the current theories, models and methodologies of Building Physics are not only relevant to study physical aspects and comfort at the building level, but also to address more challenging problems related to climate change, energy consumption at the city-level and outdoor comfort. It reflects the underlying idea that different disciplines can potentially claim or move into emerging fields such as smart buildings and smart cities. Why should also discipline not be one of these?

The Graduate School stimulates students to choose their profile. It can be more traditional; it can also be on the boundary of disciplines. Apart from a limited core program, in principle the student is free to change the remaining components.

The globalization of the world continues. Engineering firms and consulting firms increasingly have become international businesses. Another key feature of the Graduate School therefore is to encourage students acquiring international experience. It can be realized by taking classes at other universities, but more importantly by spending time in international leading research groups, institutes or firms to obtain more experience working in different cultures.

Finally, many engineering jobs are back office jobs. However, the complex problems and innovations in industry require leadership, vision, social skills and personality development, in addition to excellent engineering knowledge and skills. The third corner stone of the Graduate School therefore is to offer opportunities to students to develop and sculpture their personal and professional skills.

The Built Environment is on the verge of dramatic changes that require innovative integrated solutions. The Graduate School has created the necessary conditions to educate the new generation of engineers to develop such solutions. It is now up to pro-active students to use this opportunity and realize their dreams in building their future and the future of the Built Environment. ■

Mollier Calendar
Past events

OCTOBER

MEET THE BOARD
The 21st board of Mollier invited every Mollier member to meet the board sober. Without the suits, the board wasn't that scary after all. We had a great time and were happy to meet up with old and new faces alike! To top it off all off there was a surprise of free Fair Trade cookies, sponsored by the GO Green Office.

LUNCH LECTURE #1: VAN HOUT & DEERNS
The 13th of October Deerns and van Hout joined for the 1st lunch lecture of this academic year. The lectures were very different. Bastiaan Beerens, a former student of the mastertrack Building Physics and Services, explained to around 30 students every detail about what Deerns has to offer as a company. Many interesting projects were displayed, within every area Deerns is involved in. Jan van Hout, gave us "Food 4 thought", as he said it. Van Hout has a mission: to reduce as much CO_2 emissions as possible with a predetermined investment. He explained possible options to reduce CO_2 emissions, and proposed a method to organize CO_2 reductions in relation with the Net Present Value (NPV). We would like to thank Deerns and van Hout for the interesting lectures and hopefully see some of our members participating in a project at one of these companies.

PUB QUIZ
The first fun activity of the year was a pub quiz! In groups of 5 we answered questions in several rounds with each a specific theme. The questions were hard, and every team wanted to win. Beer improved the creativity throughout the evening, which was visible in the answers. Every two rounds the best group received a price. It was a quiz to remember.

BIO TOUR THROUGH VERTIGO
One of the goals of the 21st board is to attract more Bachelors to the Master Building Physics and Services. The BIO tour through Vertigo is the first activity that aims for this goal. During the one hour tour, PhD and lecturers explained several components of the building services. In this way bachelor students gained practical knowledge of the theoretical course material. The 21st board guided the students around. The tour ended on the Vertigo roof, where everybody had a great view over the TU/e campus.

MEET THE BOARD

SEPTEMBER

OCTOBER

INAUGURATION

LUNCH LECTURE #1

Deerns vanhout adviseurs en installateurs

NOVEMBER

STABIPLAN: SUM 2016

Mollier had the honor to receive an exclusive invitation for the SUM 2016 organized by Stabiplan. It's a big event for all clients of Stabiplan (including many of our sponsors and future employers). For more information see page 9, where Marius has written about this mayor event.

LUNCH LECTURE #2: ARCADIS & VOORT

Arcadis and Voort were invited to provide the second lunch lecture of this academic year. Arcadis profiled itself as an international consultancy firm which gives top priority to sustainability and the clients wishes. Voort is a secondment agency, which originated from the fusion of KP&T and Tracé. Both companies brought with them an alumni from the Master of Building Physics and Services. Ilse Schoenmakers and Silke Seuren told their story of how they became the employee of the company they are working at. Both gave a different perspective of how to deal with the next step in our career. We would like to thank Arcadis and Voort for the interesting insights and hopefully our members will contact them in their following career. More information can be found at the Mollier booth at the 2nd floor of Vertigo or by asking the 21st board.

START ACTIVITY

After some traffic jams near Luik, we arrived in Trois-Pont, a small village in the middle of nowhere in the Ardennes. After a quick dinner and a couple of beers, we drove near Luik and dropped three groups in random places for a small walk of 7 km to find their way to the city center. After arriving in Luik, we still had a couple of hours to party. Somehow, this resulted in visiting a gay bar for the rest of the night. Sounds familiar...

Saturday was the activity day. One group went for a mountain bike tour of 23 km and the other group had an archery class. The mountain bike trail was fit for experienced mountain bikers, so some people had some struggles to reach the end. In the archery group, Roy Botman won the archery competition and went home with a bottle of champagne. After these activities, it was time for dinner. A proper winter BBQ was served and after that, it was game night.

To close off the weekend, we went to the Val-Dieu Abbey to visit the brewery over there. We had an interesting tour and of course could taste several abbey beers and abbey cheeses. After everybody had bought enough beer and cheese, the Start Activity was over and we drove back to Eindhoven.

We want to thank everyone for joining us on the Start Activity and for making it an amazing weekend! See you at the next activity!

DECEMBER

LUNCH LECTURE #3: BAM & ...

December 13th, another lunch lecture will be held by BAM and Stabiplan. Eva van Eck (from BAM) will speak about her project at the department of Energy Systems.

PUB QUIZ

LUNCHLECTURE #2

ARCADIS

voort

LUNCHLECTURE #3

bam

NOVEMBER

DECEMBER

TOUR VERTIGO

START ACTIVITY

Kuijpers

Resultaat door betrokkenheid

Kuijpers & Mollier

Kuijpers is een professionele technisch dienstverlener. We zijn een familiebedrijf - opgericht in 1921 - en ontwerpen, bouwen én onderhouden technische installaties in gebouwen en industrie. Onze ambitie is om alleen nog energieneutrale en gezonde installaties te realiseren. Maatschappelijke betrokkenheid en persoonlijke relaties met onze klanten en medewerkers zijn voor ons erg belangrijk. Samen ontwikkelen we ons. Om zo het beste in elkaar naar boven te halen. Met een betrokkenheid die leidt tot resultaat!

Echte mensen.
Echte oplossingen.

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... en nu **Voort**

Voort is een bundeling van kracht en expertise van KP&T en TRACÉ. Onze persoonlijke aanpak hebben we behouden. Ons landelijk netwerk aanzienlijk vergroot.

Wij geloven in de mensen achter de techniek. Bij wie innovatie voorop staat. De ambitieuze denkers en de ijverige doeners. Zij die het onmogelijke mogelijk maken. Door hen te verbinden ontstaat vooruitgang. Dat is wat we doen. We brengen technische professionals bij elkaar. En we brengen ze verder. We doen er alles aan om ze boven zichzelf uit te laten stijgen. De juiste persoon op de juiste plek. Dat is een plek waar je kunt groeien. Jezelf kunt ontwikkelen.

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Groei verder. **Ga voort**

Occupant behaviour and thermal comfort in buildings

Author
L. (Loes) Visser

Supervisors
B.R.M. (Boris) Kingma
L. (Lisje) Schellen
M.G.L.C. (Marcel) Loomans
E.M. M. (Eric) Willems
D. (Wouter) van Marken Lichtenbelt

BACKGROUND

Studies indicate that the energy performance gap between real and calculated energy use is for 80% caused by the occupant. This human factor may be composed of routine and thermoregulatory behaviour. When occupants do not feel comfortable due to high or low operative temperatures and resulting high or low skin temperatures, they are likely to exhibit thermoregulatory behaviour. The aim of this study is to understand and monitor this thermoregulatory behaviour of the occupant. This study presents a detailed monitoring study of two females living in a near Zero Energy Building (nZEB).

METHODS

During this study the two females were measured three weeks over a time span of three months to get insight in their preferred thermal environment and related thermoregulatory behaviour. During this study the following parameters were monitored: activity level, clothing worn, micro climate, skin temperatures, and thermal comfort and sensation. Micro climate to assess exposed conditions and skin temperature at five positions on the body were measured with wireless sensors. They wore an Actiwatch® to measure their activity level, and every two hours the subjects filled in a questionnaire regarding their thermal comfort and sensation vote (7-point scale), clothing, activities, and thermoregulatory behaviour.

RESULTS

During this study the sensation and comfort vote are handled separately [1]. For both test-subjects no correlations could be found between skin temperatures and comfort or sensation vote (respectively $R^2 = 0.0087$, $p = 0.1947$ and $R^2 = 0.0007$, $p = 0.7212$). Figure 1 shows the comfort vote against the sensation vote for one of the test-subjects (7-point scale).

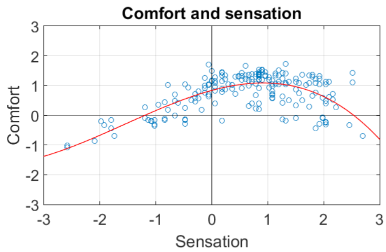

Figure 1. Comfort and sensation vote for test-subject 1

A significant correlation can be found ($R^2 = 0.5000$, $p = 0.0279$). As can be derived through the trend line, this test-subject is most comfortable at the top of the trendline, which corresponds with a sensation vote of 1, 'slightly warm'. The other test-subject shows the same trend. In addition, both participants show a unique pattern when looked at the relationship between exposed- and skin temperatures. Three areas could be distinguished in the measuring data (Figure 2), one sleeping area (a) and two living areas (b and c).

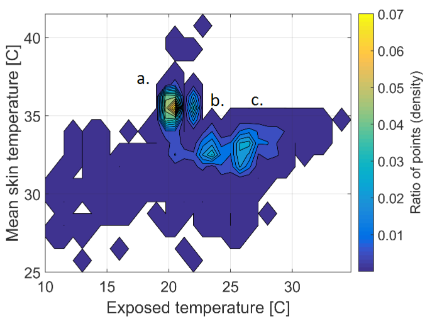

Figure 2. Contour plot of the mean skin temperature vs. exposed temperature for one individual, with three centres (a, b, c)

These three centers represent the thermal environment of this test-subject in real life. After combining the parameters filled in in the questionnaires, center a. corresponds with the measurements during the night. The test-subjects wore the sensors continuously, this means that there are many measuring points during the night. Center b. corresponds with standing activities in an indoor environment with regular winter clothing (e.g. jeans and sweater, clo-value ±0.8 [2][3]). Center c. corresponds with sitting/resting activities and lower clo-values (<0.6). All three areas are associated with maximum comfort. Thermal sensation was not significantly related to any of the single variables, e.g. (mean) skin temperatures, operative temperature, clo-value and activity level.

CONCLUSION

This study gave an insight in the thermal environment of occupants in real life situations. Three centers could be distinguished. These three centers represent the thermal environment of this test-subject in real life. The differences between the two living areas could be explained by differences in activity level, clo-value and ambient conditions. The first living area matches with standing activities with average clo-values, the other area with sitting activities with lower clo-values. In conclusion, the subjects acted on their thermal comfort and sensation vote by changing their clothing or their activity level. ■

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Environmental concrete based on treated MSWI bottom ashes

Author
V. (Veronica) Caprai (MSc)

Supervisor
Dr. Dipl. Ing. M.V.A (Miruna) Florea
Promotor
prof. Dr. Ir. H.J.H. (Jos) Brouwers

INTRODUCTION

Municipal solid waste (MSW), more commonly defined as garbage, involves all the items that are discharged by the public every day. Everybody is a source of municipal solid waste, as our activities (from eating to working) are often linked to the production of indistinct garbage. Depending on the country, the amount of MSW can vary, as well as its source and composition. You can easily imagine that a man would dispose different types of trash, depending on the type of alimentation, income, habits and culture. According to Eurosat, the Netherlands produced more than 500 kg of MSW per capita in 2014, roughly 10 kg per week per person. Denmark holds the title in Europe for the same period with 756 kg per capita. Although a reduction in the MSW production has been observed between 2004 and 2014, household waste will always being produced.

So, how can we use this waste that we cannot avoid to accumulate? The European Union promotes four main approaches: recycling, composting, incineration and landfilling. Due to the limited availability of space, many European countries decided to apply incineration before landfilling, as it reduces the waste by about 90% in volume and 70% in mass [1][2]. With a decreasing trend from 1995 (114 million tons), in 2014 in Europe only 65 million tons of MSW have been processed in this way. Recently, more space has been given to the recycling and composting process, while incineration is now used firstly for energy production, by waste-to-energy plants.

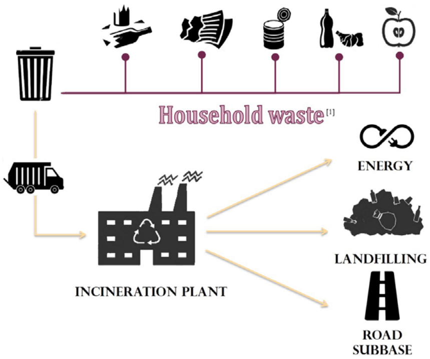

Figure 1. Waste-to-energy plant process, from the collection of the MSW to its treatments and applications

The production of energy from waste can be achieved by combustion, gasification and pyrolysis, and the level of pollutants emitted is sensibly reduced, compared to the past. After incineration, the obtained by-products are classified as municipal solid waste incineration (MSWI) residues, which consist of bottom ash (BA), fly ash (FA) and air pollution control residues. Among those, approximately 80% of the residue is BA [1].

Since 2011, the Netherlands launched the so called "Green Deal" programme for supporting environmentally friendly initiatives. This program aims to achieve the substitution of landfilling with the recycling process, stimulating the active reuse of the waste. According to this new legislation, BA from waste-to-energy incinerators may only be used as secondary building material. This will allow the prevention of leaching of potentially toxic contaminants from the collected waste to the groundwater. In addition, the accumulation of those compounds on landfilling soils might lead to the impossibility of redeveloping these sites for other purposes, due to an excessive contamination of the soil itself. Due to the high variety of sources and numerous incineration processes, a wide range of BA types can be developed.

