

Academic year 2012 - 2013 #2 | June

**MOLLIER**



# iNSIDE iNFORMATION

MOLLIER | UNIT BPS | STUDENTS | ACTIVITIES | MEMBERS

## Windcomfort at underground railway stations

Graduation project Jochem Straathof

## Rural Spark India

Cofely helps with bringing light to the rural areas of India

## PhD Twan van Hooff



# Foreword

Dear reader,

**EDITOR**

Jelle Loogman



In front of you is the second and also the last INSide Information of this study year. Before I tell you about the contents of this issue, I would like to thank Jordi van Laarhoven for his effort and enthusiasm for being the chief editor of the INSide Information. From now on I will take over his task with newly profound energy.

It is nearly the end of this study year, which means that a lot of Mollier activities took place. You can read about these activities in this issue of the INSide Information. One of the most engaging activities was the studytrip to Ho Chi Minh City, in the south of Vietnam. From my own experience of this trip, I am glad to say that it was a tremendous success. The travel journal of this trip, with inspiring pictures included, could be read on page 40, which is written by the studytrip committee. For the members who did not have the opportunity to go two weeks abroad, as well for the ones who did, there were other activities organized, like the excursion to the Foamglass and Wienerberger factories, as well as the Meet & Greet.

Besides the activities organized by Mollier, attention is paid in this issue to the research going on within the BPS unit, as well as graduation projects of students. There are two articles related to CFD engineering. The first is a graduation project on wind comfort in train tunnel platforms, and the other about the experiences of Twan van Hooff during his PhD program. If this is still not enough, there is also the possibility to join the Urban Physics autumn school, about which can be read on page 35. Beside these CFD articles, there are also articles about acoustics, innovation in building materials and personal comfort control systems.

Furthermore, several companies have contributed to this INSide Information by providing a wide range of articles about new and innovative building concepts or lighting supply in the rural areas of India.

I wish you all the best with the upcoming exams, finishing a master project and for some people their graduation. Hopefully you will all have some time left for a holiday trip.

I sincerely hope you will enjoy reading this INSide Information,

Jelle Loogman

**EDITOR**

Jordi van Laarhoven



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Dennis Pennings



## COLOPHON

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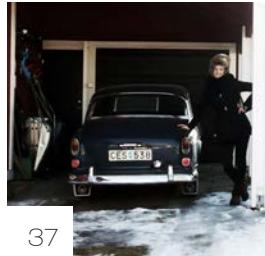
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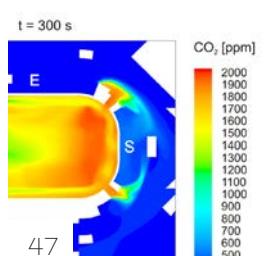
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# Wind comfort at underground railroad platforms



Jochem Straathof

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**H**igh wind velocities are noticed when a train passes through a tunnel. This study reveals the wind phenomena that occur when a train passes through a tunnel with a high blockage ratio and shows the wind velocities that can be felt at an underground railroad platform. Results have been obtained by performing various transient CFD simulations and have been validated with experimental data.

## INTRODUCTION

The Netherlands has one of the world's busiest railway networks where many small platforms are located at the routes between the large stations. The Intercity trains only stop at the larger stations and are allowed to travel along the smaller stations with a maximum velocity of 140 km/h. It is unlikely for a moving passenger train to cause dangerous gusts at a platform located in the open air. However, a phenomenon called "the piston effect" occurs in tunnels, hence underground platforms, causing high wind velocities in front of and behind the train.

Air in a tunnel is confined by the tunnel walls. Therefore, the movement of air is restricted. In open air, when a vehicle travels along, air is being pushed and can move in any direction. But inside a tunnel, air cannot move through the tunnel walls. Air is being pushed along the tunnel, creating a compression wave in front of the train. Behind the moving vehicle, as air has been pushed away, suction is created and air is pulled to flow into the tunnel. This phenomenon is schematized in figure 1 and is called the 'piston effect'. (Wikipedia, 2012)

Baron et al. (2001) state that the occurring piston effect is mainly dependent on three factors: 1) the shape of the nose and end of the train, 2) the blockage ratio, 3) the speed of the train.

## VALIDATION STUDY – EXPERIMENTAL DATA

In order to obtain reliable results in the case study, the input of the numerical model needs to be validated. A validation study has been performed with use of experimental data from the Birmingham Center for Railway Research and Education. The faculty has access to The TRAIN (Transient Railway Aerodynamics INvestigation) Rig. This is a moving model rig



Figure 2 Moving model rig at Birmingham Center for Railway Research and Education

that consists of a 150m long track along which model vehicles can be propelled in both directions, at speeds of up to 75m/s. Experiments performed by Gilbert et al. (2012) at the TRAIN rig have been used for validation of the CFD input. Wind velocities have been measured halfway an 8 m long tunnel where a 1/25 scale model of a German ICE-2 train is running through with a speed of 32 m/s. Figure 2 shows the experimental setup and the black line in figure 4 shows the measured wind velocities.

## VALIDATION STUDY – SIMULATIONS

The mesh of the numerical model has been created with the use of computer software package Gambit 2.4.6. This mesh, including boundary conditions, has been implemented in commercial code ANSYS fluent 12.1 with which the simulations have been performed. Figure 3 shows how the mesh of the German ICE-2 has been composed. First faces have been created, covering the exact volume of the train. Afterwards a volume is created around the faces, which is provided with cells.

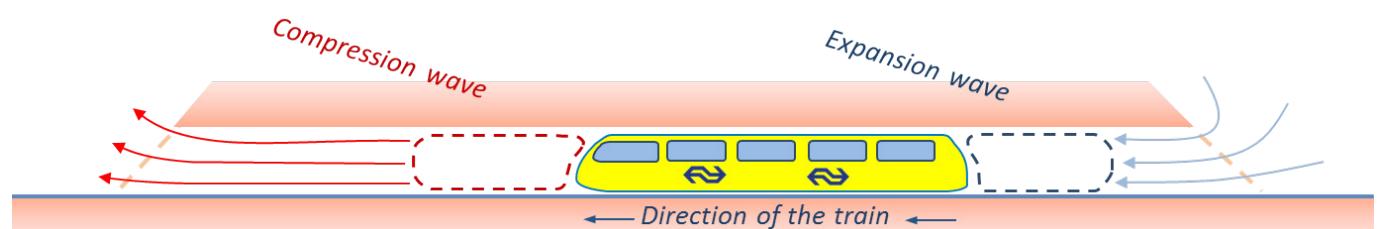


Figure 1 Visualization of the Piston effect in a train tunnel



Figure 3 Mesh composition of the German ICE-2 train

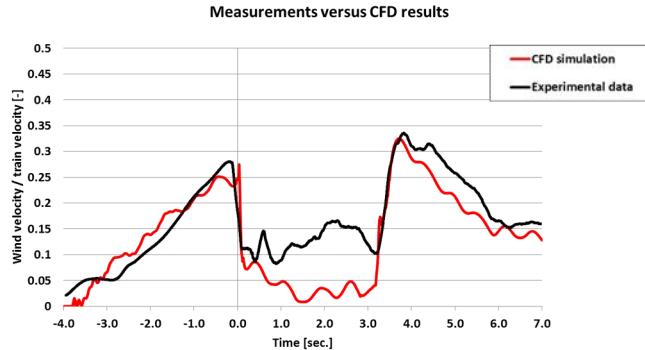


Figure 4 Measurement versus CFD results

Unsteady RANS simulations have been performed using the Realizable K- $\epsilon$  turbulence model for turbulent closure. Motion of the train has been accomplished with use of the sliding mesh method. Different solution methods have been compared where "Fractional step" in combination with second order spatial discretization appeared to be most accurate. Calculation time has been reduced by using of the Non-iterative time advancement method. Results are affected by the use of compressible air (Novak, 2006). Therefore, the calculations have been performed including the compressible aspects of air. The following figure shows a comparison of the results from the CFD simulations with the experimental data. The measured wind velocities are divided by the speed of the train, which results in dimensionless values on the Y-axis. The black line shows the measured wind velocities halfway inside the tunnel in the experiment, whereas the red line shows the results extracted from the CFD simulation. Although the lines do not completely match, the peak values of the gusts show good agreement. Since the peak gusts are most important in this study, the numerical input that has been used for the validation study has also been used for the case study.

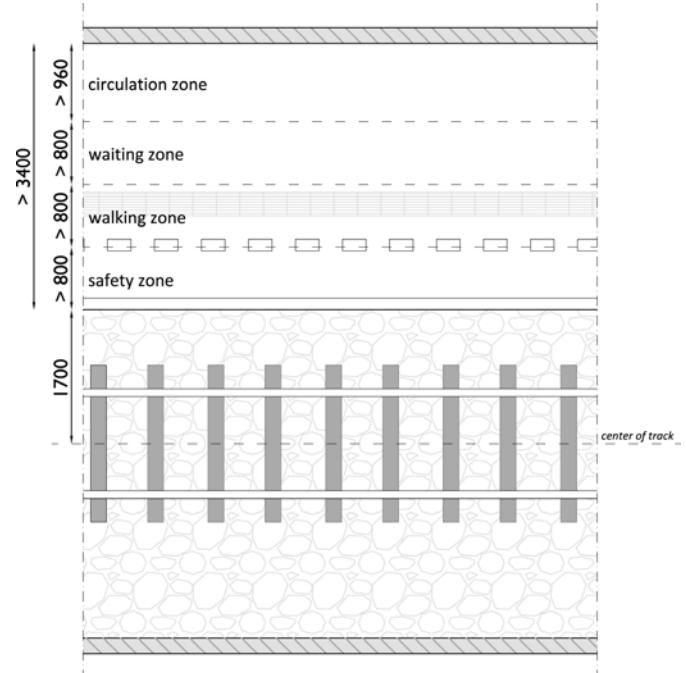


Figure 5 Platform design guidelines by Prorail

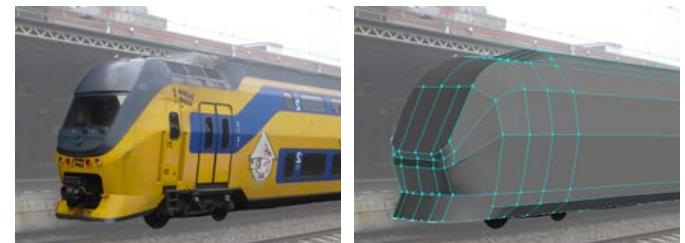


Figure 6 Mesh composition of the VIRM intercity train

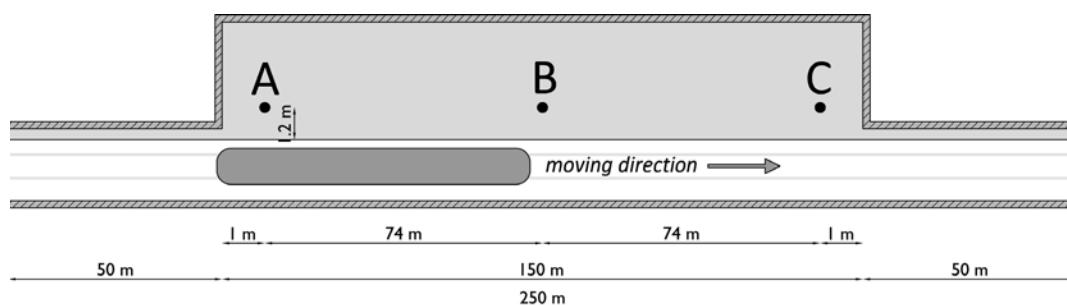


Figure 7 Position of the measurement spots

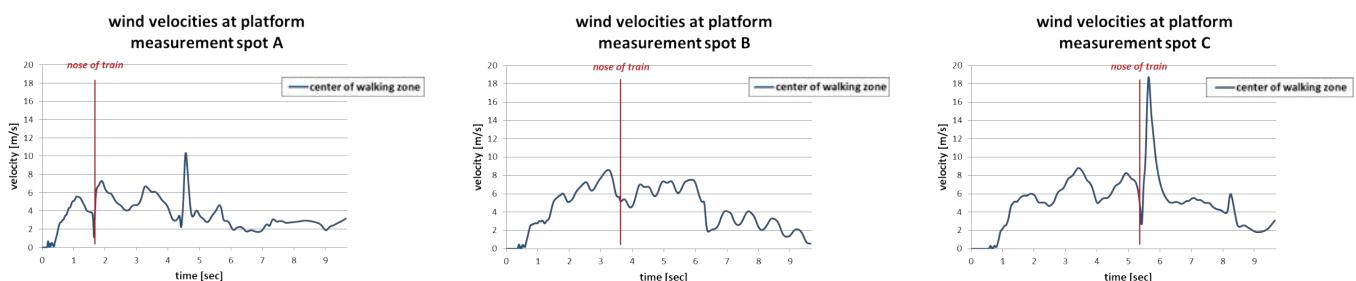


Figure 8 to 10 Resulting wind velocities at the underground platform

The mesh of the numerical model has been created in the same manner as for the validation study. Figure 6 shows how the mesh of the intercity train has been composed. Due to the complex geometry of the train it was not possible to just use hexahedral cells. Tetrahedral and prismatic cells have been used for the parts with rounded faces.

More or less the same graphs as in the validation study were expected, but the wind velocities caused by the occurrence of the piston effect showed lower values. However, when looking at the measured wind velocities at point C, an abrupt peak can be seen just after the nose of the train has passed the measurement spot. This peak is caused by the sudden increment in pressure ahead of the train. The zone with high pressure is being cleared by a lower pressure zone at the platform. This is schematized in figure 11. This figure shows the air velocities in m/s. The train is indicated in black and moves from left to right. The red arrow shows the moving direction of the air and the dashed line indicates the platform border.

#### CASE STUDY – WORK IN PROGRESS

At the time of writing this article, the analysis of the results is still in progress. A second simulation will be performed concerning a freight train running along this very platform. Although their maximum allowed running speed is considerably lower than a passenger train, they are less aerodynamic. Therefore, high wind velocities can still be expected. Experiments performed by Soper et al. (2012) prove that the robust shape of a freight train can cause wind discomfort at platform level. Another reason to assess the wind discomfort of a freight train is the fact that NS and Prorail are thinking of increasing the maximum allowed speed of a freight train from 80 km/h to 100 km/h, in order to ensure a better flow on the overcrowded Dutch rail network.

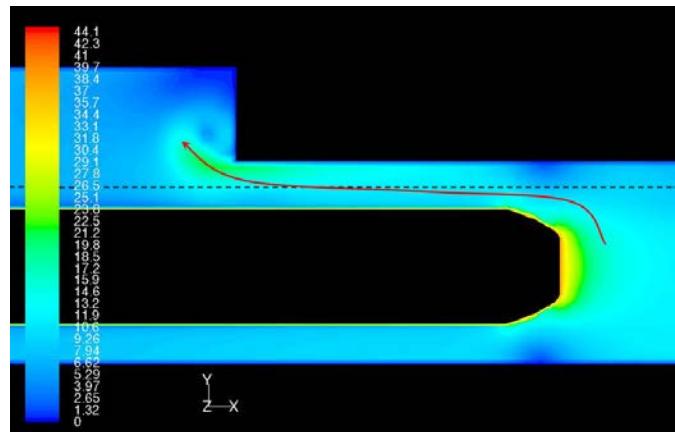


Figure 11 Wind velocities due to the movement of a train

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## Kuijpers & Mollier Resultaat door betrokkenheid

Kuijpers is een professionele technisch dienstverlener met ruim 800 medewerkers en een omzet van 160 miljoen euro. Kuijpers verzorgt alle technische installaties in gebouwen en industrie én zorgt voor het onderhoud daarvan. Hierdoor voldoen zij jarenlang aan de gestelde eisen. Het bedrijf profileert zich met oplossingen op het gebied van milieuvriendelijkheid, energiezuinigheid en veiligheid. Kuijpers combineert zijn sterke klantgerichtheid met de aandacht voor de ontwikkeling en belangen van zijn medewerkers. Resultaat door betrokkenheid is een belangrijke drijfveer. Enkele projecten waar Kuijpers aan heeft gewerkt zijn het Rijksmuseum in Amsterdam, de Aquanura van de Efteling, **de trainingsaccommodatie van Vitesse** en het nieuwe ziekenhuis Bernhoven in Uden. Het 4e generatie familiebedrijf heeft vestigingen in Arnhem, Den Haag, Helmond, 's-Hertogenbosch, Roosendaal, Tilburg en Utrecht.

Binnen Kuijpers zijn er mogelijkheden voor traineeships, afstudeeropdrachten en stageplaatsen en zijn er diverse uitdagende functies.

Ook bij Kuijpers resultaten behalen? [www.kuijpers.nl](http://www.kuijpers.nl)

# Kuijpers draagt bij aan nieuw trainingscomplex Vitesse

Kuijpers werkt aan interessante projecten binnen de marktsegmenten gezondheidszorg, onderwijs, cultuur & recreatie, bedrijfshuisvesting en industrie. Onlangs heeft Kuijpers de nieuwe trainings- en opleidingsaccommodatie van Vitesse op Papendal opgeleverd en het complex is vanaf februari 2013 in gebruik genomen.

Kuijpers was hier verantwoordelijk voor de totale engineering van de werktuigbouwkundige en elektrotechnische installaties van de nieuwe trainingsaccommodatie. Veluwezoom Verkerk heeft de bouwkundige werkzaamheden gerealiseerd. Het trainingsonderkomen telt vier verdiepingen, waarvan drie boven de grond. Het complex is een ontwerp van Geesink Weusten Architecten.

De nieuwe accommodatie van Vitesse is één van de meest moderne van Nederland én Europa. Naast veldverwarming, om onder alle omstandigheden te kunnen trainen en verlichting, is er in het nieuwe complex onder andere ruimte voor fysio, krachttraining en pers. Kuijpers heeft de wensen van alle betrokkenen meegenomen in het ontwerp, zodat de accommodatie voldoet aan de wensen en eisen van deze tijd. Zo worden in het kader van energiebesparing de installaties aangesloten op een wko en voorzien van warmtepompen. De bronnen voor deze wko liggen 120 meter diep. Daarmee wordt het trainingscomplex op een duurzame wijze van energie voorzien. In de zomer wordt het koude grondwater gebruikt voor de koeling, terwijl warmte wordt opgeslagen in de bodem voor de winterverwarming.

## KUIJPERS VITESSE STREET LEAGUE

Kuijpers is niet alleen betrokken bij de bouw van het complex, maar ook bij de maatschappij. Dat blijkt onder andere uit de bijdrage aan de Kuijpers Vitesse Street League. Recent heeft de officiële finale plaatsgevonden. De Kuijpers Vitesse Street League is een unieke straatvoetbalcompetitie waarin 12 teams uit verschillende wijken uit Arnhem en

Figuur 1 Het nieuwe trainingscomplex van Vitesse op Papendal



Figuur 2 Het overall-winnende team, team Presikhaaf, met op de achtergrond Joost de Wit, algemeen directeur van Vitesse en Patric Vranckx, vestigingsleider van Kuijpers Installaties Arnhem. Fotograaf Kevin Hagens

omstreken het tegen elkaar opnemen. Bij de Street League draait het niet alleen om prestaties op het veld, maar ook om fairplay en het leveren van een positieve bijdrage in de eigen woonomgeving.

## STICHTING VITESSE BETROKKEN EN KUIJPERS: EEN LOGISCHE KLIK!

Alle projecten van Vitesse Betrokken zijn gebaseerd op de pijlers gezondheid, sportiviteit, respect en talentontwikkeling. Waarden die naadloos aansluiten bij hoe Kuijpers haar rol in de samenleving ziet. Geen wonder dat er direct een logische klik was tussen Vitesse Betrokken en Kuijpers. Patric Vranckx van Kuijpers: "De grote gelijkenissen is dat we beide elke dag bezig zijn met beter worden en het bewustzijn dat de jeugd de toekomst heeft. Wanneer we jongeren zaken als discipline, het belang van teambuilding, ambitie en structuur bij kunnen brengen, helpen we daar bovendien niet alleen hen, maar ook onszelf mee. Om ze enthousiast te maken voor techniek, hebben we de jongeren uitgenodigd op het nieuwe trainingscomplex van Vitesse en lieten we ze kennismaken met alle facetten van de technische installatiebranche."

Meer weten over het trainingscomplex van Vitesse? Scan onderstaande QR-code om een animatie van het trainingscomplex te bekijken.

Werkt de QR code niet? Probeer dan <http://www.youtube.com/watch?v=Ojw4Gkms8Qw>



Geschreven door Kuijpers

# Excursion

## Foamglass Building + Wienerberger NV

*Written by:*  
Argyrios Papadopoulos  
Tom Thomassen



On the 28th of March, Mollier went on an excursion to FOAMGLAS®, a cellular thermal insulation company, and Wienerberger, a brick bakery company in Belgium. The day started at 07:15 with a cold breeze in TU/e campus. After the assembly of the 15 people's group of MSc and PhD candidates and the minibus driver Rob who drove us thought a nice countryside tour in Tessenderlo, Belgium. We arrived at the FOAMGLAS® company, located next to the local canals, at 09:00 and we were welcome with a lovely breakfast of coffee, tea, juice and Belgian cookies.

Peter, the sales manager, has given a short introduction to us about the FOAMGLAS® product and the historical evolution of the company, starting with a short movie. The product was invented in 1934 in the USA and the start of production at 1942. After the export of the product to Europe in 1957 the company was established in Pittsburgh in 1962. The 1st European production facility opened in 1964 and currently the distribution of the FOAMGLAS® products is global. Not only it has achieved a high quality standard guaranteed worldwide by permanent external material control, but it is also expanding continuously its production capacity and achieving the objectives of the company to further strengthen its position on the world market.

### PRODUCT OVERVIEW

So what is this material that reached availability on the insulating materials markets in Europe, the USA, Asia and the Middle East? FOAMGLAS® is a high-quality thermal insulation material for structural engineering and for technical operating plants. According to the company's representatives the insulation is manufactured primarily from high quality recycled glass (60%), carbon and natural minerals with almost limitless resources, therefore it is abbreviated as "foamed glass". Its unique properties derive from the delicate production process explained later on this article, which is the "secret" knowledge of the company's patent that provides them the ability to monopolize its production.

Figure 1 Product overview of foamed glass.

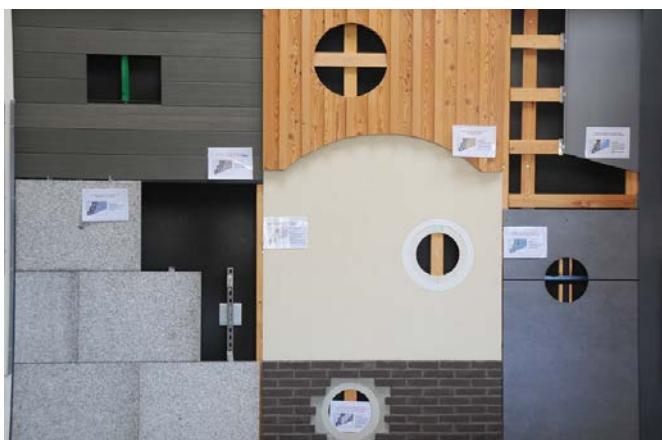


Figure 2 Use of FOAMGLAS® in structural engineering.

### APPLICATION

What is the FOAMGLAS® material used for in structural engineering and industry? Nowadays the material is used in a wide variety of applications in structural engineering categorised in facades, roofs, interior insulations, slope insulation, cold bridge insulation, and multiple underground purposes. For each of these applications the FOAMGLAS® is developed to cope with the special extra desired properties. For example, the sloped FOAMGLAS® is ideal for flat roofs, where the structure cannot provide the slope. The material will be delivered with a plan for construction to make sure the slope will be realized as desired. FOAMGLAS® is also used for roofs with a function as a roof garden, parking, and other features. The material is in most situations glued, resulting in no cold bridges in the construction. In industrial applications it is mostly used to insulate piping and duct work. The material can easily be taped or strapped around the piping or ducts; only on special components like filters or flanges the product is glued to make sure the component can be easily accessed and the FOAMGLAS® can be placed back to its position, and glued, after maintenance.

### PROPERTIES

So what is that makes this material different from others? First of all, the material has nine properties, besides the insulation property, which separates the product from other insulation materials that cannot meet all of them. These properties are pictured in figure 3 and described on the next page.

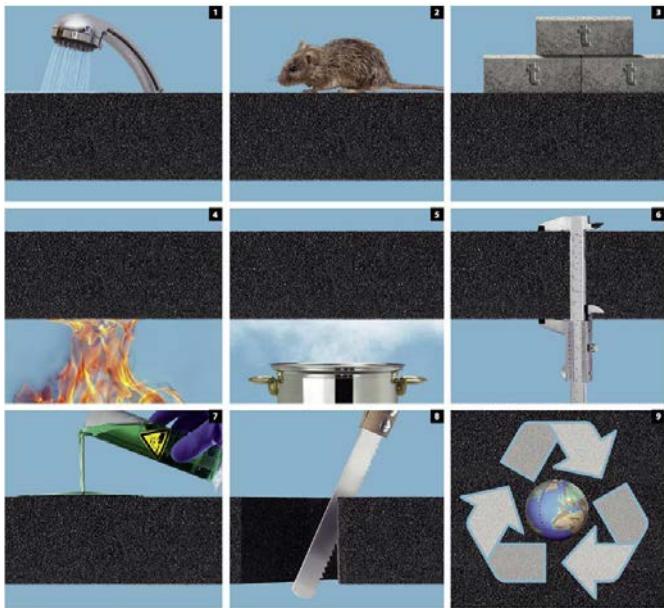


Figure 3 The nine properties of FOAMGLAS®.

1. FOAMGLAS® is waterproof consisting of closed cell cellular glass which does not absorb any moisture and does not swell, without the water being able to affect the insulation value.

2. It is pest-proof and cannot rot since it is an inorganic material, making nesting, breeding, and seed germination impossible.

3. Compression proof, due to the high compressive strength, even with long-term loads it shows almost no deformation. This high compressive strength is a result of the cell geometry. This property makes the material easy applicable for load-bearing thermal insulation without the risk of cold bridges or deformation.

4. FOAMGLAS® is incombustible since it exists mostly of pure glass. In the event of fire flames cannot spread and there is no smoke or toxic gas development due to the insulation.

5. The material is not only waterproof but also vapour-tight, because the cellular structure consists of hermetically sealed glass cells. This makes the use of a separate vapour barrier unnecessary. Ensuring a constant thermal insulation value over decades while it cannot soak.

6. Dimensional stability, because the material neither shrinks nor swells, making the coefficient of expansion nearly equal to that of steel and concrete.

7. Its acid-resistance, due to it consisting mostly out of pure glass, making the insulation resistant to aggressive mediums and atmospheres.

8. FOAMGLAS® is easy to work with because it consists of thin-walled glass cells, enabling the use of simple tools to cut or saw the insulation to the desired dimensions.

9. The material is ecological, because it can be recycled and re-used as granulate.

Table 1 Properties of FOAMGLAS®.

Type	$\rho$ [kg/m <sup>3</sup> ]	k [W/(mK)]	$C_p$ [kJ/(kgK)]	a [m <sup>2</sup> /s]	PL [mm]	CS [kPa]	BS [kPa]	TR [kPa]
T4+	115	$\leq 0,041$	1	$4,2 \times 10^{-7}$	$\leq 1,5$	$\geq 600$	$\geq 450$	$\geq 100$
S3	130	$\leq 0,045$	1	$4,1 \times 10^{-7}$	$\leq 1,0$	$\geq 900$	$\geq 500$	$\geq 100$
F	165	$\leq 0,050$	1	$3,5 \times 10^{-7}$	$\leq 1,0$	$\geq 1600$	$\geq 550$	$\geq 150$
W+F	100	$\leq 0,038$	1	$4,4 \times 10^{-7}$	-	$\geq 400$	-	$\geq 100$
HL	200	$\leq 0,058$	1	$3,5 \times 10^{-7}$	$\leq 1,0$	$\geq 2750$	-	-

The nine properties described above elevate the product over commonly used insulating products on the market, but what about the insulating property? FOAMGLAS® is above all an insulating material with additional properties, making it applicable in many situations where other products on the market would not be sufficient. The material properties of the FOAMGLAS® products are summarized in the table below.

## PRODUCTION PROCESS

The gas trapped in the glass cells provides the insulating properties of this exceptional insulation, following the company's undisclosed procedure. First, from the fusion of recycled glass, sand, dolomite, lime, iron oxide etc. a glass with precisely defined properties is obtained. Then, the glass is ground, mixed with a small amount of carbon and put in high-grade steel moulds. The moulds then pass through a furnace where the glass foam powder is expanded. This is how a material structure with thin glass air cells emerges, which are retained in a controlled cooling process. Due to the cell structure, millions of the smallest possible hermetically sealed glass cells give the material extraordinary compressive strength, waterproofness and good insulation values. An analysis of the production line below will analytically explain the elementary practice stages of the material's process.

1. Mixing and batching of the raw materials: Recycled glass at a 60 to 67 percent, depending on the properties required for the end product, feldspar, sodium carbonate, iron oxide, sand, sodium sulphate and sodium nitrate.

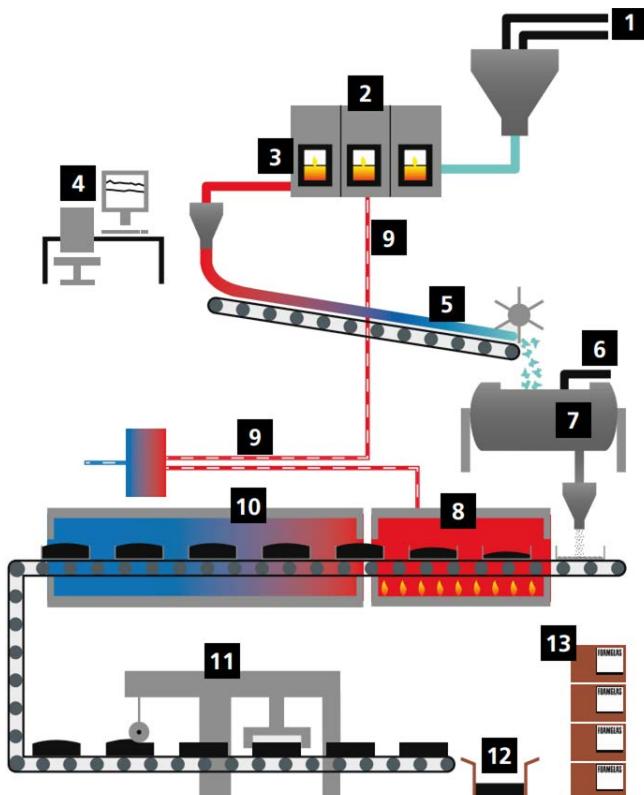


Figure 4 Production line of FOAMGLAS®.