Depending on the chemical composition and contaminant level of the produced BA, various applications are possible for recycling its main components. However, the existing regulations, the lack of economic incentives and the uncertainty concerning the properties of those residues impedes the easy application of BA in alternative ways [1].

BA APPLICATIONS: STATE OF THE ART

Depending on the legislations and on the chemical composition of the BA produced, the possible applications for recycling its main components are varied. In the Netherlands, about 50% of the stockpiled municipal waste incinerator BA is used as secondary building material, in road construction and as raw material for the ceramic industry [2]. The application of BA in road subbases and embankments always needs to take into account additional requirements, such as:

- Reduction of net infiltration.
- Necessity to use the BA at least 0.5 m above the highest groundwater source.
- The disposal of the material at the end of its service life.

However, according to Saveyn et al. (2014), there have been cases in which specifications were not fulfilled initially or in time, due to changes of conditions no longer fulfilling the criteria. From there, the necessity to find alternate routes to utilize BA, in order to ensure respecting of environmental requirements.

Despite of the numerous studies concerning the application of this waste in the construction field [4][5][6][7][8], the utilization of BA is not widely adopted. There are many parameters influencing the application of BA, including its chemical and physical properties. The formers depend on the origin of the waste as well as on the incineration process. Consequently, the behavior of the material can differ depending on the period of the year, or on the source of the waste. The latter can also affect the application of BA as building material, by modifying parameters such as porosity and thus water demand, grain size distribution, soundness and color. Additionally, the main components of BA include magnetic metals, paramagnetic metals and unburned organic matter. Metals accumulate mainly in finer particle sizes (1-6 mm), and by reducing the particles size, the acid/insoluble heavy metals ratio increases (Φ < 1 mm)[2]. The unsuitable chemical composition of the raw material requires treatments to reduce the heavy metal content, as well as to reduce the metal Al particles and increase the reactivity of the powder.

Among the possible applications, a common attempt is as a passive replacement of Ordinary Portland Cement (PC) [9][10][11]. The inactive material has been placed in mortars up to 30% of the binder mass and mechanical performances were evaluated. In general, an increment of viscosity is displayed due to the widely porous surface of the BA particles. Furthermore, its application often implies the presence of a thermal treatment to reduce the organic matter and increase the dissolution of particles. Finally, although treated before the application, the BA shows inner cracks caused by hydrogen released by the reaction between H2O and metallic Al in the paste.

In the case of normal concrete, the BA has been used for manufacturing aggregates or pellets [5][12]. The coarse, fused and glassy texture of the BA particles makes them an ideal replacement for aggregates [13]. The manufacture of lightweight aggregates (less than 1000 kg/m3) is also possible by using coarser particles. Mostly the manufacture of aggregates with BA results in lightweight aggregates applied in lightweight construction blocks and ground insulation layers in buildings. However, many issues are involved in this application. Firstly, the high surface area characterizing the incineration residues causes high water absorption on the porous aggregates, leading to a reduction in the flow characteristics of the fresh concrete.

CONTRIBUTION OF THIS STUDY

This study aims to define alternative applications of BA in concrete. The incineration Bottom Ash and sludge (0-3 mm fraction) will be provided by Heros Sluiskill NL, The Netherlands. The company already applies the coarser fraction (2-12 mm) as aggregates replacement in concrete up to 40% (Granova).

Among the possible solutions, the activation of BA by applying an alkali activator is taken into account. This approach is commonly used for other type of by-products as slag or fly ash, due to their highly reactive properties. The alkali activation of by-products favors the dissolution of particles by the creation of a highly alkaline environment. This process leads to their dissolution and recombination in alternative reaction products, characterizing the matrix of the binder. Depending on the strength of the matrix as well and on the efficiency of binding harmful compounds, the BA can be used as partial or total replacement of concrete constituents. This will reduce the use of cement as building material, decreasing consequently also the environmental impact related to it.

On the other hand, this study evaluates the application of BA as lightweight aggregates, by implementing it in a pelletization process. This process involves the use of an inclined rotating pan and it is mainly used for the size enlargement of granules. Initial parameters, such as the optimal particle size and morphology of the pelletized aggregates, is modelled in function of their crushing value, strength in mortars and leaching behaviour. Once pelletized, the improvement of the aggregates is performed by curing the material in autoclave. Steam curing is a thermal curing mainly applied to accelerate the strength development of cementitious products [14]. The increasing pressure leads to a reduction in the voids content, and thus higher strength values [15]. Variables as curing time, pressure and temperature are modelled in relation with the reaction products and the performances of the manufactured pellets (mechanical and chemical). The production of aggregates by this methodology can improve the initial properties of the BA aggregates produced, such as crushing value and open porosity, but also enhance the thermal performances of concrete if applied in combination with cement paste.

Moreover, possible treatments to enhance the final concrete properties are evaluated. Many studies applied the so-called "impregnation" treatment, a surface coating technique based on the application of polymers (such as epoxy resin) but also pozzolans on the surface of recycled concrete aggregates. However, this treatment has never been applied on incineration residues, such as BA. This methodology involves pre-soaking dry aggregates in the oven with a solution of micro-

Figure 2. Possible application of BA as secondary building material

particles and drying them again before their application in concrete. The main beneficial effects achieved by this treatment are threefold: (i) the surface of the porous aggregates is smoother, enhancing the roundness of the particles; (ii) filling the pores of the particles results in a lower water absorption [16] and (iii) the presence of surface particles available for reaction increases the amount of reaction products improving the aggregate-matrix transition zone [17]–[19].

CONCLUSIONS

The application of BA as secondary building material has always been a challenge. In spite of its many disadvantageous properties, the recovery of this by-product is nowadays necessary to ensure a higher quality of life to future generations. Despite the specific investigation concerning this topic, the project can be inserted in a wider background where the reuse of by-products provides a higher quality of life. By the removal of landfilling sites, the leaching of contaminants in groundwater can be limited, contributing to reducing the pollution of water sources and, thus, the sea. Furthermore, the absence of landfilling sites will enable the reuse of lands for different purposes, such as dwellings, schools or infrastructure, due to the higher availability of space.

The alternative applications of BA will ensure a smart living environment, where the waste produced is not useless,but becomes the brick for our future cities. ■

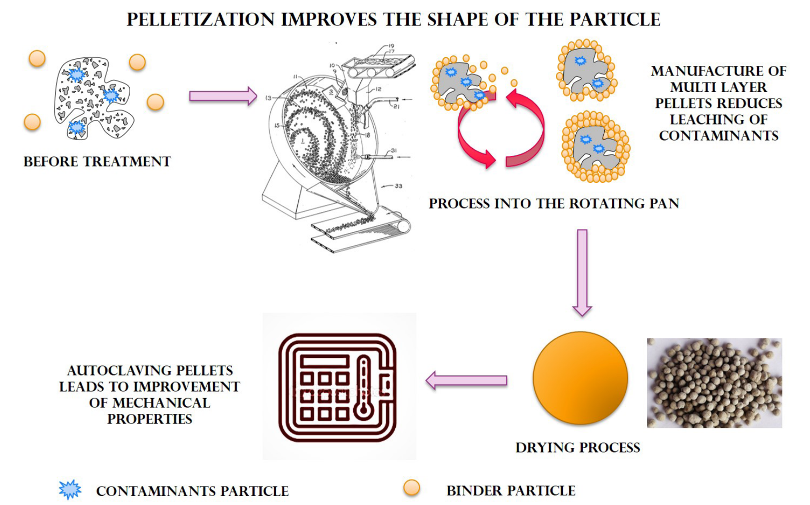

Figure 3. Pellettization process of bottom ash and autoclaving procedure, to enhance mechanical and leaching properties

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Noise screen performance

Author
L. (Lenny) Mennen

Supervisor
Dr. ir. M.C.J. (Maarten) Hornikx

INTRODUCTION

Traffic noise is a well-known problem for people living near highways. Therefore noise screens are placed, which obstruct the sound waves from propagating to receivers and dwellings in its vicinity. However, certain meteorological conditions could refract the sound waves. A downwind, when the sound is propagating in the same direction as the wind, could be disadvantageous because it refracts the sound downwards to the receiver. The same accounts for a positive temperature stratification, where the temperature of the atmospheric boundary layer increases over height. Upwind and a negative temperature stratification have the exact opposite effect [1].

The purpose of this research was to investigate the influence of certain meteorological conditions on the performance of a noise screen.

METHOD

Three wind conditions are researched: a mean downwind, a mean upwind, and a turbulent upwind flow. The wind data is obtained from an earlier research [2], and the wind speed is in every situation 3 m/s. From this wind data three different Richardson numbers (Ri) are provided and can be used, expressing the thermal process of the boundary layer. There is a neutral boundary layer (Ri=0.000) with the absence of a thermal process, and two stable boundary layers with a positive temperature stratification (Ri=0.098, Ri=0.147). The highest Richardson number expresses the most stable boundary layer. The calculations are done in Matlab, all calculated variants can be seen in table 1. To find the effect of the different meteorological conditions their excess attenuation (EA) is evaluated on a broadband scale over a distance of 0 to 150 meters behind the source. To obtain the EA, the researched variants are always subtracted by a reference situation without wind and with a screen. The sound spectrum of traffic is used following the CNOSSOS model [3].

Table 1. Calculated variants

	No wind		Mean wind field		Turbulent wind field
			Downwind	*Upwind*	*Upwind*
	No screen	*Screen*	*Screen*	*Screen*	*Screen*
	Ref1	Ref2			
BL0 Ri = 0.000			MD-BL0	MU-BL0	TU-BL0
BL1 Ri = 0.098			MD-BL1	MU-BL1	TU-BL1
BL2 Ri = 0.147			MD-BL2	MU-BL2	TU-BL2

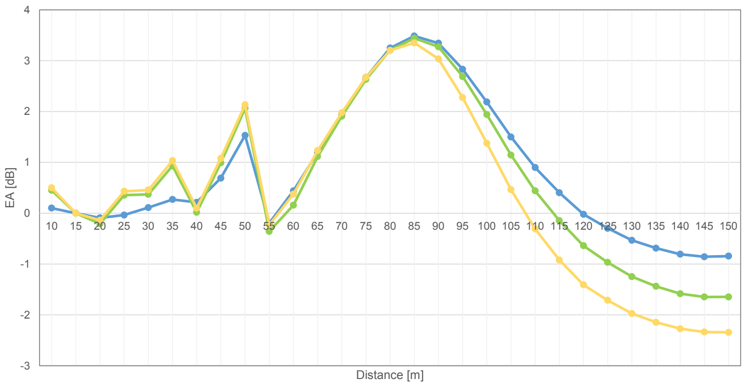

Figure 1: Broadband EA over distance mean downwind situation, y=1.5 m

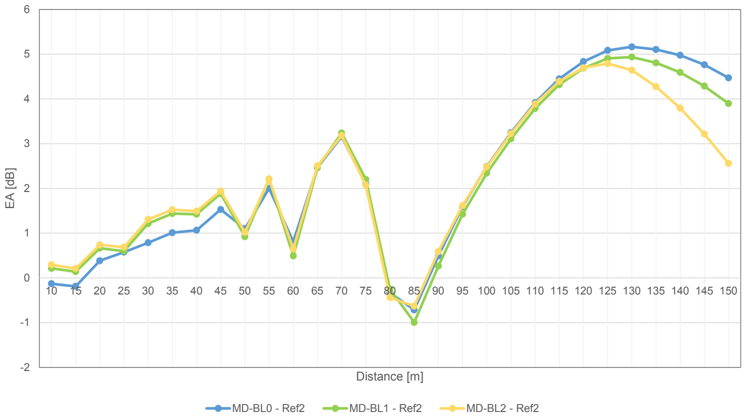

Figure 2: Broadband EA over distance mean downwind situation, y=4 m

RESULTS

In figure 1 and 2 the broadband EA for the mean downwind situation can be seen, at a receiver height of 1.5 meters and 4 meters respectively.

Figure 3 shows the broadband EA for the mean upwind situation at a receiver height of 1.5 meters.

In figure 4 the mean upwind and turbulent upwind situation at a receiver height of 4 meters are plotted in the same figure to clearly show the differences.

CONCLUSIONS

It is found that the wind effect increases over height for the downwind situation and over distance for all variants. The effect of temperature stratification becomes more evident when there is upwind. Especially when it also contains turbulence, which is suppressed under the influence of temperature stratification. However, over distance the influence of turbulence seems to increase.

The most outstanding improvement of the noise screen of almost 8 dB occurs for the mean upwind situation with a neutral boundary layer at a receiver height of 1.5 meters, and the most outstanding deterioration of the noise screen of 5 dB occurs for the mean downwind situation for all boundary layers at a receiver height of 4 meters. ■

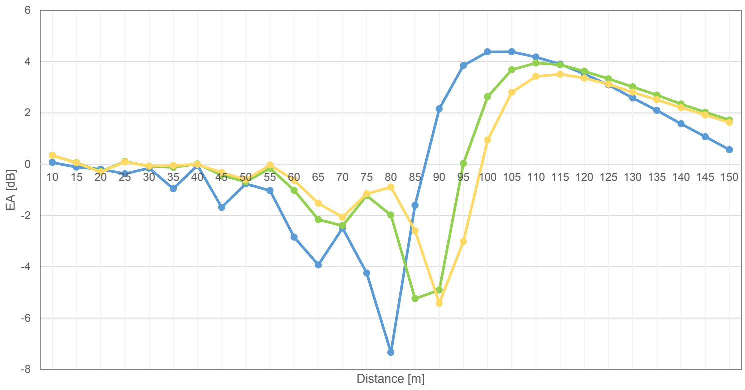

Figure 3: Broadband EA over distance mean upwind situation, y=1.5 m

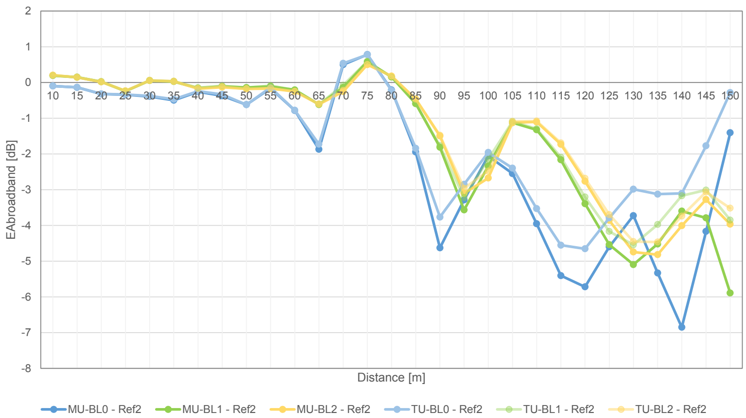

Figure 4: Broadband EA over distance mean and turbulent upwind situation, y=4 m

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Five step method towards energy flexibility

Author
prof. ir. W. (Wim) Zeiler
Professor Building Services

Building industry has agreed with the Dutch government on a further tightening of the requirements in the near future, in order to move towards nZEB in 2018 (governmental buildings) and 2020 (all other buildings). However, at the moment the Dutch offices have a relatively high energy consumption of in total around 225 PJ/year, compared to around 370 PJ/year for households. More important, the energy consumption of office buildings are increasing slightly, see Fig. 1, despite the 2020 targets.