# Duurzaam transformeren



Beeld: OPL Architecten

**Deerns**

...brengt ideeën tot leven

Bijdragen aan een optimaal duurzame en comfortabele leef- en werkomgeving is de kern van onze missie. Dat doen we door de ontwikkeling en duurzame transformatie van innovatieve en energiezuinige gebouwconcepten zoals bij De Daalse Kwint in Utrecht.

Deerns is het grootste onafhankelijke adviesbureau in Nederland. Met projecten over de hele wereld en zestien vestigingen in Europa, Dubai en de Verenigde Staten is Deerns bovendien een toonaangevend internationaal bureau.

[www.deerns.nl](http://www.deerns.nl)

2. The melting glass furnaces have a constant temperature of 1230-1250°C, with a capacity of 85 and 130 tonnes of liquid glass. The temperature is kept at this level in order to keep the oxygen inside, which provides the insulating values. The walls of the furnace are made of 25 cm of fire resistant masonry that decrease 45 mm per month, with a 4 years lifetime. The furnaces are rebuilt every 2 years in order to avoid accidents. Copper electrodes are used into heating the glass and every day 7 mm of copper are placed into the melted glass. The electricity used there comes from green energy.

3. Molten glass is drawn out of the furnace through a completely fire proof structure.

4. Control room for monitoring the production.

5. The glass is drawn off and falls onto the conveyor band where it cools down before entering into the ball mill. The thickness of the tubes is 0.8 mm, in order to make it formable, and water is puured on the trecnes in order to avoid the glass sticking. From now on only cooling takes place.



Figure 5 Molten glass during the production process.

6. Addition of "carbon black".

7. Ball mill grounds all ingredients into a fine powder before putting into stainless steel moulds.

8. The filled moulds pass through a cellulating oven (Foaming furnace) with a temperature of 850°C. This is where the material gains its unique cell structure. It is the stainless steal molds that increase the cost of the material, because of their 4 months lifespan caused by low tensile strength. The molds are ordered from Scandinavia and are reprocessed and recycled.

9. Energy recovery of heat

10. The FOAMGLAS® blocks passes through an annealing oven to allow carefully controlled cooling of the blocks without thermal stress.



Figure 6 Moulds filled with FOAMGLAS® passing through the oven.

11. The blocks are cut to size and sorted by batch, through a completely automated surface control. Production waste is recycled.

12. FOAMGLAS® slabs are then packaged, labelled and palletized, according to their size and material.

13. Finished FOAMGLAS® products are stored and prepared for transport.

## TRAINING ROOM

After the walk through the production process, the team was guided at the training room facility, where the application process at façade, roof and underground systems was explained. All the systems are fully recyclable and can be grinded back and reused. The concrete where the material is applied has to be completely flat. At roof systems hot or cold based bitumen is used as glue between the concrete and the material, and the material pieces as well. This bitumen is also applied between the FOAMGLASS® and the roofing. The whole process has to happen at dry conditions, otherwise the moisture between glass cells would freeze and might break. Using this bitumen prevents the creation of thermal bridges and hence the 3% correction of calculations for thermal bridges, as the system works as a single plate. The only thermal bridges are anchors used for fixing something on the façade. In the end we got time for some questions and Eric and Peter were pleased to cover our inquiries.

## LUNCH

In the afternoon we all got hungry after the first part of the program which already was very educative. As promised by Peter, his Belgium colleagues really know what a lunch means. Some jokes about our Dutch lunch habits, 'broodje kaas' and so on, started the conversations as an ice breaker. The soup was served, wine glasses filled and the bread and creamy butter where waiting for us to start with. All this followed by a nice buffet of all kinds of hot meat in different sauces, pasta, potato dish and of course a desert. Finishing the lunch with some nice words of Karin thanked Peter and Eric from the FOAMGLAS® company and rewarding them with traditional Mollier glass and other goodies. Peter and Eric on their turn spoke a word of thanks and provided us a goody bag for each of our group.

## WIENERBERGER VISIT

After the lunch it was time to go and see the production process at Wienerberger. At the end of the lunch, the company's representative showed us a movie about the company and the development of their products and process. When FOAMGLAS® is recycled the last granulate, which is not usable for the FOAMGLAS® company, is one of the ingredients of the bricks Wienerberger bake.

The production plant of Wienrberger starts with a lot of piles raw material. The materials are fed in the plant by loaders, and speed controlled transport belts dose the materials. With the right amount of each raw material the mixing process starts. After mixing the materials the clayish product comes out of an extruder and passes through the cutter. The clay which is then stacked in big racks goes through the oven, leaving the oven for the cooling process. After the cooling process the bricks are packaged and the product is ready to be sold.

## END OF THE TRIP

The trip has ended in a very nice atmosphere. We returned all the safety equipment and congratulated the organizers. Everybody was in a good mood when we got on the bus to get back to Eindhoven, since we learned a lot from our visit. On our way back it started snowing and the trip organisers were so caring to provide us with some hot Mollier beverages! We returned to the university at 17:00 and greeted each other, till the next excursion!



Figure 7  
FOAMGLAS®  
after the  
cooling  
process.

# Drijvende stad komt eraan

'Duurzaam Drijfland' is een antwoord op de vraag naar ruimte in dichtbevolkte kustgebieden. Het concept bestaat uit een duurzaam en energieleverend systeem van drijvende betonnen caissons. Door zowel de ruimte in de caissons als er bovenop te benutten, krijgt dubbel ruimtegebruik een nieuwe, maritieme dimensie. De mogelijkheden zijn onbegrensd, van een jachthaven met attractiepark voor een willekeurige kustlijn tot drijvende vakantieappartementen of een complete stad.

Geschreven door Deerns

## INTRODUCTIE

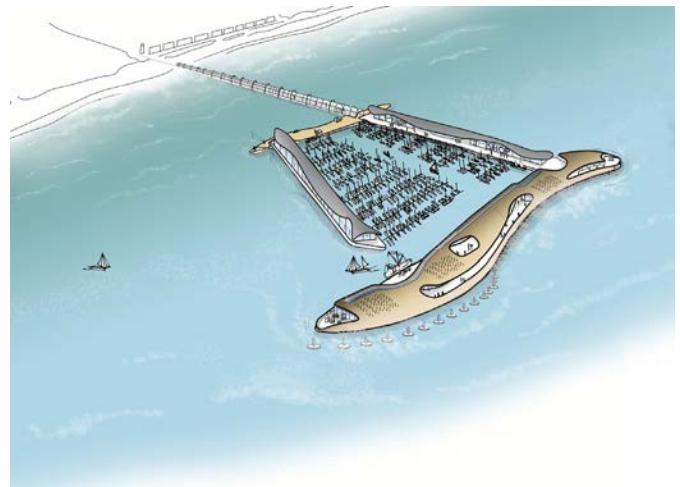
Het idee voor duurzaam energieleverend Drijfland leefde al langer bij Deerns. Er werd al diepgaand over nagedacht. Maar het was de prijsvraag 'Een duurzame toekomst voor Zuid-Holland' van de provincie die de senior consultants Bert Nagtegaal en Paul Stoelinga ertoe bracht er concrete invulling aan te geven, in een creatieve samenwerking met architectenbureau Kraaijvanger.

In plaats van inpolderen – het winnen van land uit zee – is dit een mooie vorm van 'uitpolderen'. "Land creëren op zee; een innovatief idee om invulling te geven aan een duurzaam drukbevolkt Zuid-Holland", vertelt Paul Stoelinga. "Duurzaam Drijfland spaart de schaarse dure ruimte op land en creëert een nieuwe attractieve kustlijn. Het resultaat is een uitgewerkt voorbeeldplan voor een drijvende jachthaven voor de boulevard in Noordwijk, gecombineerd met een Klimaat Experience Centre in de ruimtes onder de zeespiegel. Het geheel is zelfvoorzienend en zelfs energieleverend."

De keuze voor een jachthaven en een attractie als een klimaatexpositie voor de kust van Noordwijk is mede ingegeven door lokale behoefte. "Noordwijk kampt met een teruglopende economische activiteit door een tekort aan bijzondere toeristische attracties", zet Bert Nagtegaal uiteen. "Een jachthaven sluit goed aan bij de bestaande wens om tussen Scheveningen en IJmuiden een passantenhaven te creëren. Met de klimaatexpo op en onder water in de drijflichamen krijgt Noordwijk een attractie die - vergelijkbaar met het Klimahaus in Bremerhaven – landelijke en internationale bezoekers zal trekken."

## BETAALBAAR?

In antwoord op de vraag of het ook allemaal betaalbaar is, maakt Nagtegaal een vergelijking met de bouwkosten van een binnendijkse haven. "De grond aan de kust van Noordwijk is kostbaar en zal tenminste rond de € 1.200 per vierkante meter kosten. Dus reken maar uit wat het uitgraven van een paar hectare grond voor een jachthaven gaat kosten, nog afgezien van de aanleg van de infrastructuur. Met dat bedrag heb je al een belangrijk deel van de drijvende jachthaven gefinancierd." Niettemin ging de Zuid-Hollandprijs 2011 aan Deerns voorbij. "Ons plan bleek te veelomvattend. Misschien



Figuur 1 Duurzaam Drijfland: Kraaijvanger Architecten - Rotterdam

te ambitieus voor de provincie. Maar het leverde ons wel een duurzame schat aan ideeën op", zegt Stoelinga. "Terwijl Duurzaam Drijfland toch een ongekende wereld aan flexibiliteit en toepassingen biedt. Het vergroot de beleefingswaarde van de kustlijn. In compacte vorm kan het ruimte bieden aan uiteenlopende recreatieve functies als horeca, theater, bioscoop, expositieruimte, sportaccommodaties."

## COMPLETE STAD

"In een groter verband kan Duurzaam Drijfland uitgroeien tot een complete recreatiestad op het water. Het zal een attractie zijn om er te verblijven. Een stad die zelfvoorzienend is op het gebied van energie en zelfs meer dan dat. Zon, zee en wind leveren genoeg energie om ook de nabije kust van stroom te voorzien."

Deerns is ervan overtuigd dat die drijvende stad mogelijk is. Omdat het concept tegemoetkomt aan bestaande en toekomstige problemen. Op tal van plaatsen biedt de zeekust vooral ruimte voor expansie. Kijk naar Hong Kong, Monaco, New York. En dichter bij huis, bijvoorbeeld voor de kust van Den Haag.

**P**aul Stoelinga verwacht dat met het huidige concept de kustlijn zal worden verrijkt zonder ernstige horizonvervuiling, mede doordat een belangrijk deel van de ruimte zich onder water bevindt en de hoogte van de bebouwing beperkt is. "Vanaf de kust ziet bijvoorbeeld de drijvende jachthaven eruit als een zandbank, niet hoger dan zes, zeven meter, aansluitend bij het landschap. Het is niet de bedoeling om de kust helemaal vol te leggen. Vrij uitzicht blijft behouden."

## MOOIE OVERGANGEN

**S**toelinga signaleert een groeiende behoefte om meer te doen met de grensvlakken tussen water land. "In Rotterdam bijvoorbeeld. Daar zijn havengebieden beschikbaar gekomen voor bebouwing door de verplaatsing van havenactiviteiten naar de Tweede Maasvlakte. In die vrijgekomen havens zou je mooie overgangen kunnen creëren van kades naar drijvende bebouwingen. Er wordt in Rotterdam al over nagedacht."

**N**agtegaal zou het concept graag op New York willen projecteren. Hij ziet het helemaal voor zich, 'de overgang van wolkenkrabbers naar een verbreding van de stad in het water'. "Wonen, recreëren en water gaan goed samen", vertelt hij. "Venetië is een prachtig voorbeeld. Het historische centrum bestaat voor een groot deel uit water. Een recenter voorbeeld van een symbiose van water en land is Port Grimaud vlakbij Saint Tropez. In de jaren zestig is dit vroegere moerasgebied getransformeerd in een soort klein Venetië. Ieder huis is met een bootje bereikbaar. De eerste mensen die er een huis kochten werden voor gek verklaard, maar zij lachen nu iedereen uit. Het plaatsje vormt nu een toeristische trekpleister. Zo'n toeristische attractie is ook voor de Nederlandse kust voorstellbaar. Door meerdere elementen naast elkaar te leggen en op verschillende manieren in te vullen, kun je een aantrekkelijk organisch geheel creëren. En wat is er nu mooier om vanaf het water naar het land te kunnen kijken."

## BETONNEN PONTONS

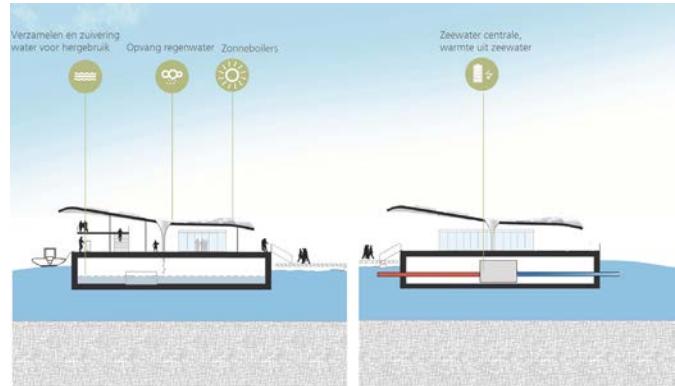
**S**toelinga: "De basis van Duurzaam Drijfland bestaat uit grote, onderling verbonden drijvende betonnen pontons. Voor de jachthaven variëren deze pontons in breedte van 20 meter tot 50 meter met een lengte van circa 350 meter. En dan nog eens zeven meter diep. Enorm ook wat je er allemaal mee kan doen, zowel onder als boven water. In het grote ponton is 13.000 m<sup>2</sup> beschikbaar voor de inrichting van een Klimaat Experience Center."

**V**erkijk je niet op de tekening; het complex heeft een enorme omvang. Dat moet ook wel om de zee te kunnen weerstaan. Dat het geheel desondanks niet als een reusachtig seamark de omgeving domineert, komt doordat een groot deel van de ruimte zich onder het wateroppervlak bevindt. "De techniek van bouwen met pontons in zee is overigens niet nieuw", zegt Nagtegaal. "Bij de landing in Normandië op D-day zijn pontons toegepast als tijdelijke havens. Een aantal jaren geleden is in de haven van Monaco een 350 meter lang drijvend caisson geplaatst die behalve als golfbeeker ook dienstdoet als parkeergarage. Drijvend bouwen kan ook op polystyreen blokken, bedekt met een betonnen plaat, die over de randen heen is gekapseld. In de Rotterdamse Rijnhaven drijven drie glazen bollen die volgens dit principe zijn gebouwd. Nadeel van dit systeem is dat het minder stabiel is en geen binnenruimte oplevert.