Traditionally, the potential for nZEBs in the Netherlands was mainly determined by the possible applications of building energy reduction measures according to the Trias Energetica method, see Fig. 2. An adapted version of the Trias Energetica method could be used in the future adding the integration of user behavior as well as energy exchange and storage systems (smart grids). Especially these possibilities become crucially important for nZEB because of the intermittent characteristics of most renewable energy sources. Energy exchange has great potential for reducing energy demand, especially when buildings with a specific heat or cold demand are combined (e.g. nursing homes, ICT data centers, swimming pools or other sports facilities like ice rinks). Coping with complex and unpredictable factors related to Decentralized Renewable Energy Source (DRES) and the grid requires a more flexible approach to process control that is increasingly bottom up rather than top down. As a result the influence of the building's design and its users' interactions becomes more important. Buildings, building services systems and energy infrastructure must be designed for more flexibility.

It is widely recognized that increasing flexibility is key for the reliable operation of future power systems with very high penetration levels of DRES. In general two kinds of flexibilities can be distinguished in energy infrastructures:

- Architectural, enables to modify configurations of the system to future uncertainty
- Operational, which allows energy modification of operating strategies without major changes

Performance results for operation of thermal comfort systems in demand side flexibility modes (that is cooling air temperature set point reset mode and fixed cooling schedule mode) indicate that improvements are needed for both models in efforts towards unitary performance metrics that capture both demand side (buildings) and power network side (grid). Specifically, availability window concept energy delivery during power flexibility periods, ramp rates and ramp duration come out as important just like power flexibility potential. Clearly the energy demand characteristics of buildings, available from Building Energy Management Systems (BEMS), are very valuable information on flexibility for grid optimization. Smart control of energy consumption and generation inside (nanoGrid) and around buildings (microGrid) can provide major flexibility contributions to address the imminent energy problems within the total energy infrastructure, the Smart Grid (SG).

However, at the moment this building flexibility on building level is still to be defined. The new IEA Annex 67 has just started their work to define this specific building energy flexibility: its ability to manage energy demand and generation according to local climatic conditions, occupant needs and energy grid requirements. To cope with the total complexity a functional layered approach is proposed, see Fig. 3.

Breakthroughs need to be realized in the field of flexibility necessary for demand and distribution process control of heat, cold and electricity. The responsiveness of Smart Grid to changing uncertainties & requirements can be partly realized through the intrinsic flexibility measures embedded in energy infrastructures of buildings. With the advent of distributed and dispersed loads in the grid, a top-down approach is no longer feasible and has to be replaced by a more distributed approach. There is a need to take a more holistic approach to system flexibility, which looks at the potential interactions between new and traditional sources of flexibility and how these sources are used by different parties. New integral approaches are needed to increase the buildings' flexibility towards the Smart Grid. ■

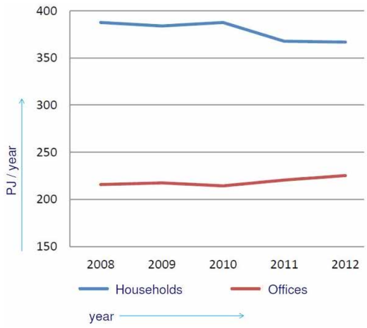


Figure 1. The total energy use for offices and for households

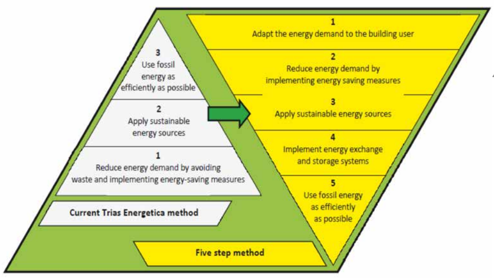


Figure 2. The Trias Energetica method and the Five step method

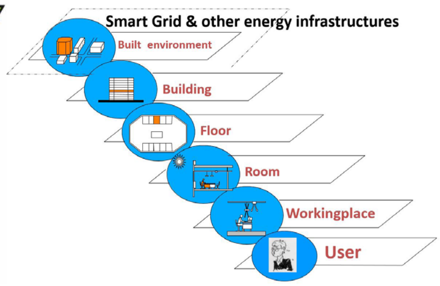
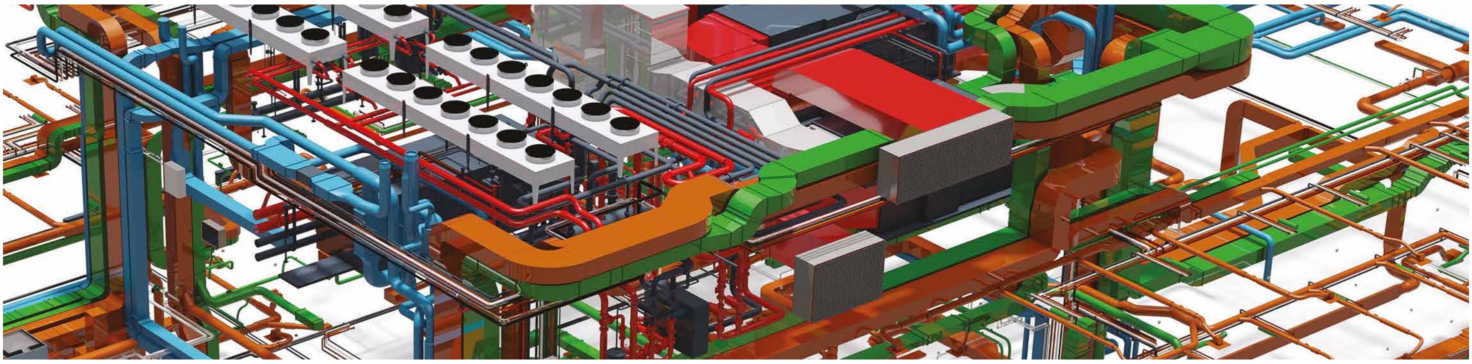
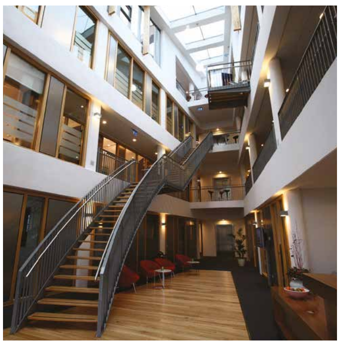


Figure 3. IEA Annex 67 Energy Flexible Buildings proposed fuctional layered approach


Bouw
Ruimte
Milieu





Lungs of the city of Eindhoven

Author
R. (Rob) Vervoort

Supervisors:
prof. dr. ir. B. (Bert) Blocken (TU/e)
dr. ir. T. (Twan) van Hooff (TU/e)
dr. ir. R. (Roel) Gijsbers (ENS)

THE EFFECTS OF PARTICULATE MATTER EXPOSURE

The collection of all solid and liquid particles suspended in the atmosphere, known as particulate matter (PM), currently is one of the most dangerous forms of air pollution. According to the World Health Organization (WHO), daily and long-term exposure to PM is strongly connected to human morbidity and mortality [1]. Furthermore, these health effects are related to the size of the inhaled particles. The largest particles can be filtered by the nose and throat. However, particles smaller than 10 μm (PM_{10}) can enter the bronchi and lungs. Moreover, particles smaller than 100 nm ($PM_{0.1}$) can directly be transported into the bloodstream. For this reason these particles can enter the brain and other organs. For this reason studies have shown that there is a direct link to respiratory, cardiovascular and cardiopulmonary diseases including lung cancer [2]. Furthermore, the studies show that the life expectancy is significantly reduced due to exposure to $PM_{2.5}$. In the most polluted cities in the WHO region, the average life expectancy can be increased by approximately 20 months when the long-term $PM_{2.5}$ concentrations are reduced to the limit of 10 μg/m³ [2]. Given that good health and a long life are highly valued in society, analysis shows that economic costs of air pollution are significant [3].

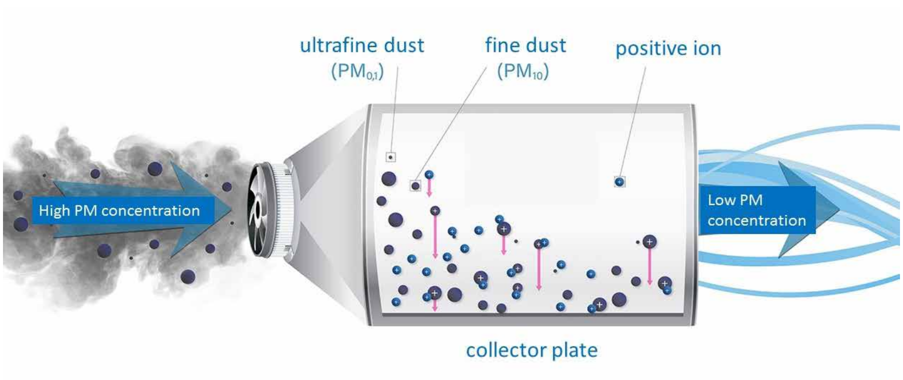


Figure 1. Positive ionization unit ENS [8]

The complex mixture of dust in air consists out of both organic and inorganic particles, such as dust, pollen, soot and smoke. The particles can have a wide range in size, composition, and origin. Particles in air can be directly emitted, for example when fuel is burnt and when dust is carried by wind, but also indirectly formed, when pollution gasses previously emitted to air are transformed into particulate matter. In the Netherlands, PM_{10} on average consists of 75 up to 80 percent of anthropogenic (produced by human activity) elements, while for $PM_{2.5}$ this percentage is approximately 10 percent higher [4].

PM limits are defined very strictly by the WHO. However, it is important to keep in mind that epidemiological studies on large populations still have been unable to identify a certain threshold concentration below which ambient PM has no effect on health [3]. It is very likely that in the human

Figure 2. Left: positive ionization unit ENS installed in a parking garage in Cuijk. Right: collected dust parking garage Cuijk [8]

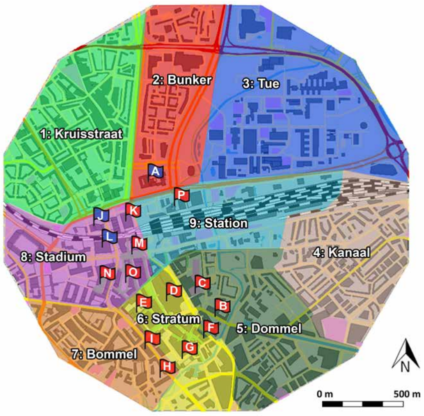


Figure 3. Location of the 16 semi-enclosed parking garages A to P in the city center of Eindhoven

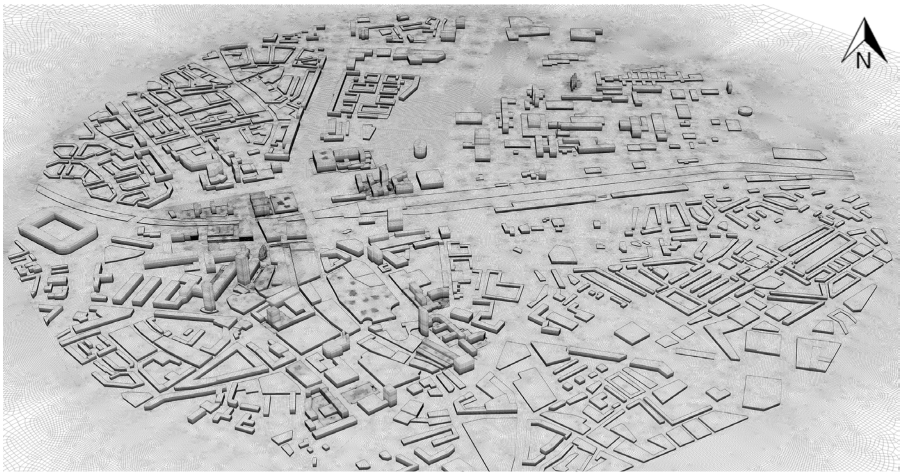


Figure 4. Overview of the computational grid of the city center of Eindhoven (65.7 x 10^6 cells)

population, there is a wide range in susceptibility. Therefore, for some humans negative health can occur while only being opposed to small concentrations of PM. Exposure to high concentrations of PM does not only occur outside but also inside buildings. For this reason PM exposure is a very serious problem, putting health at risk.

PM PURIFICATION

Various solutions are available to limit PM emission. Some examples are porous media filters, cyclonic separators, wet scrubbers and electrostatic precipitators (ESP). Due to high local traffic intensities in cities, high concentrations of PM are measured as a result of tire wear, tailpipe emissions and braking wear [5]. These concentrations are mainly dependent on traffic intensity, meteorological conditions and urban geometry. Logically high local concentrations of PM can be found in parking garages [6-7].

These high concentrations of PM can be reduced with the use of the previously described techniques. ENS (Environmental Nano Solutions) [8] is a manufacturer of efficient electrostatic precipitators. Positive ionization is used to remove ambient PM from the air. PM particles are charged due to ionization process and subsequently the particles are collected on a grounded plate where agglomerates of particles are formed which are not airborne thus not inhalable (Figure 2). This principle is shown in Figure 1. Two of these units are currently applied in a parking garage in Cuijk (Figure 2).

Measurements are performed to obtain insight into the effects of the installed units. PM_{10} reductions up to 84% are measured inside the garage. Moreover significant reductions (exceeding 60%) are found in the stores in the surrounding [9]. This raised the question if is it possible to purify the air in a city when applying ESPs on a large scale in parking garages, thus function as 'lungs of the city'. For this purpose a virtual case study for the city center of Eindhoven, where ESPs are included in 16 parking garages, is setup. ANSYS Fluent is used to perform Computational Fluid Dynamics (CFD) simulations. The study provides a preliminary indication of the PM10 reduction potential for a specific set of boundary conditions. ESPs with a collection efficiency of 70% at a volume flow rate of 9,000 m^3/h are applied (in accordance with the specifications provided by ENS).

CFD MODEL EINDHOVEN CITY CENTER

The city center of Eindhoven is characterized by a mixture of commercial and residential buildings, which are mainly low-rise buildings with only a few high-rise buildings. Figure 3 shows the location of the 16 semi-enclosed parking garages (labels A to P) which are included in the simulations. The area of interest covers an area of approximately 5.1 km^2.

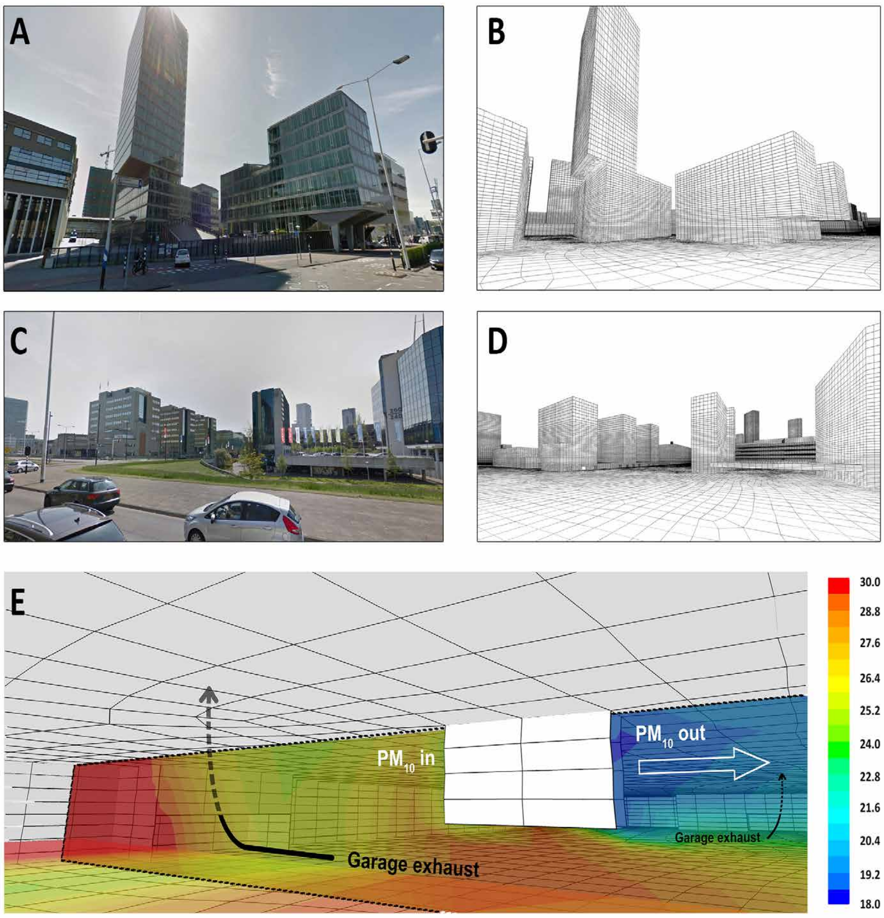


Figure 5. (a-d) Detailed images of some parts of the computational domain. (e) Detail of the computational grid and ESP unit inside an underground parking garage G. Contours are PM_{10} concentrations in µg/m^3

A computational grid of the city center of Eindhoven, consisting of 65.7 x 10^6 cells, is generated. The grid that is used for the present case study is an edited version of the grid created by Papadopoulos [10]. Due to the chosen generation method the quality and resolution of the grid are high. The available best practice guidelines are satisfied to the largest extent. In Figure 4 and 5, images of the computational grid are shown. Figure 5a-d includes more detailed images of some parts of the computational domain while Figure 5e provides a view inside of the semi-enclosed garages (garage G in Figure 3).

To determine the sources of PM_{10} in the model, traffic intensity, traffic emission data, parking garage use and background PM_{10} concentrations are considered. Terrain roughness is taken into account by assigning the correct aerodynamic roughness height, equivalent sand-grain roughness height and roughness constant to the wall surfaces. PM_{10} traffic emissions are uniformly distributed over the volumes between buildings for each of the colored subdomains, as presented in Figure 4. The source terms is assigned to a volume with a height from 0 to 1.5 m. The logarithmic law is used to determine the velocity profile, with a reference wind speed of 1 m/s at a height of 10 m and south-east direction, at the inlet of the computational domain. Thermal effects are not taken into account. Three different cases are modeled in the study: a reference case including 0 units, a case including one unit per 65 parking spots (99 units total) and a case including six units per 65 parking spots (594 units total) over 16 parking garages. Interaction of air between the garages and the streets is ensured by assigning a fixed velocity to the garage outlets. The required ventilation is calculated based on the Dutch building regulations (10.8 m^3/m^2h) [11].

In this study, steady Reynolds-Averaged Navier-Stokes (RANS) in combination with the realizable k-ε turbulence model is used for turbulence closure. This specific model is used due to the fact that it has shown a good performance for wind flow around buildings and provides a good agreement with full-scale measurements in urban environments. Standard wall functions are used to model the near-wall region. For PM dispersion, the advection-diffusion equation is solved with the standard gradient-diffusion hypothesis. Second-order upwind schemes are used for the numerical approximation of momentum, species, turbulent kinetic energy and turbulent dissipation rate. For the pressure, the standard interpolation scheme is used. The SIMPLEC scheme is used for pressure-velocity coupling.

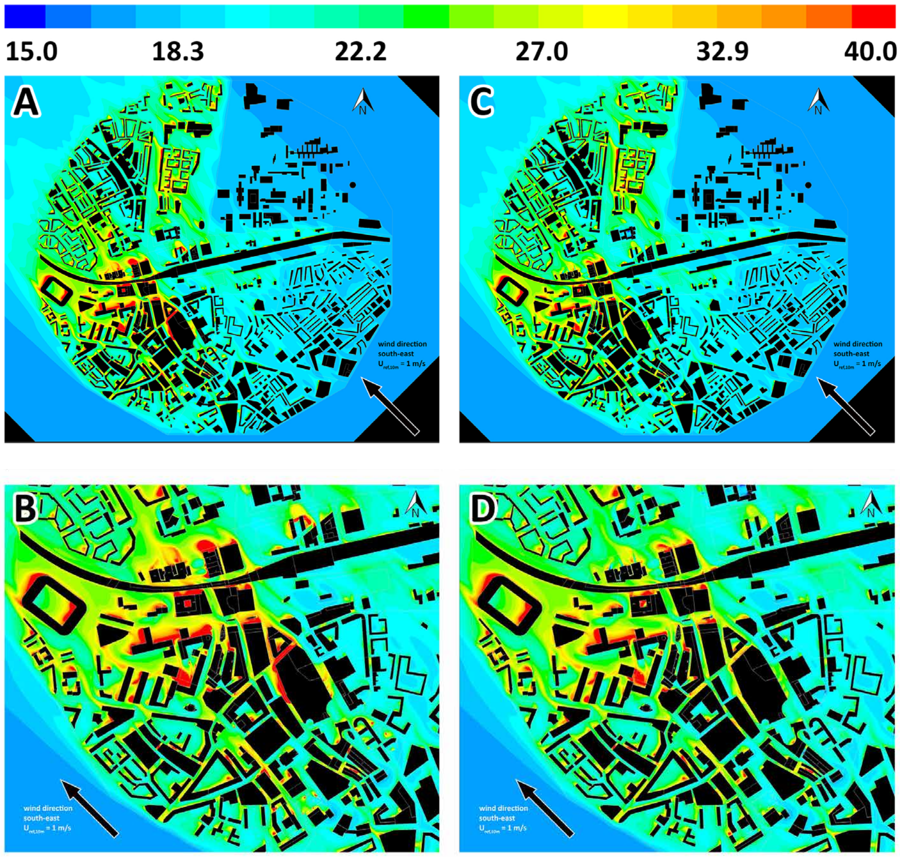


Figure 6. Contours of PM_{10} concentrations (μg/m^3) in a horizontal plane at 1.75 m height without ESPs (a-b) and including 594 ESPs (c-d) installed over 16 parking garages in the city center of Eindhoven

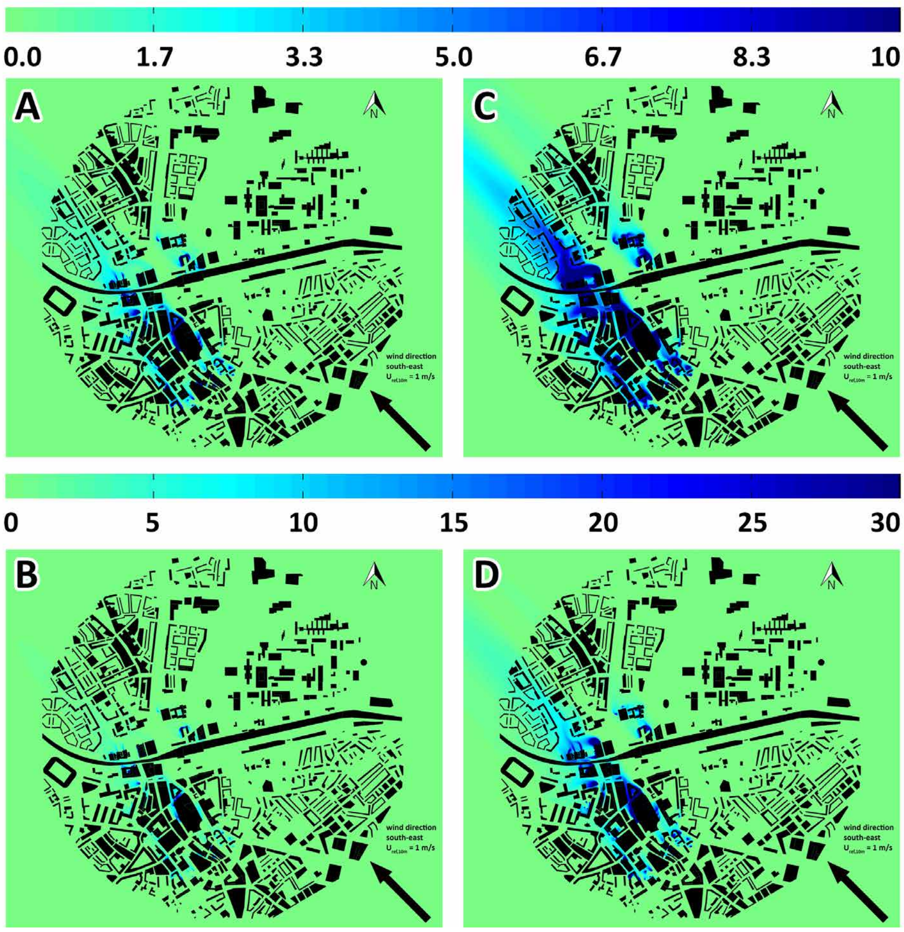


Figure 7. PM_{10} concentration reduction at a height of 1.75 m for the case with 99 ESPs (a-b) and 594 ESPs (c-d) relative to the reference case without units

The results of the case study are carefully validated using wind tunnel measurements of gas dispersion in regular arrays of rectangular building blocks by Garbero et al. [12]. The validation study is performed to provide an indication of the physical modeling uncertainty and to determine the computational parameters and settings case study of Eindhoven.

CASE STUDY RESULTS

In Figure 6 the PM10 concentration contours at a height of 1.75 m (pedestrian level) are shown for the reference case without ESPs (Figure 7a-b) and for the case including 594 ESPs (Figure 7c-d). Figures 7b-d provide an overview in the region where most of the parking garages are located and where the urban density is relatively high. The concentrations exceed 50 μg/m^3 but in this case the limit is set at 40 μg/m^3. Due to the chosen set of boundary conditions, the maximum concentrations are rather limited. All the emissions are uniformly distributed over each of the nine subdomains and the emissions are averaged over a period of 10 hours. It can be expected that during rush hours local concentrations are higher. In the figures it is clear that PM10 is accumulated inside the parking garages, relatively high concentrations are found near the exhaust openings. Due to the fact that the parking garages are concentrated in the southwestern region of the explicitly modelled domain, high PM10 concentrations are modelled in this region. Furthermore, in this region the urban density is relatively high resulting in relatively low wind velocities.

As visible in Figure 7a-d, PM10 concentrations are significantly reduced in the garages and in the exhaust flow. Furthermore, reductions are found further downstream of the garages at the edge of the domain in which buildings are modeled explicitly.

In Figure 7, the PM10 concentration reductions at a height of 1.75 m (pedestrian level) are shown relative to the reference case. Figure 7a-b presents the results for the case including 99 ESPs and Figure 7c-d presents the results for the case including 594 ESPs. For the case including 99 ESPs, reductions up to 10% are found near the garage. Further away from the garages the reductions are insignificant. For the case including 594 ESPs reductions up to 30% are found near the garages (very locally even up to 50%). Further away from the garages reductions of 5 up to 10% are found.

DISCUSSION AND CONCLUSIONS

In this study, the outdoor PM concentration reduction potential, by local removal by positive ionization units (produced by ENS) inside parking garages, is assessed. Although the current study has some limitations, it can be concluded that local removal in semi-enclosed parking garages can be an effective strategy towards improved outdoor air quality. Future research will focus on the limitations of the current study. First of all, unequal spreading of the traffic intensity (and resulting traffic emissions) over the domain should be taken into account. Furthermore unequal spreading of the traffic intensity should be taken into account (e.g. unsteady RANS simulations). Furthermore, thermal effects can be included. In this way, the dispersion of emissions can be taken into account in a more accurate way and different pollution situations can be modeled. Finally, aerosol dynamics, such as deposition of PM, can be included.