**D**earns is niet de enige die toekomst ziet in drijvende bouwwerken. Stoelinga: "Er zijn op verschillende plekken in de wereld meer partijen bezig met de vraag wat je allemaal kan laten drijven. Woningen op drijvende vlonders zetten, gebeurt al vrij veel. Wat wij ons ten doel stellen, is van een andere orde. Wij laten verschillende technologieën en toepassingen in elkaar grijpen, op een schaal die niet eerder is verstoond. In die zin is Duurzaam Drijfland echt vernieuwend."

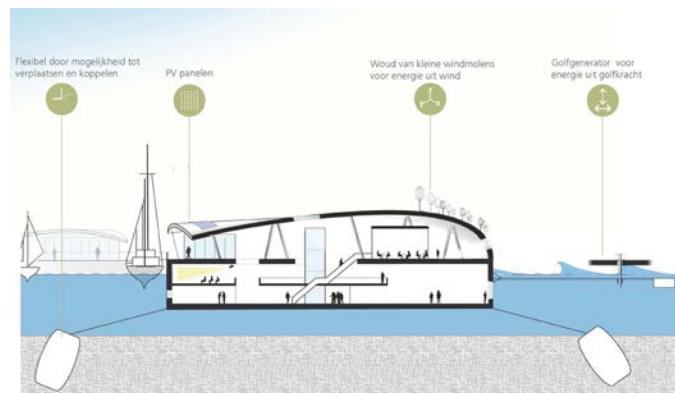
## ENERGIELEVERANCIER

**H**et energetisch concept van de drijvende jachthaven laat zien hoe zee, wind en zon zorgen voor de benodigde warmte, koude en elektriciteit. Een zeewaterwarmtecentrale onttrekt warmte en koude aan het zeewater. Genoeg voor verwarming en warm tapwater, alsook voor de gewenste koeling van de horeca. Dit principe wordt al met succes toegepast in de Scheveningse wijk Duindorp.



Figuur 2 Energetisch concept gerelateerd met de zee

**G**olfgeneratoren aan de buitenzijde van de ponton produceren een belangrijk deel van de energie, evenals zonnepanelen en kleine, minder in het oog springende, windturbines. De 25 golfgeneratoren werken dag en nacht, het hele jaar door, ook zonder wind en zon. Dat levert per jaar 3,5 GWh elektriciteit op, vrijwel genoeg om autarkisch te kunnen functioneren. Daar komt nog eens 240 MWh per jaar bij, geproduceerd door 120 kleine windturbines die op de gebogen overkapping aan de zeezijde van het eiland staan opgesteld. Plus 250 MWh per jaar van de 1250 m<sup>2</sup> zonnepanelen die op het dak van het grote ponton zijn geplaatst. Alles bij elkaar zorgen zon, zee en wind voor energie voor het eiland en de schepen in de haven en voor een flink elektriciteitoverschot, dat voorts geleverd wordt aan Noordwijk.



Figuur 3 Energieopwekking door middel van zee, wind en zon.

## ALLES KAN

**H**et zal niet bij het plan voor een drijvende jachthaven voor de kust van Noordwijk blijven, is de overtuiging van het team van Dearns. Stoelinga: "Er zullen gesprekken volgen met ontwikkelaars om het idee verder rijp te maken. Ook voor hen is Duurzaam Drijfland een interessante propositie. Wat met een stapel stenen op een vaste locatie niet kan, kan met drijvende bouwelementen wel. Vergroten, verkleinen, verplaatsen naar andere bestemmingen, je kunt er alle kanten mee op. Bij gebeurtenissen als de Olympische Spelen bijvoorbeeld. Stel je eens voor wat je voor de deur van dit toernooi aan drijvende voorzieningen had kunnen neerleggen. Hoeveel flexibeler je bent met het invullen van tijdelijke wensen op specifieke locaties."

# Modelling acoustic propagation with a wave-based calculation method

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## ABSTRACT

Computing the acoustics of indoor and outdoor spaces is traditionally carried out by simplified calculation methods at a low computational cost. The use of such methods does however exclude various acoustical aspects as meteorological influences, modal effects, periodic surface structures and a realistic auralization. A wave-based calculation method that does include all these aspects at a reasonably low computational cost, the pseudospectral time-domain (PSTD) method, is currently developed. This method computes the time and spatially dependent sound pressure. An overview of the state-of-art of PSTD as well as planned developments is given here.

## INTRODUCTION

### SIMPLIFIED CALCULATION METHODS

For the quantification of the acoustics of indoor and outdoor spaces, simplified calculations methods have been available for quite a long time. These methods allow computing important quantities as the sound pressure level and the reverberation time by hand. The calculation methods apply strictly for extreme situations as a free or diffuse sound field. The latter can be assumed to hold for certain enclosed spaces and the higher frequency range. The diffuse sound field assumption is however not valid for a wide range of enclosures, e.g. as corridors and sport halls, and the lower frequency range. In the last two decennia, computational room acoustic methods have been developed called geometrical acoustics methods (see [1] for an overview). These models mainly rely on the assumption that the sound field can be described by a summation of rays, which is analogous to calculating the illuminance in enclosures. The geometrical acoustics methods are applicable for various rooms and the accuracy has been frequently investigated [2]. Besides geometrical acoustics methods, other methods have been developed as the radiosity method or a method relying on the diffusion equation. These models have a similar accuracy as the geometrical acoustics methods. An overview of these methods can be found in literature [1].

Various acoustical aspects can however not be captured by the above-mentioned methods. The interference effect caused by the seat height in room acoustics (also known as the seat-dip) represents such an effect [4]. Also, modelling modal effects in small enclosures is problematic. Acoustic materials have an angular dependent impedance which cannot be accounted for by only imposing a surface impedance, the latter being a custom in geometrical acoustics methods. Other deficits are related to diffraction of sound waves near edges and near material discontinuities. Various developments have been presented to overcome these shortcomings, for example the inclusion of analytical diffraction methods [3]. An

important development within acoustics in the built environment is auralization [5]. Using auralization can be seen as a complement to the currently widely used visualisation tools for the design of buildings. An accurate acoustic prediction method is however necessary for a realistic auralization, and the current geometrical acoustics methods partly fail for these purposes [6].

To model urban acoustics, a similar evaluation of the computational methodologies as sketched above applies. Accurate prediction methods already exist for the computation of long-range sound propagation (see [7]), but such methods are limited for inner city environments. In the Netherlands, the 'standaardrekenmethode II' is often used for these environments, and other European countries use similar methods. The biggest drawback of this method is that multiple reflections as typically occur in inner city environments are not included, diffraction of sound waves to areas geometrically shielded from noise sources is included to a limited extend, which also holds for effects induced by meteorological conditions. Moreover, the directionality of sound sources is not included.

### WAVE-BASED PREDICTION METHODS

Wave-based time-domain methods have emerged in the last 10 years. These methods solve the wave equation and thereby do not make assumption on simplifying the sound field. Besides the technological challenges to develop such methods, a large restriction is the calculation time needed to solve problems of realistic dimensions and frequency range. The most used method is the finite-difference time-domain method [8], in which finite differences are used to solve the wave equation, or the linearized Euler equations (see Section 2). The method discretizes the whole volume and typically requires 10 spatial points per wavelength. For a three dimensional problem of 30 m x 30 m x 5 m and a maximum frequency of 4 kHz, this corresponds to 7.3 10<sup>9</sup> (7300 million) calculation points. It is obvious that this requires a high computational load. In the Building Acoustics group of BPS, a more efficient wave-based time-domain method is being developed, the pseudospectral time-domain (PSTD) method. This method only requires 2 spatial points per wavelength. Still, PSTD requires many calculation points (5.8 million in the above example), but offers more perspective in modelling realistic geometries.

In this article, the principles of PSTD are briefly mentioned in Section 2, as well as the developments that have been made to make PSTD useful to model acoustic propagation in the built environment. Section 3 present a selection of applications of the PSTD method. We conclude with a discussion and give a glance of future plans with PSTD.

## THE PSTD METHOD - PRINCIPLES

Sound propagation in indoor and outdoor spaces can be described by means of the linearized Euler equations (LEE). The acoustic pressure and velocity components are the variables of these partial differential equations:

$$\begin{aligned} \frac{\partial p}{\partial t} + \mathbf{u}_0 \cdot \nabla p + \rho_0 c^2 \nabla \cdot \mathbf{u} &= 0, \\ \frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}_0 \cdot \nabla) \mathbf{u} + (\mathbf{u} \cdot \nabla) \mathbf{u}_0 + \frac{1}{\rho_0} \nabla p &= 0, \end{aligned} \quad (1)$$

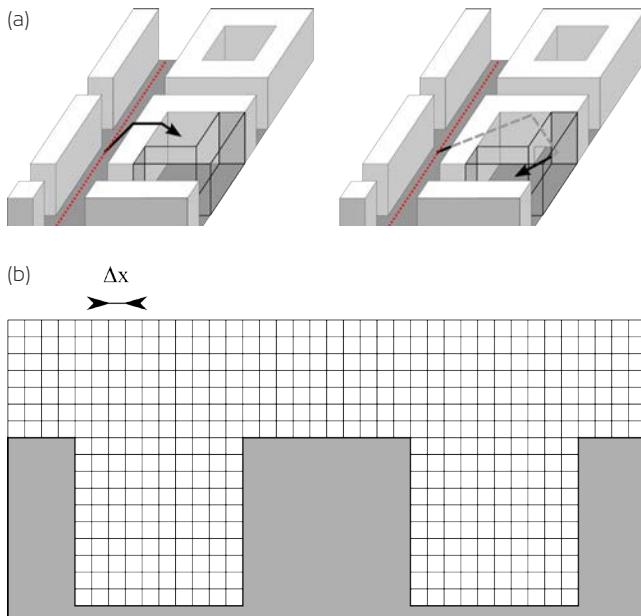
With  $p=p(x,t)$  the acoustic pressure,  $\mathbf{u} = \mathbf{u}(x,t) = [u, v, w]$  the acoustic velocity components and  $\mathbf{u}_0 = \mathbf{u}_0(x) = [u, v, w]$  the mean velocity component of the propagation medium. The density is expressed by  $\rho_0 = \rho_0(\mathbf{x})$ , and the adiabatic speed of sound by  $c = c(\mathbf{x})$ . All acoustic variables depend on space  $\mathbf{x} = [x, y, z]$  and time  $t$ , and the medium properties depend on space (the density and speed of sound do for example depend on the spatial variations in temperature). For cases with a zero mean velocity of the propagation medium, the wave equation can be derived from the LEE:

$$\nabla \cdot \left( \frac{1}{\rho_0} \nabla p \right) - \frac{1}{c^2 \rho_0} \frac{\partial^2 p}{\partial t^2} = 0. \quad (2)$$

All acoustic effects of interest do appear from method that solves equation (1) completed by boundary and initial conditions. For situations that cannot be described analytically, we need to resort to a numerical method to solve equation (1). Such a numerical method discretizes the complete volume of interest by discrete calculation points, in which an approximation of the exact solution is searched for. The solution converges to the exact solution when the discretization is refined, but at the same time entails a larger calculation time due to the higher number of calculation points.

In the PSTD method, a geometry is discretized by an equidistant Cartesian grid. Figure 1b shows a geometry with a PSTD grid. The time is also discretized, with a solution converging to the exact solution with refining the temporal steps.

The spatial derivatives in equation (1), i.e.  $\nabla p$  and  $\nabla \cdot \mathbf{u}$ , are computed per time step. This is done using the Fourier pseudospectral method, in which derivatives are computed in



the wavenumber domain. This implies that a Fourier transform and inverse Fourier transform is applied to the acoustic variables. More information can be found in literature [9]. PSTD leads to an accurate solution requiring only 2 spatial points per wavelength. As an example, a discretization of  $\Delta x = 0.1$  m corresponds to a highest resolved frequency of  $f = c/(2\Delta x) = 1700$  Hz for  $c = 340$  m/s.

## DEVELOPMENTS

In recent years, developments have allowed to apply the PSTD method to sound propagation in the built environment. At first, a method is developed to accurately include boundary conditions [9]. The boundaries are modelled by explicitly treating the bounding media as propagation media. This method allows modelling an angular independent absorption coefficient between 0 and 1. Also, it is approximately possible to model a locally reacting medium, implying an angular dependent absorption coefficient [11]. An attempt to model frequency independent boundary conditions has been made too, but a high accuracy is not obtained in general [12]. The equidistant Cartesian mesh implies that a grid refinement is global. A multi-domain PSTD method has therefore been presented, which enables a local grid refinement without affecting the global grid spacing [13]. This more efficient method moreover does not entail an extra numerical error. Recently, a start has been made to develop the PSTD method for non-Cartesian geometries [14], enabling to model inclined or curved surfaces.

## APPLICATIONS OF THE PSTD METHOD

The PSTD method has already been applied to a variety of cases. Here, various applications of the PSTD method are presented to illustrate the possibilities of the method.

Sound propagation to urban courtyards Urban inner yards have the potential to be quiet areas, but various acoustic propagation paths could cause the propagation of noise from road traffic into these areas, see Figure 1a. With PSTD, calculations have been carried out to compute the contribution of sound propagation through an opening to the courtyard as well as the sound propagation path over the building block, see Figure 1c. It is clear that sound propagation at low frequencies is dominated by propagation over the building block, and that higher frequencies are dominated by propagation through the opening. Details of the calculation can be found in [15].

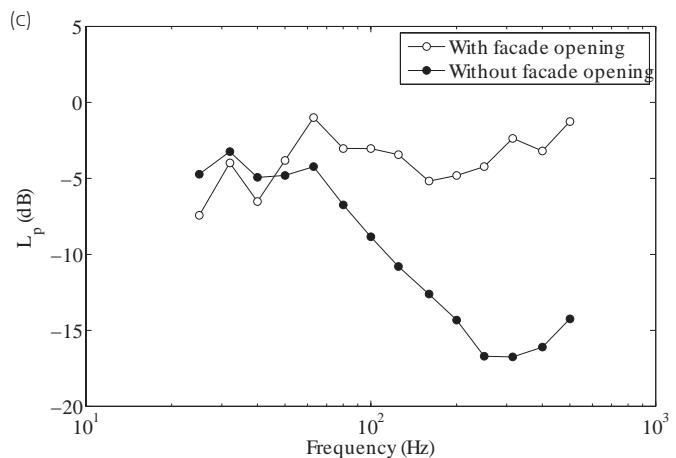


Figure 1 Sound pressure level in an urban courtyard due to noise from road traffic. (a) Two sound propagation paths from street to courtyard, (b) Two dimensional cross-section near the inner yard with the PSTD grid schematically shown, (c) Averaged sound pressure level at the courtyard relative to the free field level due to the nearby road traffic.

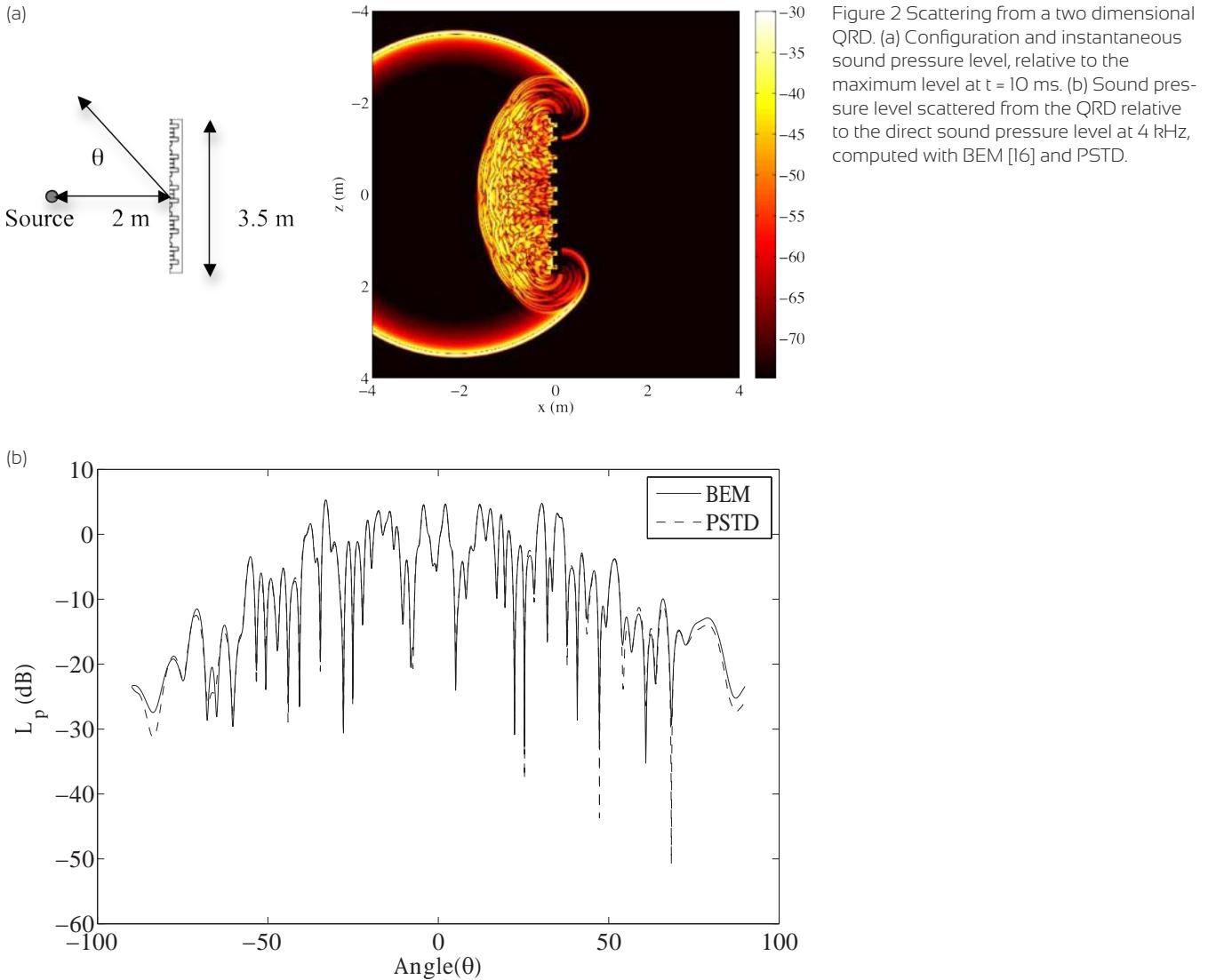


Figure 2 Scattering from a two dimensional QRD. (a) Configuration and instantaneous sound pressure level, relative to the maximum level at  $t = 10$  ms. (b) Sound pressure level scattered from the QRD relative to the direct sound pressure level at 4 kHz, computed with BEM [16] and PSTD.

## DIFFUSERS

It is a custom to use diffusers in theatres and concert halls in order to obtain a spatially more evenly distributed sound field. The sound scattered from a quadratic residue diffuser (QRD) has been computed by PSTD. The multi-domain PSTD method has here been applied: a refined computational grid is used to model the sound field close to the QRD, and a coarse grid is used away from the QRD. Figure 2a shows the sound field at  $t = 10$  ms. Diffraction of the sound behind the diffuser is visible, as well as the diffuse character of the reflected sound field from a surface. The angular dependent sound field is compared to calculations according to the boundary element method (BEM) and is shown in Figure 2b. Results exhibit a close agreement.

## SPORTS HALL

Predicting the room acoustical properties of enclosures as a sports hall with a non-uniformly distributed amount of boundary absorption is difficult with simplified prediction methods as geometrical acoustical methods, and we need to rely wave-based methods for such cases. The sound field in a sports hall is here computed using the three dimensional PSTD method. The acoustic absorption of the applied materials of this example is highest for the upper part of the hall. Figure 3a shows two instantaneous sound fields, clearly showing the wave front. Figure 3b shows the impulse response for the receiver position as indicated in Figure 3a. The repetition of room reflections, also known as a flutter echo, is visible in the impulse response.

## METEOROLOGICAL EFFECTS

In atmospheric sound propagation, meteorological effects are of high importance. PSTD has successfully been applied to compute sound propagation over a noise screen in the presence of a mean wind field [9]. The effect of wind is qualitatively shown in Figure 4 for a simplified configuration of sound propagation over a rigid surface without noise screen. Figure 4b shows the sound field excited by a point source after 4.5 s. Results are shown in the absence and presence of a wind field. It is clear that the wind field causes multiple reflections with the ground surfaces and an increase of the sound field close to the ground.

## DISCUSSION

This article illustrates the possibilities of modelling acoustics of indoor and outdoor spaces by using a wave-based calculation method, PSTD. The various examples demonstrate that the method comprehensively shows the mechanisms behind sound propagation (diffraction, reflection, refraction etc.) and that accurate solutions can be obtained that are important for a variety of cases. An underexposed aspect here is auralization, which can be carried out with the impulse responses as computed with PSTD. Still, PSTD has its drawbacks. It is currently not possible to model frequency dependent surface-impedance values. Besides this aspect, there is a need for a user-friendly interface. Within the European project openPSTD, an open-source software of the PSTD method is currently under development ([www.openPSTD.org](http://www.openPSTD.org)). The PSTD developments as planned

in openPSTD include coding some of the parallel calculations behind the PSTD code on the Graphics Processing Unit (GPU) besides the traditional CPU. With the planned developments, it will in the near future be possible to compute the acoustics of indoor and outdoor spaces for realistic geometries and frequency range.

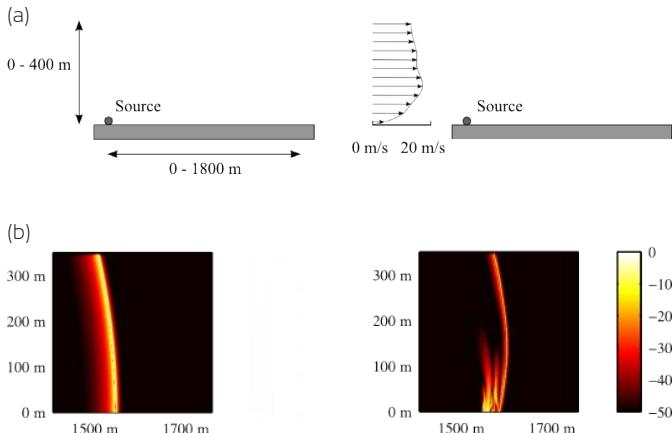


Figure 3. Sound field in a sports hall. (a) Instantaneous sound pressure level relative to the maximum value of the initial level, (b) Impulse response at receiver position O due to source position B.

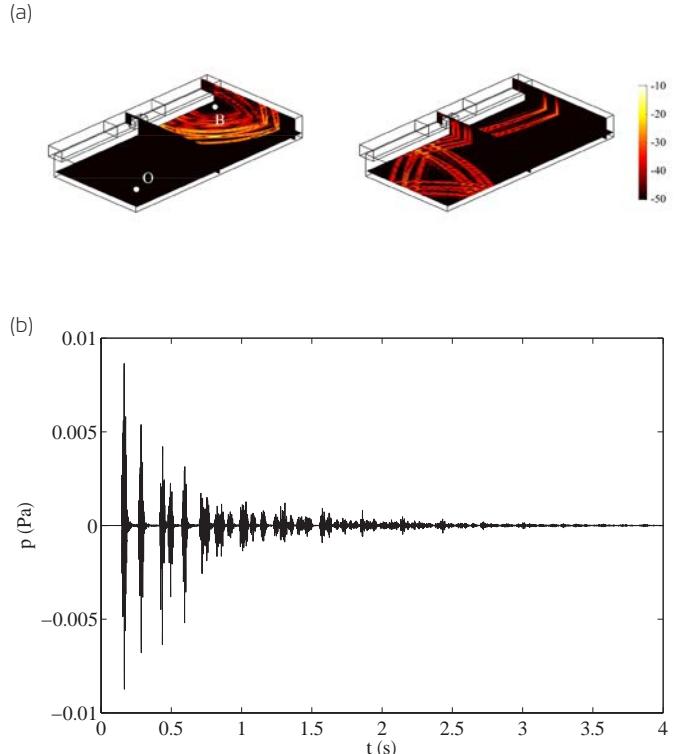


Figure 4. Sound propagation over a rigid ground surface in the absence and presence of a wind velocity profile. (a) Two configurations, (b) Sound pressure level relative to the maximum instantaneous level at 4.5 s. Left: without wind, right: with wind.

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# Merano

Karin Conen  
Christina Randjet-Singh  
Eef Brouns



A long time ago in a kingdom far far away five brave students of the Eindhoven University of Technology faced the challenge of participating in a winter school for young acoustics...

Organized by the European Acoustics Association ambiguous students got the opportunity to follow lectures from the best professors and acousticians from all over Europe. In three days we followed ten lectures on various subjects in the field of acoustics. Besides basic acoustics, also more advanced courses were given.

The course 'Fundamentals' was given by prof. dr. Michael Vorlander. More information on vibrations and types of waves was given. Though, we already knew the basics, a different way of teaching, gave us new insides in this knowledge.



Also the lecture 'Noise control' given by Joachim Scheuren had some eye-openers: the development of noise control equipment is a hot-topic, but even though this subject is of sufficient matter, the development of new equipment cannot decrease the amount of noise pollution as a result of the increasing noise levels emitted by amongst others traffic and industry.

For us quite unfamiliar subject, but not less interesting, was the course on underwater sound. Professor Michael Taroudakis presented us the origins of measurements on sound levels and propagation under water. He explained to us the differences in sound propagation through water respectively air, and showed us some modern modeling approaches. Underwater sound is a field of study which offers ongoing research subjects interesting for not only acoustician, but also other researchers. Subjects of research can be submarines, geology and animal behavior.

The last course was given by Murray Campbell, from the University of Edinburgh: a very enjoyable class on musical acoustics. Several types of instruments -stringed, woodwind, percussion and brass- were demonstrated to us, after which he explained the how and what behind the unique sounds of each instrument. With this amusing though informative lecture the winter school was almost over. All of the participants had to fulfill a final examination on the courses followed. Fortunately, all five of us passed the exam and received a certificate for participating and passing the winter school.

With a head full of new knowledge on various subjects in the field of acoustics, a heart full of pride from being part of this happening and a list full of new contacts, the five brave students of the Eindhoven University of Technology travelled back home and they lived happily ever after.

# Solliciteren, de do's and don'ts

## BEGINNEN BIJ HET BEGIN

Tegenwoordig zijn er veel verschillende manieren om aan een afstudeeropdracht of baan te komen. Verschil met het solliciteren van een aantal jaar geleden, is dat jij als sollicitant niet alleen kan zoeken naar bedrijven of vacatures, maar dat het steeds gebruikelijker wordt om bedrijven en vacatures jou te laten vinden. Denk aan het aanmaken van een profiel op een jobboard of het inschrijven voor searchagents (bijv. die van KP&T op kpt.nl/searchagent) om de laatste vacatures te ontvangen. Maar natuurlijk ook aan het presenteren van jezelf middels diverse online profielen.

## PERSONAL BRANDING

Jezelf professioneel presenteren om in aanmerking te komen voor die ultieme afstudeeropdracht of baan kan op diverse manieren. We maken onderscheid in de traditionele manier en via online / social media.

## TRADITIONEEL

D deze manier kennen we allemaal: het opstellen van een cv Den dit (eventueel met motivatiebrief) naar aanleiding van je gevonden vacature, sturen naar de betreffende organisatie / contactpersoon. Niets mis mee! Maar als je het doet, doe het wel goed. Hier volgen een aantal tips:

- Check je CV op taal- en typefouten
- Zorg voor een overzichtelijk CV  
Bouw je cv op van heden naar verleden en zorg dat de werkgever binnen 3 seconden de belangrijkste informatie uit je cv kan 'scannen.'
- Zet duidelijk je werkervaring in je CV  
Vermeld niet alleen bijbaantjes en vakantie werk, maar ga zeker ook in op projecten en opdrachten vanuit je opleiding en stages die je hebt gelopen.
- Vergeet zeker niet je softwarekennis en eventuele talenkennis in je CV te vermelden
- Voeg een persoonlijke noot toe in de vorm van hobby's, vrijwilligerswerk etc.
- Zet niet zomaar referenties met naam en contactgegevens op je cv, maar vermeld altijd op aanvraag

## ONLINE / SOCIAL MEDIA

Middels online / social media kun je niet alleen zelf solliciteren, maar het biedt ook de mogelijkheid om jezelf 'vindbaar' te maken voor werkgevers. Het online vindbaar zijn heeft uiteraard voordelen, maar er schuilen ook 'gevaren'. Hieronder een aantal aandachtspunten:

- Maak een LinkedInprofiel aan  
LinkedIn is een zakelijk netwerk en je profiel een soort digitaal CV. Anders dan het standaard CV, kun je via LinkedIn om aanbevelingen vragen, je interesses kenbaar maken door je bij groepen aan te sluiten etc. Waar je voorheen visitekaartjes verzamelde, voeg je nu contacten toe via LinkedIn. Daarnaast blijf je gemakkelijk in contact met (oud) studiegenoten, docenten en (oud) werkgevers. Organisaties gebruiken het daarnaast meer en meer om de geschikte kandidaat voor hun vacature te vinden.



- Scherm profielen die je privé wilt gebruiken goed af  
Profielen als facebook en twitter worden door veel mensen privé gebruikt. Daar staat soms informatie op waarvan je niet wilt dat je (toekomstige) werkgever deze vindt.
- Google jezelf!  
Werkgevers zoeken hun sollicitanten tegenwoordig altijd op via internet. Zorg dus dat je weet wat ze gaan vinden. Online informatie kan naast een positief beeld ook een negatief beeld schetsen van wie je nog meer bent naast je cv. Denk aan partypics, maar ook onvolledige / niet up to date profielen.

## EENMAAL UITGENODIGD VOOR HET GESPREK

A ls je eenmaal bent uitgenodigd voor een sollicitatiegesprek, begint het echte werk. Je hebt maar één kans om een goede eerste indruk achter te laten. Een goede voorbereiding is dus een must. Hieronder een aantal veel gemaakte fouten:

- Je weet niet met wie je een gesprek hebt  
Als je bij de balie niet kan aangeven met wie je een gesprek hebt, sta je al 1-0 achter. Daarnaast kan het verdiepen in je gesprekpartner (bijvoorbeeld via LinkedIn) waardevolle informatie opleveren die je tijdens het gesprek kunt gebruiken.
- Je hebt je niet goed genoeg verdiept in de organisatie  
Je bent een TU student, dus met alleen weten hoe het bedrijf heet en waar ze gevestigd zijn, kom je niet weg! Goede oefening is zorgen dat je een 'minipresentatie' van 5 minuten kunt houden over het bedrijf waar je solliciteert.
- Je kent de ins en outs van de vacature niet  
Als je niet precies weet op welke vacature je solliciteert, kun je ook nooit goed onderbouwen waarom je in aanmerking zou moeten komen voor de functie.
- Je weet tijdens het gesprek geen vragen te stellen  
Bedenk daarom vooraf een aantal vragen. Niet alleen vragen die jij kunt stellen aan de werkgever, maar vooral vragen die je van de werkgever kunt verwachten. Doordat je al vragen en antwoorden achter de hand hebt, kun je je echt concentreren op het gesprek en inspelen op wat er gezegd wordt.