FURTHER INFORMATION CAN BE FOUND IN THE (OPEN ACCESS) ARTICLE

Blocken B, Vervoort R, van Hooff T. 2016. Reduction of outdoor particulate matter concentrations by local removal in semi-enclosed parking garages: a preliminary case study for Eindhoven city center. Journal of Wind Engineering and Industrial Aerodynamics 159: 80-98. ■

PARTNER

ENS
Environmental Nano Solutions

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The Amazing Lunch Club

Building Physics and Services has a lot of small communities. Besides the never-ending job of gaining knowledge, it is also very important to maintain hobbies and social contacts, for example in the form of: food!

In the group of Building Performance foreign PhD candidates could not get used to brown bread with cheese for lunch "We are not overwhelmed by two slices of bread with a slice of cheese". So around December 2015 two PhD candidates (Isabella and Luyi) from the Building Performance group took the initiative to take their native food with them to the TUE and introduce some fine cuisine in Vertigo.

What started with two people has become a group of about seven people that gathers five times a week and regularly entertain and feed guests and colleagues. Especially, Dutch colleagues seem to have a soft spot for the daily desserts!.

The concept is that the previous evening one of the group cooks a characteristic dish from their own country. Around noon the group gathers at the pantry on floor 6 where the beforehand prepared food is heated. When the food is done, they go to Plaza where they will enjoy a nice warm meal and sometimes a special dessert. They try to alternate the continents so there is a balanced diversity of food every week.

During their lunch the PhD candidates sometimes discuss their research projects and how to tackle some of their problems. However they mostly talk about the recipes of the meal of the day, which also could be found at their own website.

The INSide committee was lucky enough to be invited by The AmazingLunchClub to get to know all the nice people and their delicious dishes. When we arrived we heard; "You're lucky, because Luyi has cooked today" so we were eager to get started. The food was wonderful: Chinese rice with curry and spinach.

During lunch there was animated talk about everything, but mostly about food: how good it is, how it is made, what is eaten tomorrow and so on. Lunch ended with vermecelli with coconut and nuts from India and of course a few Dutch colleagues happened to be "in the neighbourhood" to get a taste of the delicious dessert.

The INside committee wants to thank The AmazingLunchClub for their warm welcome and delicious food. Despite this, we will keep eating brown bread in the future to prevent after-dinner-dips during classes after lunchtime. ■

CORE MEMBERS:

- Isabella Gaetani
- Hemshikha Saini
- Luyi Xu
- Marie de Klijn
- Rajesh Kotireddy
- Rongling Li
- Vojtech Zavrel

WEBSITE:
https://amazinglunchclub.wordpress.com/

ENGIE bestaat in Nederland uit ENGIE Energie, ENGIE Services, ENGIE E&P, ENGIE Fabricom en ENGIE Laborelec. Wij zijn het bedrijf dat voorop loopt in de energietransitie en dat, dankzij innovatieve en duurzame energieoplossingen, de energietransitie ook echt waarmaakt. Wij geven richting aan deze verandering en helpen klanten (bedrijven, instellingen en consumenten) om de stap van een fossiele naar een 100% duurzame energiehuishouding, en tevens de beweging naar decentralisatie, zo snel en zo kostenefficiënt mogelijk te maken.

ENGIE telt wereldwijd 154.950 medewerkers en boekte in 2015 een omzet van 69,9 miljard euro. In Nederland werken circa 6200 medewerkers.

ENGIE Services is Europees marktleider op het gebied van duurzame technologische oplossingen voor energie en milieu. Hierdoor kan de klant zich volledig concentreren op de realisatie van de eigen doelstellingen. Wij doen dit met innovatieve concepten en integrale, duurzame oplossingen. Onze efficiënte en effectieve toepassingen in technologieën verbinden wij met vakkennis in financiële, proces- en beheersmatige aspecten van het werk dat wij uitvoeren voor onze klanten. Of dat nu gaat over nieuwbouw, onderhoud en beheer en services.

Onze specialisten hebben een passie voor techniek en zitten vaak al in de conceptfase bij de klant aan tafel. Naast het ontwerp en het realiseren van de technische installaties, beheren en onderhouden we als geen ander de installaties van onze klanten: het totaalpakket is bij ENGIE in goede handen.

Markante projecten zijn hiervan het resultaat: de warmte/koudeopslag op het Oosterdokeiland in Amsterdam, de aanleg en het onderhoud van de installaties in de Beneluxtunnel, en de bekabeling van baggerschip Vos Maxima. Wij werken voor allerlei klanten zoals; Heineken, Schiphol, Shell en Rijkswaterstaat. Geen dag is hetzelfde – dat is typisch ENGIE. Samen werken we met plezier aan het eindresultaat en daarbij aan het behoud van onze klanten.

ENGIE. Ver vooruit in duurzame technologie

Ice Breaker

Author
S. (Sultan) Çetin Öztürk

Hi! I am Sultan. I am from Ankara, the capital city of Turkey. I was born and grew up in there. I had a great childhood with my twin brother in a small neighborhood surrounded by our relatives. Luckily, our generation was able to play on the street, learn from previous generations, nature and books. Due to limited possibilities, we would create games out of abandoned materials. This, definitely, impacted upon my creative skills at architecture school.

Figure 2. EYE Film Museum

After completing high school, I moved to another city called Eskisehir, which is very similar to Tilburg in size and population. Eskisehir is one of the modern cities in central Turkey where you can find various cultural events, enjoy pretty canals and have a lot of fun! I started studying civil engineering in 2005, and architecture in 2007. I completed both programs by 2011 and began my career.

I started working at a famous architecture studio for 6 months in Turkey. Then I moved to another job which was extremely challenging. This role was in Russia and required strong personality to manage a team consisting of five technical staff. When you grow in your field, more responsibilities would follow. My last role before coming to the Netherlands was in Azerbaijan at Trump Tower Hotel Project. I worked for a British company as a Design Manager and coordinated the design team on site with other engineering groups. The responsibility that I took at this project was yuuuuge, as I was reporting to Trump Hotel Management too.

Figure 1. Ivanka Trump's site visit

Why the Netherlands? After working for almost 5 years, I realized that I am not adding any value to society, to environment and to future. Especially, witnessing wrong applications that leads to wasting materials on site and poor sustainable design approach in the industry, made me feel guilty and I grew a strong desire to change this. The change must start with yourself and the best way to do it is 'education'. Doing masters was always in my mind. But, where? I focused on searching universities in Europe. Dutch universities were on the top of my list.

I had visited Tilburg, Amsterdam and Rotterdam before I applied to TU/e. Back then, I found Dutch people very friendly, and Dutch cities very beautiful! My very favorite thing in the Netherlands is the transportation system. I hate driving. So, I feel like I am in heaven :) I can cycle everywhere! I love trains too. Buying a cup of coffee at the station and enjoying it while watching an amazing landscape through the window is something that I would never change with something else. I am interested in cinema and music. The Netherlands seems like a perfect place for music and film festivals. North Sea Jazz Festival, Transition Jazz Festival in Utrecht, World Cinema Amsterdam, Rode Tulp Film Festival are my favorites so far. Moreover, Rialto and Eye Film Museum are the places that I find very appealing.

Being a Turk in The Netherlands: No other country but Turkey has a unique history with The Netherlands. Since 1960's, The Netherlands received thousands of Turkish labors and it led to emergence of Turkish neighborhoods, as well as an interesting Turkish culture in Dutch cities. When I listen to Dutch radios, I always catch the words on the news: 'Turkije', 'Erdogan', or I see Turkish brands in the supermarkets proving that Turkey is a part of this nation. This is very surprising for me though! Sometimes I feel very strange when people say that I don't look like Turkish. Somehow Dutch people have a Turkish stereotype in their mind that I don't fit in. Well, I do look like Turkish :) There are millions of modern Turks also who are secular, democrat, liberal, gay, or non-Muslim.

Finally, I can see that Dutch people do care about new ideas and innovations. They are great traders. I feel like I can improve myself not only technically, also in business aspects and in realizing new ideas too. The slogan of TU/e proves it: 'Where innovation starts'. I am definitely in the right place! ■

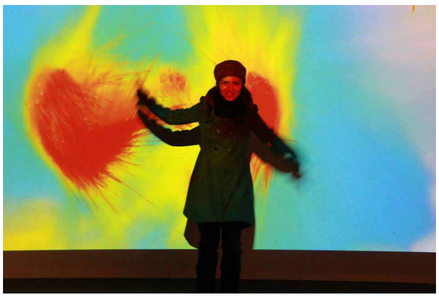


Figure 3. Exhibition at the EYE Film Museum

Decision-making in building design

Author
J. (Jan) van Hout
S. (Sander) ter Mors (MSc)

Bedrijf
Van Hout adviseurs en installateurs

When renovating or designing a building there are a lot of options. Even when you make a selection for parameters which influence the energy demand and energy use of a building a long list remains. Each individual aspect requires attention in the design, but it is not possible to fully design, engineer and calculate every option because there simply isn't enough time or money available. For early stage decision making, you don't need to know every detail. Knowing what you need to know is important..

Figure 2: Quiz (without all necessary information)

WHY WE NEED BETTER DESIGNS

We all know the importance and necessity of energy-efficiency in the global warming. Following the Trias Energetica and lowering energy demand, using sustainable sources and increasing efficiency all lowers your energy use. A lower energy use means lower CO2 emissions and lower energy costs. We believe that if you make the correct design and calculations, sustainable is ALWAYS more valuable / profitable than conventional. But how do you achieve this design and ground this statement?

WHAT DO WE NEED TO KNOW

There are a lot of factors which influence the energy use of a building, with aspects such as insulation values, building orientation, glass surfaces, climate installations, ventilation and lighting but also perhaps most importantly the building user and activities that will take place in the building. How do you start to compare and combine all of your design options? For engineers, the first step is usually to analyse which options are technically feasible. This is a very important step which is almost never forgotten. And during a study at a Technical University, this should be the focus of your studies. But there are other aspects which are at least as important, which can be summarised in two words: CAPEX and OPEX. CAPital EXpenditures and OPerational EXpenditures. You need to know the investments and benefits for all options. In this case benefits can be fuel savings, savings on maintenance and operational costs and possibly subsidies. All for a certain period of time, which can be the technical lifetime of components or the duration of a lease agreement.

Figure 1: CO2 emission = Energy = Money

BE SMART(ER)

As was mentioned before, time is usually a limiting factor in the design process. Engineering and calculating to determine the CAPEX, OPEX and technical feasibility can be very time consuming. Simplification of your calculations is a very effective way to decrease the lead time of your design, which is necessary if you want to investigate multiple variants. For this you can keep in mind the simple Pareto principle that 80% of the output is determined by 20% of input. Of course you need to know the right 20% and it is very important that the remaining 80% of input is engineered correctly, otherwise the system won't work as designed. You need quality control.

An example of simplification in engineering; For a bivalent heating system, where you have a base load and peak load heating system, you ideally need to measure or simulate your hourly heating demand for a full year to determine which part of heating demand can be met by your base load system. This can be simplified by using the β factor from NEN 7120 [1], chapter 14.6.3 This gives an indication that with 30% of peak heating capacity, you can deliver 79% of yearly heating demand for an average office building. Sizing your preferent heating system capacity at this 30% often gives the best results in financial terms; it is a good trade-off between OPEX and CAPEX.

DECISION TIME

When you have created all of the different variants for your building design, you still have to determine which is the preferred design. Should you

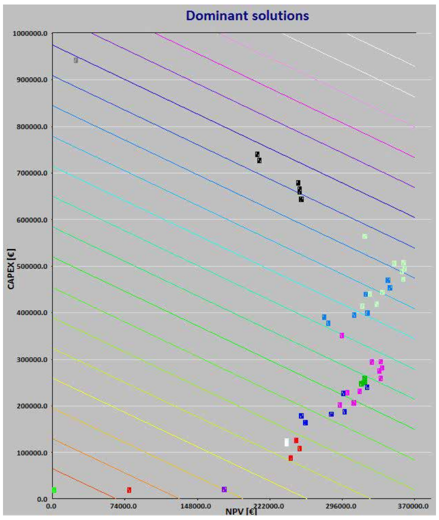


Figure 3: Pareto optimum design options

increase your roof insulation from an Rc of 6,0 m2k/W to 10,0 m2K/W? Or is it better to invest the money this would cost in Photovoltaic panels, efficient HVAC systems or lighting? Or in which order should you take these measures? This is not an easy decision to be made.

Looking only at CAPEX or OPEX is not advisable. At the lowest investment, you probably won't get the best system. For the lowest operational costs, the required investment is probably (too) high. There are various financial indicators to evaluate your options. For the best reliability you should include aspects such as inflation of maintenance and energy costs in your financial analysis.

A very important value in financial analysis is the Net Present Value. This value is a result of discounted cash flow and represents the total value of a project, when compared to a certain given discount rate. It shows the total value of the investments and all future cash flows during the project duration, discounted to today's currency. If this is a positive value, the project has a higher Return On Investment (ROI) than the discount rate. But it also indicates the actual value of savings, so in the NPV you can see, in one value, the total saving potential. The ROI is a useful value itself, but it has the downside that it does not indicate the absolute value of your investment. So a high rate of interest does not necessarily mean high savings.

Another financial indicator which is often used is the Payback period. This is the time it takes to earn back your investment, through the savings you realise. Although it has a cool name, the Payback time is not a very good indicator. It does not tell you anything about the total saving potential of a project and long-term variations in operational costs are not reflected in this value.

TOOLS

This design process includes various calculations, and even with the simplifications it can take a lot of time if you need to evaluate each option and possible combination for your analysis. You want to engineer options for building insulation, renewable energy production, efficient lighting and HVAC systems and compare these based on financial parameters. Preferably all within the same program to decrease time required to generate input and also increase reliability that your compared options all consider the same base design.