- Je hebt geen schrijfmateriaal bij je  
Schrijfmateriaal is niet alleen handig om tijdens het gesprek aantekeningen te kunnen maken, maar ook om hier op voorhand de vragen in op te nemen die je zeker beantwoord wilt hebben (In case of black-out!).

#### TIJDENS HET GESPREK

Daar zit je dan, aan tafel met je misschien wel toekomstige werkgever en het gesprek begint. Heb je een open of gesloten houding? Maak je een geïnteresseerde of juist een zenuwachtige indruk? Zeg je niet te vaak uhm..? Stel je de juiste vragen? Hoe beter je bent voorbereid, hoe meer je tijdens het gesprek kunt letten op hoe je overkomt. En hoe sluit je het gesprek professioneel af? Hier volgen nog een paar laatste tips:

- Zorg dat je altijd een tweetal vragen achter de hand hebt wanneer de werkgever aan het eind van het gesprek vraagt of er nog vragen zijn  
Bijvoorbeeld: Hoe ziet de sollicitatieprocedure er verder uit? Zijn er nog meer kandidaten? Wanneer hebben we weer contact en wie neemt contact op met wie?
- Zorg dat jij en de werkgever aan het eind van het gesprek een duidelijk beeld hebben van elkaars verwachtingen. En maak concrete vervolgafspraken!



Ben jij benieuwd naar onze andere sollicitatietips? Wil jij feedback ontvangen op je CV of middels een training bij KP&T bovenstaande tips in praktijk brengen als voorbereiding op jouw sollicitaties?

Neem dan contact op met:

Marcelle Marks  
m.marks@kpt.nl / 06-10204387

**Benut je talent  
en haal het beste uit jezelf!**



... wij gaan voor 'n tien!

Ben jij bijna klaar met je studie en op zoek naar een leerzame startersfunctie? Of ben je nog op zoek naar een (afstudeer)stageplek voor volgend schooljaar? Onze gespecialiseerde adviseur begeleidt je bij het in kaart brengen van je wensen en ambities, in de voorbereiding op je sollicitatiegesprek en tijdens het opdoen van je eerste werkervaring. Zo helpt KP&T je doelgericht in je zoektocht naar een passende uitdaging!

**KP&T, voor jouw baan in Bouwkunde, Civiele Techniek, Elektrotechniek, High Tech, Installatietechniek en Werktuigbouwkunde.**

# Meet & Greet

Marije Te Kerve

On Thursday the 28<sup>th</sup> of February the fifth floor of Vertigo was dominated with a feeling of excitement. Yes, it was the day the Meet & Greet of Mollier would take place. So all Mollier students were looking forward to 4 o'clock. But it seemed like the clock was ticking slower than ever. Another cup of coffee, doing some simulations, reading a paper, all to let time go faster but it was hard to concentrate.

Meanwhile in the Mollier corner students were busy preparing snacks and drinks, making coffee and tea, preparing the presentation, decorating the room and packing the gifts. They did their very best to make sure everything was ready in time. And before they realized, the first people already entered the room. It was time to get started. While the delegates of the different companies were displaying their promotional materials, the first students also entered the room. After a cup of coffee the colloquium room was filled with students and delegates of nine companies.

The activity started with a short introduction of all companies. So all students knew with who they wanted to get in contact with. The students who were a bit shy, first grabbed a beer to gain some courage. Some ambitious students thought of a strategy to contact as many people as possible. Other students went for their goal directly. Conversations about future plans, internship and jobs filled the room with a pleasant sound. Nice and interesting meetings took place and business cards and contact information were exchanged.

After 7 o'clock, people slowly left the room and went home. But some students gathered together and started to develop other plans. Indeed again future plans, but this time for the really near future. They did not want to go home yet. So where to continue after leaving the building, where to have dinner, and where to continue drinking beer? These questions were not as easy to answer as it seemed but finally everyone went home, with or without some stops in between.



The information of the companies was exposed on one of the tables



The introduction of Wolter & Dros



An attentive audience during the introduction of the companies



Many people were connecting during the informal drinks

# *Durf jij in een dynamische situatie een sprong te wagen?*



BAM Techniek is op zoek naar talentvolle, ambitieuze collega's die willen samenwerken aan innovatieve en duurzame oplossingen. Collega's die 'techniek in hun genen' hebben en verder willen kijken dan wat voor de hand ligt. Wij moedigen je aan om anders te denken en te handelen.

BAM Techniek biedt een dynamische werkomgeving met goede doorgroei mogelijkheden en permanente aandacht voor technische innovatie én individuele ontwikkeling. Handel vandaag al anders en kom met ons praten over een stage, traineeship of een vaste baan in een professionele werkomgeving met een energieke en collegiale cultuur.

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# Energy-efficiency gains by an innovative cover of greenhouses

## INTRODUCTION

The question that was addressed some decades ago by the Dutch government to the Wageningen University is: "how can the energy use of Dutch greenhouses be improved?" Since 1990 the LEI Wageningen UR institute researches the energy topic of greenhouses in the Netherlands. A monitoring of the sector's energy use and energy-efficiency is since then annually published [1].

The monitors by LEI primarily indicate the progress that is made in the energy reduction of the sector in the Netherlands. A large reduction can be seen over the period 1990 – 2010. In 1990 the sector used 40,9 m<sup>3</sup> natural gas equivalent/m<sup>2</sup>, and it used 29,6 m<sup>3</sup> gas equivalent/m<sup>2</sup> in 2010. This realization was due to some explicit policies, of which the cogeneration policy, an implementation of combined heat & power systems in greenhouses, has been most effective. This strategy enables the sector to produce power commercially from natural gas, and use the cogenerated heat for its own heating purpose.

However we will formulate here also criticism on the realizations that are carried out. 1) Due to the CHP-concept and its amounts of 'free' heat, the energy-efficiency of greenhouses in the Netherlands is improved, but one can also see that these policies mean a barrier for real (vital) progress. The proportion of sustainable energy as used in Dutch greenhouse is low: only 1.8% of the used fossil energy (fig. 2). Applied high tech innovations of greenhouse design, like aquifers and heat pumps, could not boost the proportion of sustainable energy use of Dutch greenhouses in recent years. 2) As disappointing is the absolute figure of energy consumption which LEI reveals, being still over 8% of the national gas consumption [1]. 3) Thirdly, it is reported in the monitor 2011 that a drawback in energy reduction has occurred in 2011. This means that the fossil energy consumption is raising again, due to two factors as represented in figure. 3.

## PROBLEM ANALYSIS

The sustainability problem described here represents an economic problem for the Netherlands. Dutch greenhouses deliver horticultural products for inland use as well as for export, and this industry is acting in an open, merely global market. The sector employs 60.000 people today, but may lose its economic position by upcoming, warmer countries due to their less energy consuming cultivation methods. As energy will be an important parameter for the future (given the tendency of energy prices to rise), the acceptance of most unsustainable energy levels will gradually enforce that Dutch greenhouses will be losing their markets.

Therefore it was resolved in the Dutch Agro covenant 2020 that a 20% proportion of sustainable energy should be used in Dutch greenhouses by 2020 [2]. However, the sector makes very little progress on this goal: the progress of the last years was 0,2 % per year, an amount which is being due to power trading mainly. The remaining progress until 2020 must now be an improvement of 18,2 %; a perspective which is completely out of reality.



Figure 1 Greenhouse

Aandeel duurzame energie in de glastuinbouw per jaar en de doelen voor 2010 en 2020

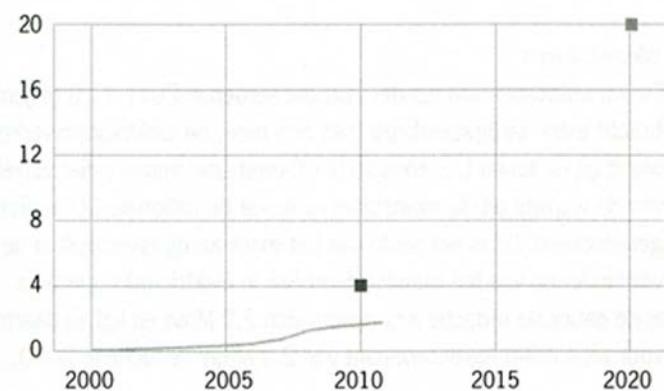


Figure 2 Sustainable energy used in Dutch greenhouses, the actual proportion (line) and targets (dots)

Fysieke productie en primair brandstofverbruik in de productieglastuinbouw per m<sup>2</sup> kas per jaar  
Index (% 1990)

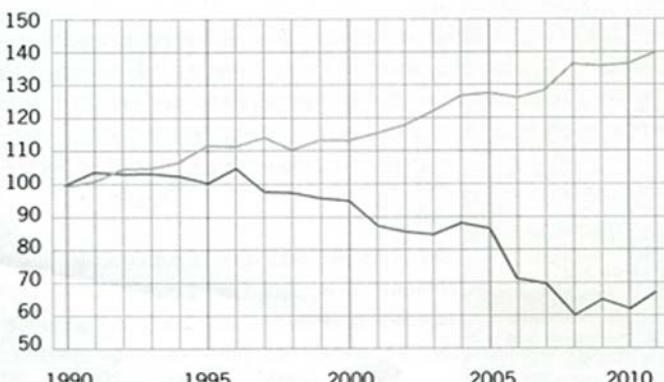


Figure 3 Actual tendency in primary energy use in Dutch greenhouses, indicated by the black line

However, the former strategies are still followed: product economization and process economization. The first strategy means cultivation of new varieties and qualities of the crops; the second is a reduction of the energy costs. The first strategy is also called 'intensification', having the goal of producing more with less. Actually, the 2011 monitor shows that the intended product intensification in terms of less energy use is not possible: gradually more energy is needed if the indoor climate of the greenhouses is 'tailored' by using artificial lighting, crop cooling, etc. This extra energy consumption is not going to be compensated by the second strategy (including the policy of CHP). As an extra inland complication the acreage of the industry should be mentioned; this is already 10 500 hectares now, being 105 km<sup>2</sup> and 0,37% of the Dutch soil.

A logical thesis for solving the problem of the greenhouse energy consumption is to reduce the heat conduction through the cover. This is illustrated by some calculations. In a greenhouse the conductive heat transfer is the linear result of the U-value of the applied cover and of the operational temperature gradient. There are U-value's of 5.8 W/(m<sup>2</sup>.K) for single layers of glass (4 mm), 3.3 W/(m<sup>2</sup>.K) for double layers of glass (4-6-4 mm), and of 1.9 W/(m<sup>2</sup>.K) for twin wall polycarbonates (16 mm). Given the mean thermal conditions, typically T<sub>in,day</sub> of 23,0 °C, T<sub>in,night</sub> of 16,0 °C and T<sub>out,year</sub> of 10,1 °C (mean outdoor temperature), the cover will cause thermal fluxes that vary from 27,0 – 82,3 W/(m<sup>2</sup>) during daytime, and from 12,3 – 37,6 W/(m<sup>2</sup>) during nighttime. This results into energy losses that vary from 0,62 GJ/(m<sup>2</sup>.year) to 1,89 GJ/(m<sup>2</sup>.year) for U-values from 1,9 - 5,8 W/(m<sup>2</sup>.K) respectively. An application of reflective coatings in order to reduce this value has serious drawbacks on the so called PAR-performance that is essential for the admission of photosynthesis active radiation for crops. Hence an applied coating on a cover will diminish the growing of the crops and consequently frustrate the intended intensification.

Conductive heat losses are being less important than convective losses in greenhouses for some reasons. The use of ventilation is based on controlling the RH of indoor air below a critical moisture level of 80% (such that crops are prevented from fungicide attacks). For ventilation an air change factor of 2,5/h is needed. The convective losses are equal to the energy needed for preheating fresh outdoor air. They have become less important firstly because the convective losses are compensated by the application of climatic devices like heat exchangers. Without the use of heat exchange devices the convective energy consumption should be estimated 270,9 KJ/(m<sup>2</sup>.h), an amount of 1,73 GJ/(m<sup>2</sup>.year). Applying a heat exchanger and/or a solar heating collector can be effective up to 75 %. However the use of aquifers in Dutch greenhouses increases, the effects are not reducing the fossil energy consumption, which is due to the fossil energy needed for the operation of the heat pump.

From these calculated amounts we see a difference with the monitored energy use, as the calculated heat losses are 1,2 GJ/(m<sup>2</sup>.year) + 0,25 x 1,73 GJ/(m<sup>2</sup>.year) = 1,63 GJ/(m<sup>2</sup>.year) in 2011. The monitored energy use in 2011 is 0,95 GJ/(m<sup>2</sup>.year), indicated by LEI. (0,95 GJ/m<sup>2</sup> means 30,2 m<sup>3</sup> natural gas equivalents.) This 0,68 GJ/(m<sup>2</sup>.year) gap is very significant and can just mean that the conductive heat losses are dominant for the entire energy use. Most of the convective losses are actually compensated by accounted effects of energy policies that are implemented. As an implication of this insight it now seems cautious that the rising energy consumption of 2011 could not be adapted; it shows that the actual trends of rising energy use may continue in the future since the average conductive heat losses cannot be reduced anyhow.

## AN OPPORTUNITY FOR SOLVING THE ENERGY CONSUMPTION PROBLEM OF GREENHOUSES

In the way we have approached the Dutch greenhouse energy problem, we have found that it cannot be solved by the applications of convection reducing services only. Hence there is a quite other way of questioning required, as is put in this question: - "can we solve the energy-efficiency problem of greenhouses by applying a new cover?"