A useful tool for this is RETScreen [2], a free to use tool developed by the Canadian government and the UN. With this tool you can perform all these computations and make a financial analysis of your design. This also has sensitivity and risk analysis options, which are very useful to check which variables have a large influence on results. These variables might need extra attention, to make sure there aren't any errors or oversimplifications in these aspects of your design.

At Van Hout we have created the Price Information Model (PIM) building optimisation method. With this software we can combine all these calculations for the built environment, just like in RETScreen, but also automatically generate and optimise design variants. In this program we can model a building, so we know the peak and yearly heating and cooling demand. Based on the building design, user climate demands, HVAC efficiency, and (predicted) user behaviour we can predict the energy use for the base case on a monthly timestep level. In this simplified model, many energy-efficiency techniques can be applied to the building to determine the saving potential. At the same time, this method gives an indication of the required investment for the measures, checks technical feasibility, computes several financial indicators and presents the relevant Pareto Optimum design options in a single chart. When you plot the CAPEX on the y-axis and NPV on the x-axis you can actually also show the (change in) OPEX in diagonal constant lines. In this figure, all options are good choices. The final decision should be made based on your budget, vision and objective/goals.

All of these financial analysis can get quite complicated when also taking into account aspects like planned maintenance, depreciation of components, salvage value at the end of the project and taxes. We'll let the financial experts keep their jobs and mainly stick with the underlying technology, but it's useful to know something about financial analysis. Trust me, I'm an engineer. ■

[1] NEN 7120 Energy performance of buildings Determination method (2011, april)

[2] Government of Canada, "RETScreen | Natural Resources Canada." [Online]. Available: http://www.nrcan.gc.ca/energy/software-tools/7465. [Accessed: 14-Nov-2016].

Audio Event Detection in hospitals

Author
S. (Stijn) Prüst

Supervisors
J. (Jikke) Reinten (MSc)
dr.ir. M.C.J. (Maarten) Hornikx

Speech recognition and Music Information Retrieval have remarkably developed in the last decades and found their way into everyday life. Siri and Shazam are two well-known examples. Audio Event Detection (AED) is, on the other hand, a relatively new field within intelligent audio analysis, and has thus not encountered such great improvements. An AED algorithm tries to automatically distinguish events based on the sound they produce (figure 1).

A vast area of applications of AED is imaginable. Gunshot localization systems have, for example, been deployed in several states in the US [1]. Hearing aids could be improved by assessing the acoustical environment, e.g. crowded vs. non-crowded environments. [2]

Test and training data have to be determined prior to the development of an AED algorithm. The training data consists of exemplary audio files combined with the corresponding labels. The test data only contains audio files, i.e. the labels are to be determined by the AED algorithm. Features of the audio files are then computed. The features provide specific information on the properties of the audio signal. The set of features can roughly be divided in time and frequency describing, e.g. short time energy and subband energy levels respectively. At the core of the AED algorithm is the classifier. The classifier is a part of the AED algorithm that compares features of test and training data. The classifier assigns a label to a test file if it has similar features as a specific event in the training data. This procedure is not exclusively for audio processing, but is applied to many other pattern recognition methods like digital image processing.

The task of recognizing sounds makes one wonder how we humans perceive sounds. No wonder that a lot of techniques are based on the human auditory system. For example, Artificial Neural Networks are one of the more promising techniques to classify sounds by loosely modeling the way the brain processes sensory information. Furthermore, Self Organizing Maps resemble the way auditory information is stored in our brain [3], and psychoacoustic features are often used. The state-of-the-art performance of AED algorithms is close to human performances when it comes to monophonic cases (one sound at a time), but the performance falls drastically when it comes to polyphonic cases (the task of recognizing possibly overlapping sounds)[4].

The goal of my project was to implement an AED algorithm to support the research done by Jikke Reinten. She analyzes the influence of audio events on the cognitive performance of nurses, e.g. footsteps, door slams, and alarms could have negative impact on their performance. The AED algorithm helps to significantly reduce processing time of long audio recordings (order of days). In the end, the algorithm was able to distinguish speech from non-speech events with a precision of approximately 85%, but needs improvements on overall performance.

In general, the most important improvements for future research are enhancements of the training audio data (representing the exact classes to recognize), optimization of feature selection and reduction, and noise reduction. ■

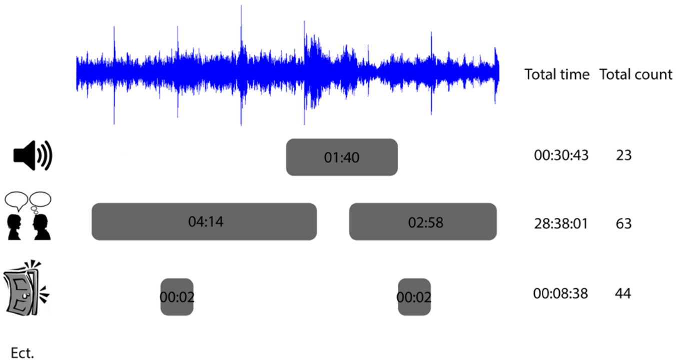


Figure 1. Illustration of the AED algorithm's output

[1] Schlossberg, T. (2015, March 16). New York Police Begin Using ShotSpotter System to Detect Gunshots. The New York Times. Retrieved from http://www.nytimes.com/2015/03/17/nyregion/shotspotter-detection-system-pinpoints-gunshot-locations-and-sends-data-to-the-police.html?_r=1

[2] Alexandre, E., Cuadra, L., Rosa, M., & Lopez-Ferreras, F. (2007). Feature Selection for Sound Classification in Hearing Aids Through Restricted Search Driven by Genetic Algorithms. IEEE Transactions on Audio, Speech and Language Processing, 15(8), 2249-2256. doi:10.1109/tasl.2007.905139

[3] Valero, X., Alias, F., Oldoni, D., & Botteldooren, D. (2012). Support Vector Machines and Self-Organizing Maps for the recognition of sound events in urban soundscapes. Institute of Noise Control Engineering of the USA.

[4] Giannoulis, D., Benetos, E., Stowell, D., Rossignol, M., Lagrange, M., & Plumbley, M. D. (2013). Detection and classification of acoustic scenes and events: An IEEE AASP challenge. 2013 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics. doi:10.1109/waspaa.2013.6701819

The perception & motivation of users on smart grids

Author
I. (Iris) Moonen

Supervisors
dr. R.(Rongling) Li
ir. C.J. (Christian) Finck

INTRODUCTION

There is a mismatch between the moments when the largest amount of renewable energy is generated and the moments when the maximum electricity is needed. If the energy consumption of our homes can be adjusted to match the renewable energy production, the renewable energy can be used more efficiently. This is the main function of the smart grid [1]. The smart grid can send recommendations to the houses about the best time to use smart appliances. The willingness of these users will have an influence on developing the smart grids and on the future implementation of the smart grids. The research question therefor was: What is the perception, motivation and willingness of residential users on smart grids?

METHODOLOGY

A questionnaire was designed, which contains 31 questions. Most questions are in a closed format. A test version of the questionnaire was sent to 10 people. Based on the feedback received, the final version was designed. The questionnaire was then sent to 410 people via email, and 55 responses were received.

RESULTS

Most of the respondents (54.5%) were familiar with the concept of smart grid before the questionnaire, while 38.1% said they didn't know about it. The participants expect to save money by using smart grids, however not much. About 73% of the participants expect to save 20% of their energy bill or less.

Figure 2 and 3 shows the willingness of the participants to follow the messages sent by the utility company to manually control their appliances, and the willingness to let the utility company remotely control their appliances. On average, people are most positive about following recommendations and manually turn on/off smart appliances (55.8%) than about letting an electricity utility remote control their smart appliances (45%). The different smart appliances are comparable to each other for these two questions.

Figure 4 shows the factors that are important to the participants for adopting smart appliances. User friendliness (39 out of 166 responses), level of electricity savings and privacy (both 35 out of 166 responses) are the most important factors, according to the respondents. Most of the respondents (58.5%) said they think the smart grids will influence their lives in a good way, while only 15.1% said they think the smart grid will influence their lives in a bad way.

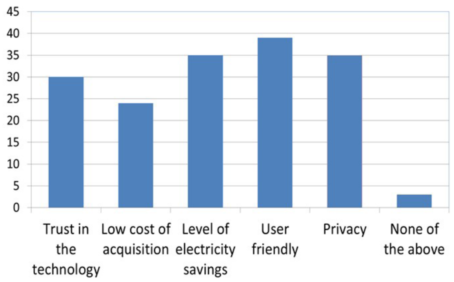


Figure 4. Which of the following factors are important to you for adopting smart appliances?

CONCLUSION

The majority of the participant does not expect more than 20% electricity bill reduction. The most favorable appliances are smart washing machine, smart thermostat and heating, smart dishwasher. Privacy, user friendliness and level of electricity savings are the most important factors for adopting smart appliances. The participants are more enthusiastic about manual control than remote control. Most of the people (about 60%) believe smart grids will change their life in a good way. ■

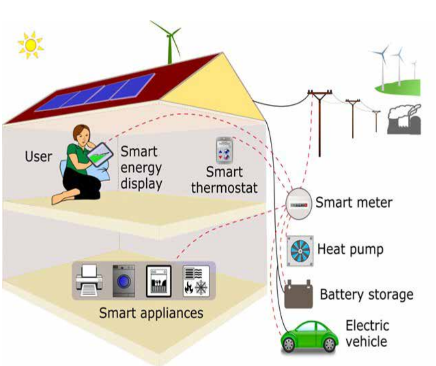


Figure 1. Users, smart house and smart grids [1]

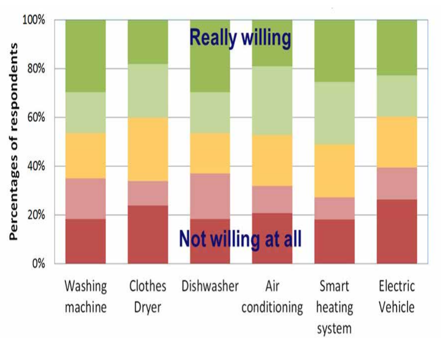


Figure 3. Would you be willing to let your utility company remotely control your appliances?

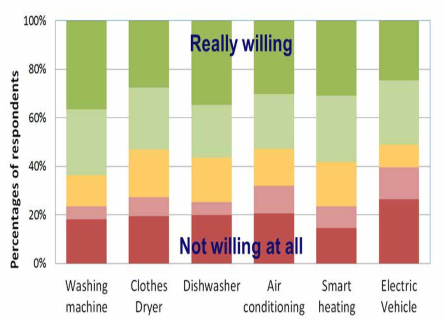


Figure 2. Would you be willing to follow the messaes sent by your utility company to manually control your appliances?

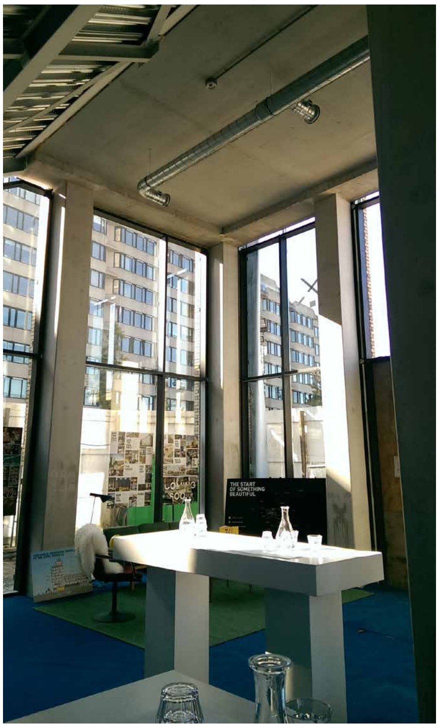
[1] R. Li, Presentation 'Questionnaire stakeholder motivation, March 10 2016

Visitation Student Hotel

Author
W. B. (Wouter) Reijnders

As you may have noticed, the BAM is building a rather large tower next to the Station in Eindhoven. Tuesday the 27th of September the Mollier board was invited to an exclusive preview in the Student Hotel. Due to different reasons they were unable to attend and the honour was bestowed upon me and Xin (secretary for 20th board), I am Wouter by the way (Chairman of the 20th board). With approximately 76 meters the Student Hotel is the 6th tallest tower in Eindhoven. Besides this fun fact it guarantees spectacular views over Eindhoven.

After the presentation at the beginning a short guided tour started. The showcase room was impressive in luxury, 18 m2, two person bed and a desk. The bathroom appeared quite luxurious and well equipped. Daylight was abundant, all rooms have a large window and corner rooms even have two. Based on the materialisation of the room I do not expect any comfort issues other than it being rather small. The fully equipped shared kitchen is easily large enough to provide for eight students. Besides shared kitchens there are also rooms available that have the kitchen included.



Then came the visit to the roof, opened just for us as the access will be closed from now on. Spectacular views over Eindhoven reminded me of how green this country is, it also emphasised the absence of high rise buildings in this city. As icing on the cake we got a virtual reality tour through the hotel.

Who is the hotel for? One might wonder. To answer this question we will go to the motivation behind the concept first. The idea that students end up with the bad stories when renting a living space was reason for Charlie MacGregor to come up with the Student Hotel. The concept is simple: it is like a hotel, so all you need to bring is what fits in your airplane luggage. While on the side everything is present in the hotel, for example a launderette, a gym, an auditorium, a lounge, a quiet study room and a restaurant. Next to housing the student hotel is also an actual hotel. Making it possible for everyone to book a room there, and specifically families of students staying at the hotel. The Student Hotel also hosts working people that need a silent study place or come for a conference.

Weak point in the concept is the price which starts at €680 a month and in my opinion students who can pay that monthly do not necessarily end up with the bad stories. Targeted people here are students that are new in the city and want to have living space while being sure of what they will get. Besides students actually everyone can get in the student hotel although it is primarily marketed towards international students. Strong point is that people are supported in a new environment, for example, new residents get an explanation of how to park your bike, which is also provided for by the hotel. This place is built to make you feel at home as fast as possible, in a comfy, welcoming and fun environment. ■

Study Abroad Trondheim, Norway

Author
J.W.P. (Jill) Vervoort

HILSEN FRA TRONDHEIM!