Ideally, aimed performances of an innovative cover would comprise: a) transmittance of light (as high as possible), b) thermal insulation (as high as possible, meaning a low U-value), c) air change capacity (enough for keeping indoor air RH below 80%). This typical choice is motivated by the problem approach that the energy-efficiency is equivalent to the 'making the best out of available natural resources'. In order to accomplish this goal we wish performances that help each other performing their functions. Performances should get positive correlation, which is why we couple them in new properties of the cover. Hence in order to fundamentally solve the problem we need to get a physical relatedness of important climatic factors. From this view we propose a new material in which transparency, ventilation and thermal insulating are one, instead of being mono-functional

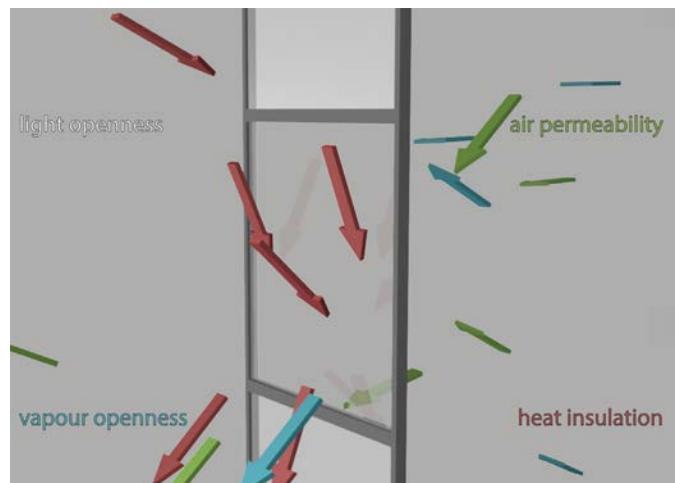


Figure 4 Conceptual representation of a greenhouse cover, based on the co-regulation of climatic factors

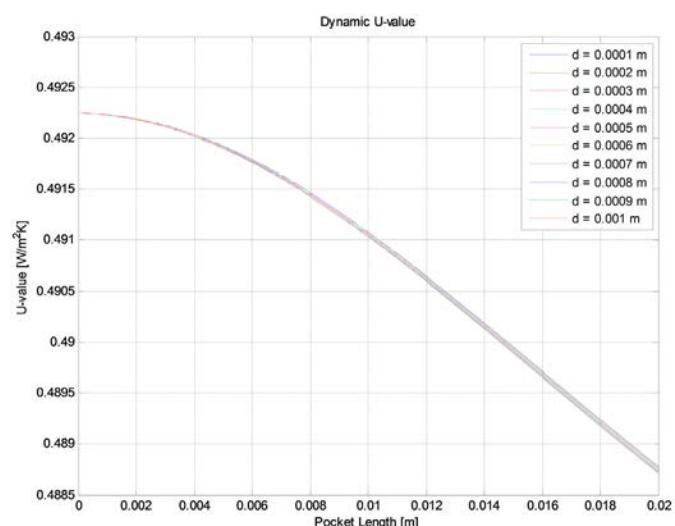


Figure 5 Calculated dynamic U-value

performances. As a result the new concept uses combined fluxes, and filters them. A flow of air and a flux of heat will co-regulate the performances. The essence is how to optimize these flows, and how to optimize the co-regulation.

## PRELIMINARY CALCULATION OF PHYSICAL PROPERTIES

In order to study the expected thermal performances of the concept, some numerical simulations have been made based on the interactions of the air flow and the thermal flux inside the material. Figure 5 shows the calculated dynamic U-value. A typical value is about 0.5 W/(m<sup>2</sup>.K), which is 4 x lower than the U-value of a two walled polycarbonate cover, and more than 6 x better than the U-value of a cover made of double glazing. It is about 12 x better than a cover made of a single glazing. The graph in figure 6 shows the calculated energy efficiency of the cover. This efficiency has a typical value of about 70%, which means that a proportion of 70 % of the static conductive heat loss will be recovered.

The author wants to thank Dr. Arjan Frijns, and the students Sebastiaan van den Eijnden, Arne van de Mortel en Rokus Ottervanger from the Department of Mechanical Engineering at TU/e for performing the numerical simulations.

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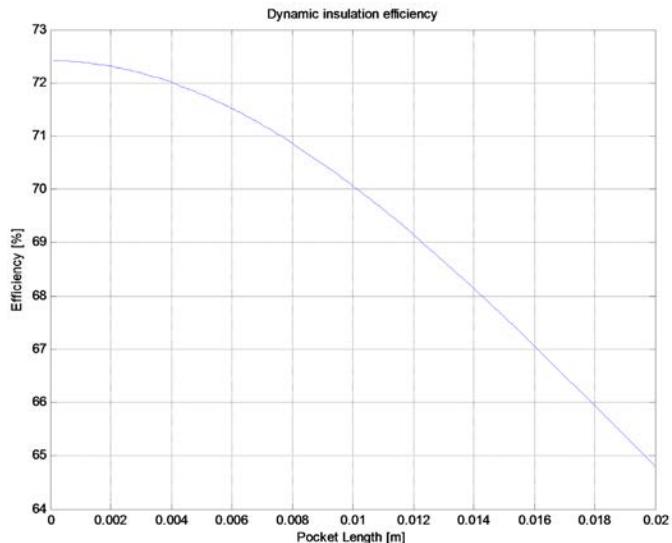


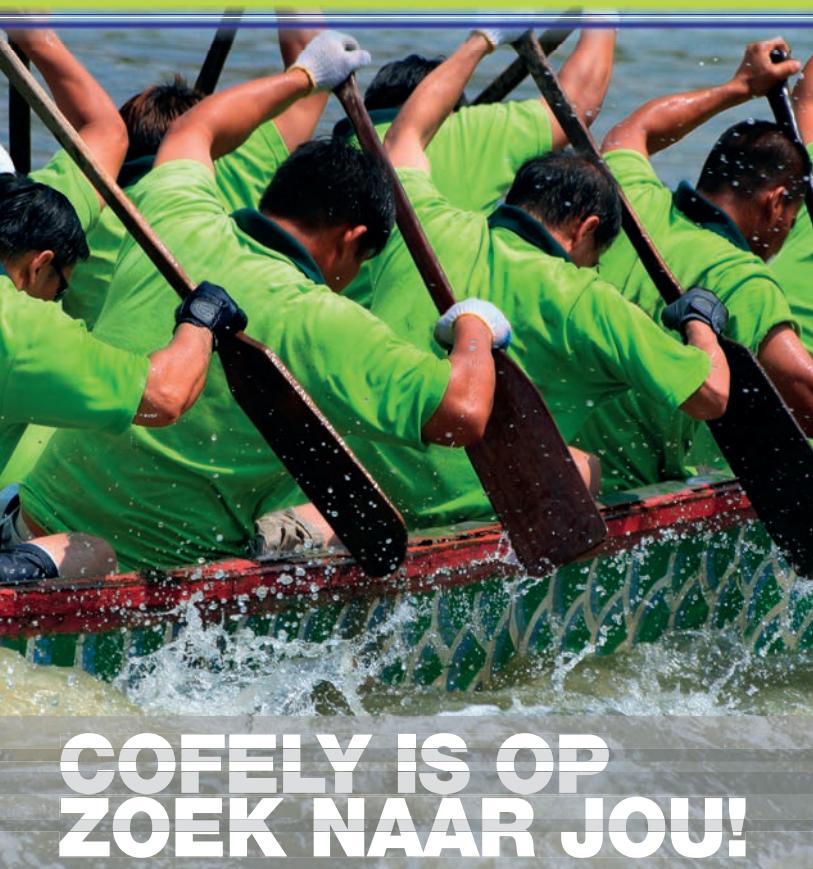
Figure 6 Calculated energy efficiency of the cover

L.A. (Bert) van Schaijk

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Unit Building Physics and Services

ver vooruit in duurzame technologie

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### ONDERDEEL VAN GDF SUEZ ENERGY SERVICES

Cofely is onderdeel van GDF SUEZ Energy Services, de Europese leider op het gebied van installaties en technische dienstverlening. Nederland is onze thuismarkt, maar Cofely is wereldwijd actief voor allerlei klanten.

Cofely ontwikkelt totaaloplossingen in de utiliteit, energietechniek en industrie. GDF SUEZ is een van de grootste energieleveranciers van de wereld, met meer dan 200.000 medewerkers en een omzet van ruim 80 miljard euro.

### WIL JIJ WERKEN BIJ DE GROOTSTE TECHNISCHE DIENSTVERLENER VAN NEDERLAND?

Met meer dan 6.300 medewerkers werken we iedere dag hard aan de beste (totaal)oplossingen voor allerlei klanten: van Heineken en Shell tot Rijkswaterstaat. Cofely bestaat uit een netwerk van bedrijven die zich richten op regionale markten, specifieke marktsegmenten en specifieke technieken.

### MOGELIJKHEDEN

Voor technieuten met passie hebben we volop mogelijkheden op verschillende niveaus door heel Nederland. Van Engineer tot Automatiserder, van Monteur tot Servicetechnicus en van Werkvoorbereider tot Projectleider. Interesse? Surf naar onze website [www.werkenbijcofely.nl](http://www.werkenbijcofely.nl) voor al onze actuele vacatures!

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# Cofely helpt met het brengen van licht op het Indiase platteland

Het platteland van India van elektriciteit voorzien. Het is de ambitieuze doelstelling van het project Rural Spark. In India zijn namelijk nog altijd vierhonderd miljoen mensen verstoken van elektriciteit. Voor deze mensen zijn gevaarlijke, ongezonde en milieuvuurvulende kerosinelampen de enige lichtbron in hun huis dat vaak niet meer is dan een hutje. Rural Spark wil deze Indiërs het heft in eigen handen geven door hen de mogelijkheid te geven een eigen slim en duurzaam energienetwerk op te zetten, een smart grid. Een project dat Cofely, en in het bijzonder Cofely'er Leo van der Linden, een warm hart toedraagt.

Leo van der Linden, serviceleider Cofely Zuid Nederland, maakte zo'n anderhalf jaar geleden via zijn collega Johan van Baardwijk kennis met het Rural Spark-project. Leo was toen nog managementtrainee, maar inmiddels werkt hij dus als serviceleider binnen Cofely. En daarnaast is hij nu ook officieel ambassadeur van Rural Spark, dat vrij vertaald 'lokale vonk' betekent. Reden voor Leo om in maart van dit jaar een bezoek van twee weken te brengen aan India. Om zo met eigen ogen te zien welke impact Rural Spark heeft op het leven van mensen op het platteland van India.

## VERSCHILLEN ONVOORSTELBAAR GROOT

Natuurlijk zal Leo het chaotische verkeer in de steden met de vele toeterende riksja's en daartussen de koeien op straat, het pittige eten en de stank van het open riool en van verbrand plastic niet snel vergeten. Maar wat hem zonder twijfel het meest heeft getroffen op zijn reis door India is de nieuwsgierigheid en leergierigheid van de mensen op het platteland. De dorpelingen die hij tegenkwam op de plekken waar Rural Spark inmiddels energieprojecten is gestart. "Ze

willen vooruit", vertelt Leo. "De mensen op het platteland zien de ontwikkeling die in de grote steden van India wel zichtbaar is, aan zich voorbijgaan. Het verschil tussen stad en platteland is er onvoorstelbaar groot. En aan die achterstand willen de mensen op het platteland een einde maken. De beschikbaarheid van elektriciteit is hierbij cruciaal. Elektriciteit verlicht immers letterlijk het leven van mensen waardoor bijvoorbeeld kinderen 's avonds kunnen lezen of studeren en waardoor ouders bij goed licht een maaltijd voor hun gezin kunnen klaarmaken."

Wat Leo bovenbeneden heeft gemerkt is dat Rural Spark ook meer sociale cohesie brengt in de dorpen waar het project al is uitgerold. De oplaadstations die Rural Spark met lokale ondernemers opzet in de dorpen vormen namelijk nieuwe ontmoetingsplekken voor de dorpelingen. "Ze komen er 's ochtends om hun lampen of kleine apparaten af te leveren zodat ze opgeladen kunnen worden. En 's avonds komen ze er hun spullen weer ophalen. Het oplaadstation is zo echt een centrale ontmoetingsplek voor de gemeenschap geworden die voorheen ontbrak", legt Leo uit. "Daarbij zie je dat mensen doordat ze langer en beter licht hebben ook meer bij elkaar op bezoek gaan. Rural Spark bevordert op deze manier niet alleen de zelfredzaamheid van Indiërs op het platteland, maar dus ook de sociale cohesie binnen de vaak kleine gemeenschappen op het Indiase platteland."

## EENVOUDIGE ENERGIEVOORZIENING

Momenteel heeft Rural Spark in vijf dorpen in India eenvoudige energievoorzieningen opgezet. Dorpen waar je in de woorden van Leo tweehonderd jaar teruggaat in de tijd. Waar mensen wonen in hutjes en waar gekookt wordt



## HET ONTSTAAN VAN RURAL SPARK

Rural Spark is een initiatief van destijds drie Nederlandse studenten die tijdens hun afstuderen op het idee kwamen om het platteland van India op een duurzame en zelfvoorzienende manier van energie te voorzien. De drie, Harmen van Heist, Marcel van Heist en Evan Mertens, hebben hiertoe hun afstudeerscripties 'Becoming indigenous at the Base of the Pyramid (BoP)', 'Creating rural energy' en 'Lowering the threshold for access to sustainable energy solutions' gecombineerd tot het project Rural Spark dat in 2011 van start is gegaan. Uitgangspunt van Rural Spark is samenwerking met de mensen in India. Zo worden de energienetwerken op locatie ontworpen. Rural Spark zoekt het bottom-up, aan de basis van de piramide, bij de lokale bevolking dus. Volgens de initiatiefnemers de beste manier om de kracht van lokaal ondernemerschap optimaal te benutten om zo te komen tot een decentraal energienetwerk dat helemaal aansluit bij de trend van vandaag: het heft in eigen handen nemen als het gaat om energievoorziening.

Duurzame smart grids op het platteland van India. Een ontwikkeling waaraan we allemaal een bijdrage kunnen leveren. Bijvoorbeeld via crowdfunding. Kijk voor meer informatie op: [www.ruralspark.com](http://www.ruralspark.com).

op een haardvuurtje veelal in het donker of bij het licht van een kerosinelamp. Dankzij Rural Spark zijn er in deze dorpen nu zes lokale leveranciers van zonne-energie actief. Drie in de staat Bihar (in het oosten van India) en drie in Madhya Pradesh (centraal in India). Dorpelingen die een zonnepaneel en een oplaadsysteem huren van de Indiase partners van Rural Spark. Daarbij krijgen ze twintig LED-lampen die ze weer kunnen doorverhuren aan hun dorpsgenoten. Zo ontstaat een goedkope en zelfvoorzienende energie-infrastructuur.

Een oplossing die volgens Leo veel goedkoper en duurzamer is dan de vervuilende kerosinelampen die op het platteland van India nu nog op grote schaal worden gebruikt. "De dorpelingen betalen de lokale ondernemer namelijk minder voor het opladen van hun lampen en apparaten dan ze normaal aan kerosine besteden", legt hij uit. "De lokale ondernemer ontvangt bovenind geld voor zijn inspanningen waardoor hij zich verantwoordelijk voelt en niet langer afhankelijk. Er ontstaat daadwerkelijk lokaal ondernemerschap." In totaal worden in de vijf dorpen dankzij de lokale ondernemers nu van 63 gezinnen hun lampen en andere kleine apparaten opgeladen", vertelt Leo enthousiast. Wat hem hierbij is opgevallen, is dat het dan behalve om lampen vooral om goedkope mobiele telefoons uit China gaat. "De Indiërs op het platteland gebruiken deze namelijk als radio", legt hij uit.

## NOG MAAR HET BEGIN

De 63 gezinnen zijn volgens Leo overigens nog maar het begin. De reacties van de lokale bevolking zijn volgens hem namelijk positief. En vanuit de ondernemers komt al de vraag naar meer lampen zodat ze meer klanten kunnen bedienen. Daarbij heeft Rural Spark volgens Leo een behoorlijk ambitieuze doelstelling. Zo wil de organisatie voor het eind van dit jaar in honderd dorpen in India actief zijn. "Waardoor het licht kan brengen in het leven van zo'n tienduizend Indiërs", rekent hij voor. Ook verwacht Leo dat het binnenkort mogelijk zal zijn om de oplaadstations uit te breiden tot kleine netwerken.