Hei du! Jei er Jill og jeg studerer for tiden i Trondheim. Jeg er fra America, en liten landsby i Limburg, Nederland. Jeg forlot Eindhoven for et par måneder for å bli kjent med det vakre Norge.

I am kidding. I didn't learn to speak Norwegian. For those who don't like the cold climate, rough nature and expensive life would probably hate Norway. However, if you simply have a prelove for the Scandinavian scenery you will definitely won't regret it!

How the hell did I end up all the way up north? First I need to confess that I am actually not for 100% a BPS student. I am probably just as much a SET student as a BPS student(SET is a master's on sustainable energy technology). I know 'sustainable' is quite a broad term for a study. For sure the study is unable to comprise all of it, but I can tell you that everyone of us is able to find a piece in the field of sustainable technology which is interesting to them. Aren't we the new generation who should use our knowledge to build a more sustainable future?

Now you know what drives me during study in the broad sense of the word. But that doesn't yet explain what I do in Norway. To complete the SET it is mandatory to fulfil an internship, before being allowed to start a master thesis. Visiting Scandinavia has always been a dream for me, so the internship was my chance to delve into this unknown environment. I chose to do a project at the Norwegian University of Science and Technology (NTNU). This project is part of a big research project called INTERACT, which is led by the Norwegian research institute called SINTEF. SINTEF in Norway is more or less comparable to TNO in the Netherlands.

When I am not busy travelling around I will be found at varmeteknisk at the NTNU Gløshaugen campus. Here I am analysing the advanced heating and cooling system at the campus of the university college in Bergen (Høgskolen i Bergen, HiB). This rather complicated system entails both a thermal energy storage as a PCM-storage, a connection to the district heating and a heat pump/chiller system. A remarkable thing about the system, is that this PCM-storage is actually used to store cold. I can ensure you, it is quite a task to get a good feeling on how this system is running!

Trondheim is the third largest city in Norway and is dominated by students and research institutes (1/5 is student). Probably you are able to state that Trondheim is the Eindhoven of Norway. The thing I love about this place is that everyone is active, people are running, cycling, and hiking all over the city. You can already recognize this their way of clothing. In order not to lag behind I decided to go along by learning how to sail, diving in the fjords, going on primitive cabin trips for some nice hikes or simply play squash in the evenings or perform some yoga at 7:45 in the morning.

If you get the chance to visit Trondheim the best spots in town are the Nedre Bakklandet, Kristians Festningen, and Solsiden. Don't forget to eat the famous Norwegian waffles with brunost (caramel cheese) on your way! Last but not least, the most amazing thing up here is seeing the northern light. It's definitely worth the dark days. ■

Figure 1: View from kristians festningen

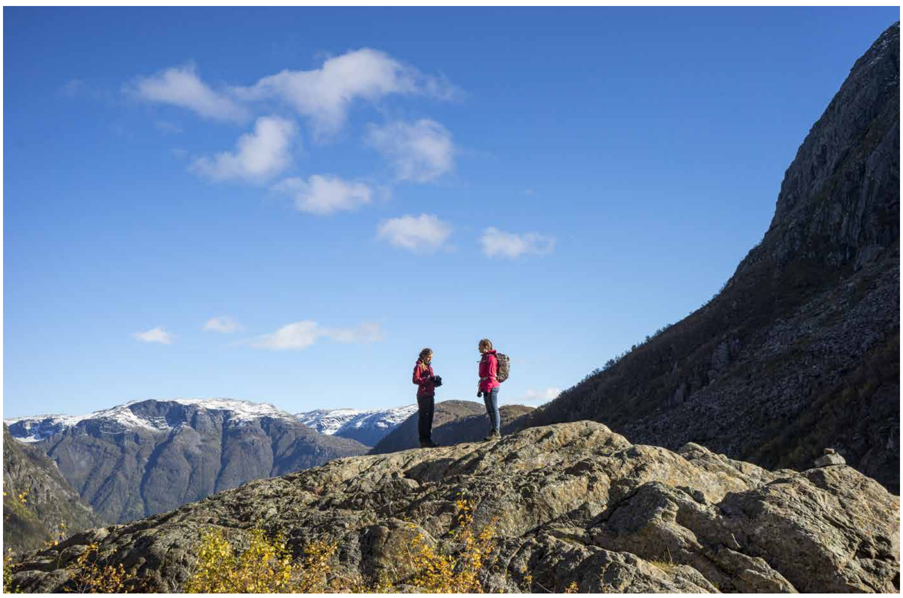


Figure 2: Hike towards the Folgafonna gletcher 'close' to Bergen

Stichting
Promotie
Installatietechniek
(PIT)

De Stichting PIT zet zich in voor promotie en innovatie binnen de installatiebranche. Wij financieren projecten die in technisch, economisch of wetenschappelijk opzicht vernieuwend zijn. Dat doen we voor organisaties die zich zonder winstdoelstelling bezighouden met onderwijs en kennisontwikkeling in de branche. Denk bijvoorbeeld aan universiteiten en onderzoeksinstituten.

Zo draagt Stichting PIT bij aan het genereren van nieuwe kennis en innovatieve ontwikkelingen waarvan de gehele installatiebranche kan profiteren. Daarbij moet altijd sprake zijn van substantiële cofinanciering. Zo waarborgen we dat er binnen de branche draagvlak bestaat voor onderzoeken en projecten die door de Stichting financieel worden ondersteund.

Alumni at work

Author
ir. J. (Jessica) van Amerongen-Verdonschot

Fourteen years ago I was asking people to write columns for the Inside information and now I am being asked myself. I was a proud member of Mollier from 2002 – 2006 and part of the 7th board. I still remember my first trip with Mollier, the beer tap that we took along and the Mollier song we wrote on that trip. It was a very nice start of my years as a student Ínstallation technology and later on Building Services.

After I graduated I started working at Peutz near Nijmegen as a junior project leader on the areas of building physics, acoustics and sustainability. I consulted on many type of projects; office buildings, residential buildings and many schools or multifunctional accommodations as they were called. The thing I liked most in this job was the interaction with the rest of the design team; architects, construction engineers, installation engineers and of course the principals and users of the building we were designing. But after a little over 6 years it started itching. Is this it? Do I want to be in this field of expertise for the rest of my life? I didn't know, so I started looking around for a new challenge.

That's when I found my current job in the design and engineering department within ASML. Our group is part of the Environmental Control & Infrastructure department which deals with the 'piping and plumbing' of the ASML machine, so it is just like Building Services, but then on a completely different scale (working with nanometers and millikelvins) and with completely different boundary conditions and accuracy requirements. But the thing that is the same, is that all the work we do, almost always depends on good teamwork, so I still get to participate in different teams and I am still meeting new people within and outside of ASML.

Figure 2: Jessica on holiday in Argentina

Figure 1: 7th board Mollier in 2002. Form left to right Jessica van Amerongen-Verdonschot, Onno van Deurzen, Luuk Bouman & Berend Doedens

I have been at ASML for more than three years now and I am still very happy that I made the switch. I am still being challenged in my job and my development within the company. There are enough career opportunities within ASML and that is a very important thing for me.

Next to my professional career, I am also married to a really nice guy with whom I have two beautiful daughters, one of 7 months and one of 2 years. They keep me busy when I'm at home. And together we still like to travel the world by car and sometimes by bike, snowboard on the mountains in Austria during winter and spent time with friends and family. ■

Sound absorption of periodically spaced baffles

Author
ir. N. (Niels) Hoekstra

Supervisors
dr.ir. M.C.J. (Maarten) Hornikx
ir. C.C.J.M. (Constant) Hak
prof.dr.ir. B.J.E. (Bert) Blocken

INTRODUCTION

In the past decades the use of baffles has increased for improving the acoustic environment in buildings. Unlike traditional absorbing ceilings, which are mounted parallel to the construction, baffles are mounted hanging. Although this might seem an uneconomical decision compared to traditional closed absorbing ceilings, it can bring advantages in specific cases. The type of open ceilings that can be created with baffles does not influence the climate or the airflows in a room too much. Furthermore, industrial buildings like factories and large halls where easy access to ducts or piping is needed benefit from the simple installation and removal of baffle systems. Additionally, the use of baffles has also increased in offices or public buildings that make use of concrete core activation. It is a technique that utilizes low-temperature heating and cooling to condition a building. For this concept to work, it is vital that the ceiling is open so that heat radiation from the construction can reach the building occupants. However, besides all these technical reasons, some building owners just prefer an industrial look; they not only use baffles for their acoustics qualities, but also for aesthetic reasons.

Due to the increased interest in baffles, architects find more ways to incorporate them in their design philosophy. Some examples are shown in Fig. 1 &2. The first example is a classroom where baffles are used to create an open ceiling with space for air handling ducts to provide ventilation air via nozzles. The second example is a train station hall where the use of baffles enables entrance of natural light. Furthermore, the architect has designed the baffles to visualize a wave-like pattern giving the ceiling a special appearance.

PROBLEM STATEMENT

Acoustic consulting based on geometrical acoustic models, and in particular ray-tracing models, is becoming more widespread. A known drawback of the ray-tracing methods is the inability to accurately simulate wave propagation in problems with complex geometries and problems where wave-based effects like diffraction and interference are important [1]. This is less important for the high frequency range as the pressure amplitude deviates less over space and makes characteristic wave-based effects less significant. For the low frequency range, however, wave-based methods are preferred over ray-tracing methods for their accuracy in solving characteristic problems incorporating complex geometries [2]. But the drawback of wave-based methods is their associated high computational costs. Fortunately, advancements in the power of computational hardware have made it possible to use the wave-based method in the low frequency range. This research has aimed to utilize this advancement and investigate the sound absorption of baffle configurations in the low to mid frequency region below 1000 Hz, by using a wave-based computational method.

GOAL

The objective of this study is to investigate the effect of different baffle configurations on the sound absorption of the baffle setup. The process started with measurements on samples of a baffle material to obtain material parameters and to determine the sound absorption. The measured data is subsequently used to validate impedance models and computational models. Impedance models are used to model wave propagation in porous materials. Computational models are used to model a baffle configuration and simulate wave propagation in and around the baffles, incorporating the impedance models. After validation, a computational study is performed with the validated models and the sound absorption of various baffle configurations is predicted. It is investigated what effects different baffle configurations have on the overall sound absorption. Finally, conclusions are drawn based on the results of the computational study.

Figure 1: Example of an open ceiling to provide space for air handling ducts

Figure 2: Example of an open ceiling to provide daylight entrance, while preserving acoustic absorption

BAFFLE MATERIAL

The baffles that are used in this study for actual measurements are supplied by Ecophon. The provided baffles are made of high-density glass wool (90 kg/m3) and are coated with a layer of paint (Fig. 3&4). A total number of 15 baffles with dimensions of 1.2 x 0.04 x 0.3 m3 are used in this study. Various small samples of the material are used to measure material properties discussed later on. The material properties are later used as input for impedance models for simulating wave propagation in the porous material.

METHOD

I. MATERIAL PROPERTIES

As mentioned earlier, the first step was determining the material properties of the baffle material. These material properties are used as input for the impedance model that is later used in simulating wave propagation through the baffle configuration. A lot of impedance models are available from literature, all only being suitable for a specific type of material [3]. What they have in common though is that they often require the same input parameters. The most important ones are the airflow resistivity (σ), porosity (Φ) and tortuosity (α_∞). The airflow resistivity is a measure of how easily air can enter the porous structure of the material and how much friction it undergoes. The porosity of a material is the ratio of the air volume in the sample material to the total volume of the sample. Values for porous sound absorbing materials usually range between 90-98%. Finally, the tortuosity describes the complexity of the propagation path of sound waves through the pore network of a porous material. It is essentially the ratio between the travel time of an unobstructed wave and a wave that passes though the porous material.
It was possible to measure the three material properties in the laboratories of the Eindhoven University of Technology and the University of Leuven.

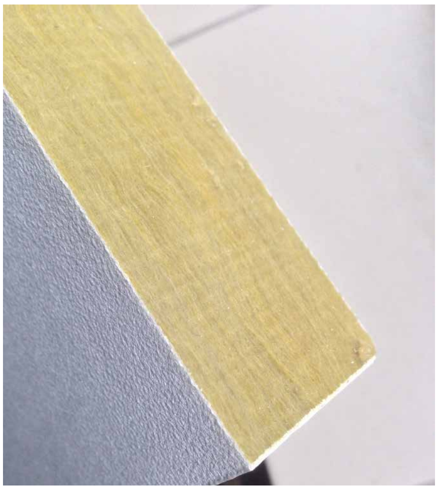


Figure 3: A sectional cut of a single baffle

II. SOUND ABSORPTION

As a second step the sound absorption of various glass wool samples was determined by means of impedance tube measurements. An impedance tube is used to determine acoustical parameters of (absorptive) materials. A small sample of the material is placed in one end of the closed, rigid tube (Fig. 5). A sound source that produces a measurement signal, is located on the other end.
The sound pressure is measured with microphones on fixed locations in the tube, from which a reflection coefficient of the material sample is calculated. From this it is possible to calculate the surface impedance and the absorption coefficient. The sound absorption data is subsequently used to fit the impedance model on.

III. IMPEDANCE MODELS

Describing wave propagation in poroelastic materials using the associated wave equations can be a complex task. Often, impedance models are used to describe the vibro-acoustic behaviour of a material in a simplified way using its material properties as input. The type of impedance model our glass wool material qualifies for is the equivalent fluid type. In literature, many equivalent fluid models can be found which are suitable for various pore morphologies. In Fig. 4, some examples of pore morphologies and the associated impedance models are shown. As can be seen in Fig. 4, some impedance models require more input parameters than the three measured ones. In that case the remaining parameters are fitted on the measured sound absorption data from the impedance tube. After fitting various impedance models to the measured data, the best fit was achieved with the Johnson-Champoux-Allard-Lafarge model. In addition to an impedance model for the glass wool, also an impedance model for the coating is necessary. This impedance model is more straightforward as it is the real part of the surface impedance of the coating, which can be measured in the impedance tube. Combining the two impedance models using the transfer matrix method [4], the sound absorption of a coating porous material can be predicted. The measured sound absorption and the sound absorption predicted with the impedance model are shown in Fig. 7. After finding the impedance model with the best fit on the measurement data, the impedance model was validated in COMSOL. Two FEM-models were created: a model of the impedance tube setup with a small sample of the glass wool and a reverberation room with 15 baffles. The simulation data is subsequently compared to the measurement data and found to have good agreement. For extensive validation data, please refer to the full thesis [5].

IV. COMPUTATIONAL STUDY

After validation, a computational study is conducted and the sound absorption of various baffle configurations is predicted. First a base model is set up that represents a baffle configuration that is often found in practice. The baffles in this configuration have a height of 300 mm and the spacing of two times the height, i.e. 600 mm. Subsequently, the geometry of the base model is modified to identify changes in the sound absorption of the configuration. In Fig. 8, an overview of the simulated baffle configurations in presented. The configurations are chosen based on the way they often appear in practice. Where the first four configurations are fairly common, the fifth 'wave motion' configuration is becoming more popular in the past years. Architects use baffles with

Figure 4: A baffle configuration as measured in the reverberation room

Figure 5: Picture of the impedance tube located in the Echo building on the TU/e campus

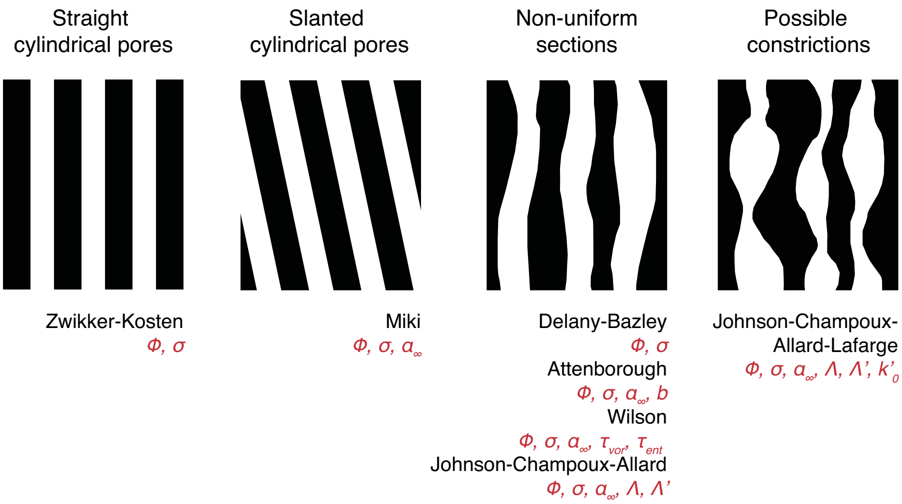


Figure 6: Examples of pore morphologies and the associated impedance models

different heights to create a ceiling with an appearance that resembles a wave motion. The presented configurations are used to study the effects of small modifications on the sound absorption of a field of baffles.

The study was mainly performed with 2D models, as 3D models come with a high computational cost. However, two 3D models were created to be able to investigate whether the results are applicable in practice. The first one resembles the 2D base configuration and the second one is a lattice configuration (Fig. 9).

RESULTS & DISCUSSION

An overview of the results of the computational study is shown in Fig. 11 in the same order as Fig. 9. Presented is the absorption coefficient of the baffle configuration as a function of frequency for multiple angles of incidence and for random incidence. The results are not discussed in great detail in this article due to its short nature, but instead a summary of the most important findings is given.

The most noteworthy observation is the fact that peaks in the absorption curve appear at half and full wavelengths of the frequencies that correspond to the spacing of the baffles. For example, in the base configuration this is at 290 and 580 Hz. In Fig. 10, the sound field around the baffle configuration is shown for these frequencies. It clearly illustrates how alternating zones of high and low sound pressure coincide with the positions of the baffles. Looking at the results for the other configurations it can be observed that the effect can be shifted to higher frequencies (denser spacing), can be decreased (suspended baffles) and can be increased (double height). Interestingly, the effect can also be extended to lower frequencies when variations in height are introduced like in the wave motion configurations. The persistence of the effect was verified for the 3D models. This shows that the found effect is also valid in 3D situations and can be expected to be in practice. For the results of the 3D models see the full thesis [5].

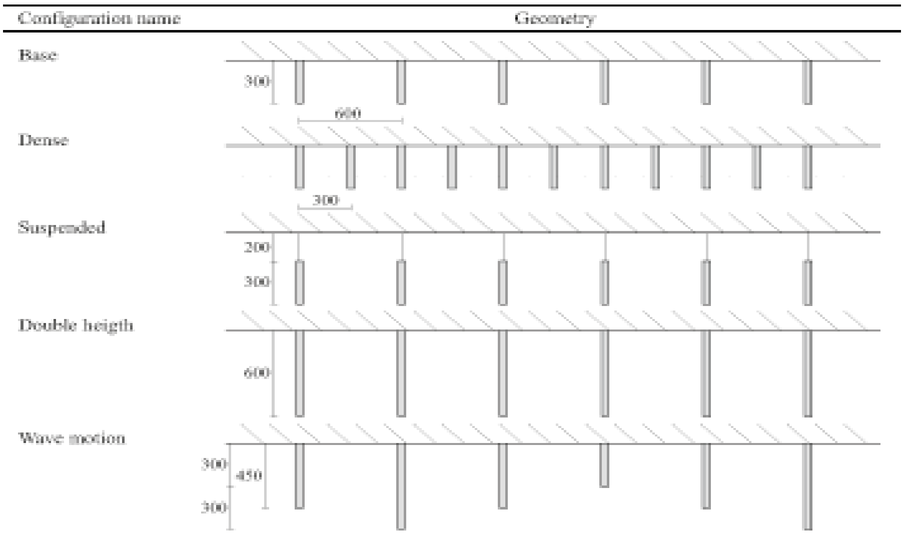


Figure 8: Overview of simulated baffle configurations

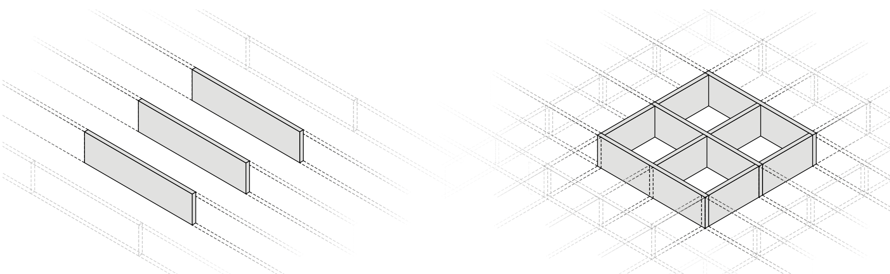


Figure 9: Isometric representations of the 3D models, with baffle height 300 mm and spacing 600 mm

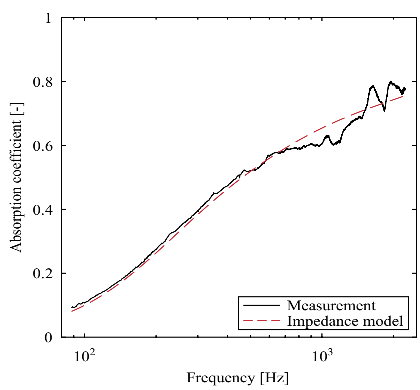


Figure 7: Comparison of measured absorption coefficient of a coated glass wool sample and the impedance model

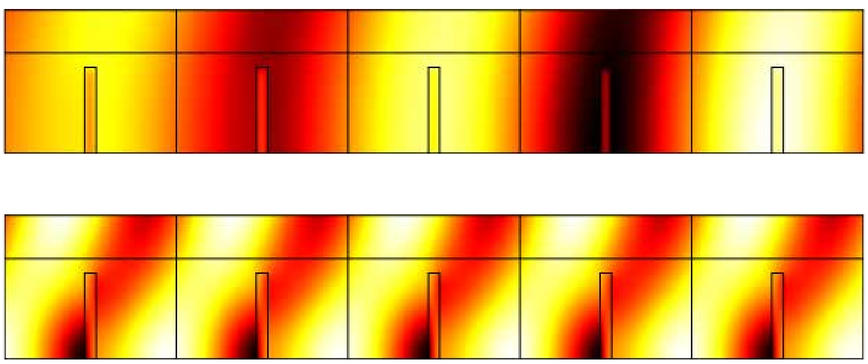


Figure 10: 2D plots of simulated sound field for 290 Hz and 580 Hz with a 70° angle of incidence

CONCLUSION

Baffle configurations have first been investigated in 2D to obtain insight of which effects influence the sound absorption of baffles while not requiring much computational power. Subsequently, several configurations have been investigated in 3D to see if the effects still persist. The following conclusions can be drawn based on the results of the study:

- In the base model, it is observed that incidence angles approaching grazing incidence lead to higher sound absorption. Moreover, peaks in the sound absorption curve appear at frequencies of which the half and full wavelength correspond to the 600 mm periodicity of the baffle configuration. The periodic spacing of the baffles seems to support the propagation of a low-frequency wave through the configuration.
- Decreasing the spacing of the baffles (making the configuration more dense) removes any sound absorption peaks in the lower frequency region and slightly increases absorption in the higher frequency region. Increasing the spacing has the opposite effect. Peaks in the lower frequency region appear and high frequency absorption is slightly lowered.
- Suspended baffle configurations reduce sound absorption in the lower frequency range around frequencies which half wavelength corresponds with the spacing of the baffles. It seems that by suspending the baffles, the propagating wave through and between the baffles loses support. The periodicity of the sound wave and the baffle configuration do not match anymore and sound absorption is lowered.
- Doubling the height of the baffles from 300 mm to 600 mm increases the sound absorption coefficient in the higher frequency region and fills a dip to the low-frequency absorption peak which half wavelength corresponds with the spacing of the baffles. The result is a smoother absorption curve without strong dips compared to the curve of the base configuration.
- By utilizing baffles of different heights and placing them in order of increasing and decreasing height, the propagation of low-frequent sound waves through the baffle configuration is supported. Peaks in the absorption curve appear at frequencies of which the half wavelength corresponds with the spacing of baffles with equal heights.
- The persistence of the effect was verified for the 3D models. This shows that the found effect is also valid in 3D situations and can be expected to be in practice. ■

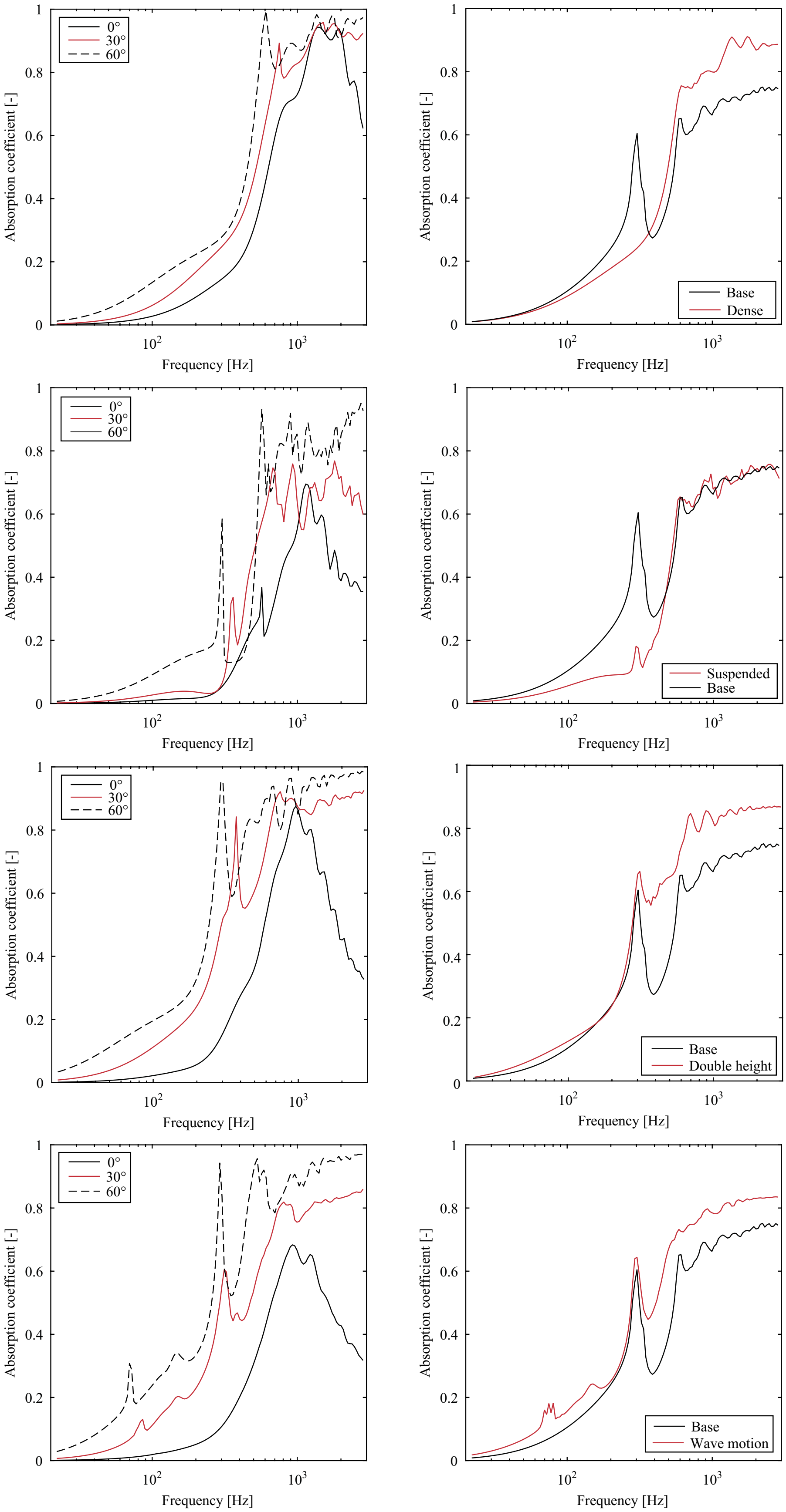


Figure 11: Overview of simulation results for various baffle configurations: (left) incidence angle-dependent absorption coefficient, (right) random incidence absorption coefficient

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