Ambitieuze doelstellingen waar Cofely en GDF SUEZ volgens Leo graag een bijdrage aan leveren. Financieel



door het project te steunen vanuit het investeringsfonds van GDF SUEZ, Rassembleurs d'Energies, maar zeker ook door kennis en kunde beschikbaar te stellen aan de projectorganisatie achter Rural Spark. Dit in de persoon van Leo, maar ook vanuit Tractebel Engineering dat namens GDF SUEZ in India actief is.

Ontwikkelingen die Leo uiteraard enthousiast begroet. Hij was immers degene die Rural Spark heeft voorgedragen om in aanmerking te komen voor een bijdrage uit het Rassembleurs d'Energies-fonds. Reden voor hem om onlangs in april in Parijs nog een presentatie te geven over het project. Een presentatie waarna het investeringsfonds heeft besloten Rural Spark definitief te gaan ondersteunen.

## SOCIAL RESPONSIBILITY

Het project op het Indiase platteland past volgens Leo helemaal in de maatschappelijke betrokkenheid en social responsibility die Cofely, GDF SUEZ en haar medewerkers steeds weer willen laten zien. Leo voelt zich dan ook absoluut gesteund door zijn collega's om van Rural Spark een nog groter succes te maken dan het nu al is. "Deze drive is sinds de eerste kennismaking met het project alleen maar groter geworden", stelt hij. "Elektriciteit en daar mee verlichting voor iedereen in India die daarvan nu nog verstoken is. Dat is ons ultieme doel", besluit hij enthousiast.

Cofely is met ongeveer 6.300 medewerkers de grootste technische dienstverlener van Nederland. Onze specialisten hebben een passie voor techniek en werken iedere dag aan innovatieve concepten, integrale en duurzame oplossingen voor allerlei klanten: van Heineken en Shell tot Rijkswaterstaat. Naast het ontwerpen en beheren van technische installaties, speelt Cofely op een verantwoorde manier in op maatschappelijke ontwikkelingen, actuele thema's in werk- en leefomgeving en de vraag naar zuinig energiegebruik.

# ICE-BREAKER

Charlotte Zhang

Hello! My name is Charlotte Zhang. Well, Charlotte is not my real name on my passport. But I like people to call me Charlotte. Anyway, my Chinese name is Zhang Xianmei. I am from Shanghai, China, a really big and fascinating city.

Many people asked me why I chose TU/e, and why building services, especially when they know I might be the only international student in Building services and physics this year. Well, it is a long story. Let's start with my background. I finished my bachelor program of intelligent buildings in Tongji University (some people might have heard of it, it is famous for engineering in China). Then I had my first fulltime job as a QS (quantity surveyor, doing cost estimation of Mechanical & electrical parts) for two years. Being as a QS provides me many chances to read more drawings of construction and building services systems of both commercial buildings and residential buildings. At the beginning I was just an assistant of the senior QS. But I worked hard because I like challenges and I like to push myself. After one year, I finally got the chance to do my own project IKEA shopping mall. During this project, I found the systems that IKEA are using are different from other project I was working on. Being responsible for the IKEA project on my own, presents me more challenges to communicate with building services engineers and construction engineers. I also had the opportunity to work with TEBODIN, a Dutch construction consultant company. It was nice to work with the engineers from TEBODIN. Actually they taught me many things as an engineer. Then I found when I was doing the commercial part, I would also consider about technical part unconsciously. This is why I was appreciated by my former boss. But when I think further, I found I like the technical part more. When I thought back to when I was doing my bachelor program, I remember I was good at technical part. I can do it better with my work experience and commercial knowledge! I need more knowledge so that I can design better systems (HVAC, Plumbing, Electric etc.) and then persuade investors to apply better systems in the buildings. I believe a wider view will make people clever. This is why I decided to come to other countries to get some other ideas of building services and explore my view. There are not many universities that have the master program related to building services. TU/e is the one closest to what I learned and what I am interested in. And now building services is combined with building physics, which means I would learn more. I am happy with it.

I never lived abroad before. Eindhoven is the first foreign city I have lived in. I feel so different living here. Because it is smaller, quieter and less busy. But I like here, I feel comfortable living here. Although, I felt really confused when I just arrived because I cannot read Dutch, I need to spend more time in supermarket to figure out if the things are what I want. I cannot understand Dutch students' jokes...well, I think it happens to every international students. I am getting used to it and trying to learn some Dutch. I look forward to my Dutch lessons. I think I will do well because I am a quick learner.



I want to know more students from my major. Then I know Mollier. But I was not lucky that I missed the annual trip with Mollier. However, it is really nice to meet people and get help with projects in Mollier.

I am a big fan of music. I am open to many kinds of music, post punk, garage, D&B, techno.... I love music festivals! Unluckily, I don't know how to play any instruments and my singing is also not great. I am also a big fan of sports. If you watched the ATP tennis games Shanghai station on TV last years, you might of seen me on TV. Because I went to the tennis tournament and I was seating at first row every year since 2006. I am a VIP of tennis fan club. And I also went to watch F1 racing and FINA World Championships for swimming tournament. Travelling is also a big hobby of mine. I am open and respect different cultures. Different cultures inspire me to explored my view.

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# FUJIFILM gebruikt energie uit afvalgassen dankzij CTO

**F**UJIFILM in Tilburg maakt onder meer offsetplaten voor de grafische industrie. De nieuwste productielijn PSIO heet op de werkvlloer 'the green factory'. Met recht, want hier wordt zelfs de energie uit afvalgassen opnieuw benut in het productieproces. Energietechnoloog Jef Verboven van FUJIFILM ontwikkelde het concept voor de Cogenerative Thermal Oxidizer (CTO). Samen met energieconsultant Frans Wolters van Tebodin vertelt hij hoe de installatie is gerealiseerd.

**V**iij grote windturbines maken al van afstand duidelijk dat FUJIFILM energie- en milieubewust is. Het fabrieksterrein van 63 hectare huisvest één van de grootste productielocaties van FUJIFILM buiten Japan, en daarnaast het Nederlandse deel van het Europese hoofdkantoor. De site werd in 1982 gekozen vanwege de beschikbaarheid van grondwater, dat zo veel mogelijk opnieuw wordt gebruikt. De windmolens zijn goed voor 15 tot 20 procent van de benodigde electriciteit. Jef Verboven: "FUJIFILM wil uiteindelijk een 100 procent energieneutraal bedrijf worden."

**D**e bouw van de fabriek begon in 1984 en was de directe aanleiding voor een Eindhovense vestiging van Tebodin, dat sindsdien betrokken is geweest bij vele nieuwe investeringen. Naar de filmrolletjes van destijds is geen vraag meer, maar FUJIFILM blijft innoveren. In Tilburg wordt bijvoorbeeld gewerkt aan geavanceerde coatings en membraantechnologie die wordt ingezet bij de winning van 'blauwe energie' uit verschillen in zoutconcentratie tussen twee watermassa's. Verboven: "De nieuwe lijn PSIO maakt 'low-chemical' platen, waarvoor in drukkerijen minder chemicaliën nodig zijn. Daarnaast kan de lijn ook alle andere offsetplaten produceren."

## NUTTIGE ENERGIE IS EXERGIE

**E**nergie gaat niet verloren, zegt de eerste wet van de thermodynamica. Alleen omzettingen van energie zijn mogelijk. Bij die omzetting gaat echter wel iets verloren,

Frans Wolters (links) en Jef Verboven (rechts) bij FUJIFILM



namelijk de kwaliteit van de energie, het arbeidsvermogen. Met de energie in aardgas kun je van alles doen, maar diezelfde energie is veel minder bruikbaar in de vorm van warmte in de schoorsteen. Warmte is de laagste vorm van energie.

**H**et nuttige deel van een energiestroom wordt exergie genoemd. Elektriciteit en brandstoffen kunnen in principe volledig worden benut: hun energiewaarde is gelijk aan hun exergiewaarde. Dat geldt niet voor de meeste andere energie- en materiaalstromen. Ter verduidelijking van het begrip exergie duidt wel eens de analogie op van een eik bij de zagerij: de hoeveelheid hout verandert niet als je de hele boom tot tandenstokers verwerkt, maar je kunt er dan geen meubels meer van maken.

## VOLLEDIGE VERBRANDING

**B**ij warmtestromen neemt de exergiewaarde toe naarmate de temperatuur hoger is. Dat zette Verboven in 2007 aan het denken. "Het procesafzuigsysteem van PSIO produceert elk uur 32.000 m<sup>3</sup> lucht van maximaal 80°C, met daarin vluchtvaste organische stoffen uit oplosmiddelen, bekend als VOC's. De emissie van zulke afvalgassen wordt gewoonlijk voorkomen met een Regenerative Thermal Oxidizer. Om in zo'n RTO ook de meest complexe ketens volledig te verbranden, zijn temperaturen van rond 900°C nodig. Er moet dus veel energie bij, die je vervolgens kwijt bent. Met een RTO gebruik je veel brandstof om brandstof te vernietigen. Het rendement is nul. Dus dacht ik: 'dat moet beter kunnen'."

## SIGAREDOOSJE

**Z**o ontstond het idee om de energie die hoe dan ook nodig is om de VOC's te verbranden, daarna nog zo nuttig mogelijk in te zetten met behulp van een nieuw soort installatie. De eerste ingevingen kregen vorm op de achterkant van het spreekwoordelijke sigarendoosje, vertelt Verboven terwijl hij een schema van de installatie ontvouwt. "Het was vanaf het begin duidelijk dat we moesten kijken naar het geheel. Het uitgangspunt was een systeemaanpak voor een installatie die levert wat de PSIO nodig heeft, namelijk elektriciteit, stoom van 30 bar en 10 bar, heet water van 90°C en gekoeld water van tussen 7° en 13°C. We wilden dus de verbranding van afgassen en vloeibare oplosmiddelen integreren in een systeem dat energie-efficiënt elektriciteit, stoom, heet en gekoeld water produceert."

## NAVERBRANDER

**V**erschillende opties kwamen op tafel, evenals 'honderd redenen om het niet te doen', aldus Verboven. Toch kwam een veelbelovend plan tot stand. Een gasturbine wekt via een 10kV generator elektriciteit op, en de rookgassen uit de turbine verwarmen de afgasstroom van 80°C tot 375°C. Die voorverwarming is cruciaal in de combustor, het hart van de nieuwe installatie. Het is een soort naverbrander, die werkt op aardgas, VOC's en eventueel ook vloeibare oplosmiddelen als brandstof. De warmte van de hete afvalgassen wordt direct



Cogenerative Thermal Oxidizer (CTO) bij FUJIFILM



gebruikt in een afgassenketel voor de productie van stoom met een druk van 30 bar. Een klein deel van die stoom wordt direct gebruikt in het 30 bar stoomnet, het grootste deel wordt via een drukverlaging in een stoommotor geleverd aan het 10 bar stoomnet. De stoommotor levert nog eens 200 kW extra elektriciteit.

"We wilden dit het liefst met bestaande techniek doen, en niet zelf een nieuwe turbine ontwikkelen. Dat is niet onze business en zou te ver gaan", vervolgt Verboven. "De grootste uitdaging lag in de koppeling met andere elementen en het oplossen van de praktische problemen die een geïntegreerde installatie met zich meebrengt. Tebodin heeft de expertise geleverd die nodig was voor het ontwerp en de bouw van een uitgebalanceerd systeem, de beveiliging en besturing. Ze hebben ook naar de juiste componenten gezocht. Wij hadden al wel de gasturbine en de combustor besteld. Aan de inspecteurs van Lloyd's die het geheel uiteindelijk moesten goedkeuren hebben we wel het nodige moeten uitleggen, want een CTO was natuurlijk ook voor hen iets nieuws."

#### PARALLEL BOUWEN

Projectmanager Frans Wolters van Tebodin coördineerde de technische detailuitwerking. 'Het is moeilijk om een dergelijke installatie te bouwen als je de componenten niet zomaar van de plank kunt halen. Vooral de onderlinge koppelingen zijn lastig, want het systeem is onlosmakelijk verbonden met PSIO en moet dus parallel worden gebouwd. Wij zijn eind 2008 voor het eerst bij de plannen betrokken. Het schema en procesdiagram bestonden toen al. Een paar maanden later werd het hele project stopgezet, omdat door de recessie onzeker was geworden hoe de vraag naar offsetplaten zich zou ontwikkelen. Pas eind 2010 konden we de draad weer oppakken, en de oplevering volgde begin oktober 2011. Tebodin heeft naast het detailontwerp ook het constructiemanagement, de procurement en uitvoeringsbegeleiding verzorgd, en de utilities tot aan de rand van de fabriek. Na het testen is PSIO in januari 2012 echt gaan draaien.'

**"Met een RTO gebruik je veel brandstof om brandstof te vernietigen.  
Het rendement is nul. Dus dacht ik:  
dat moet beter kunnen"**

Jef Verboven is goed te spreken over de inbreng van Tebodin, die heeft geleid tot de toevoeging van componenten die het rendement van de CTO opschroeven tot 91,9 procent.

Naast de stoommotor zijn dat onder meer warmtewisselaars en een absorptiekoelmachine, die uit een deel van de stoom op efficiënte wijze gekoeld water produceert. Zelf is Verboven inmiddels afgestudeerd op het onderwerp CTO, dat al veel belangstellende ingenieurs, adviseurs en studenten naar Tilburg heeft gebracht.

#### INVESTERINGSBESLISSING

Met de PSIO was een investering van 100 miljoen euro gemoeid. Het is een bijzonder flexibele productielijn, die ongeacht de markontwikkelingen zal kunnen blijven draaien. "De CTO betekende een behoorlijke meerinvestering", zegt Verboven. "Toen de bouw van PSIO werd uitgesteld, leek het mij onwaarschijnlijk dat de plannen nog zouden worden uitgevoerd. Gelukkig besliste de directie dat niet alleen onze producten duurzaam moeten zijn, maar ook de manier van produceren. Het is een logische volgende stap, die goed past in de filosofie van FUJIFILM. De recessie gaat ook weer voorbij, zo was de positieve instelling. Toch zou de beslissing vandaag anders zijn uitgevallen. Vergelijken met 2008 is de prijs van elektriciteit gehalveerd. Niemand bouwt nog een gascentrale, maar wij hebben hoe dan ook gas nodig om stoom te produceren. De hele installatie kan trouwens ook op ongezuiverd biogas draaien, dus we zijn goed voorbereid op een duurzame toekomst."

Artikel aangeleverd door Tebodin,  
Geschreven door Richard Schippers

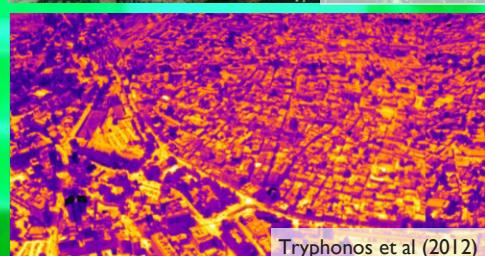
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The Urban Physics Autumn School is organised by Eindhoven University of Technology in collaboration with the Swiss Federal Institute of Technology in Zurich and the University of Cyprus. It follows the previous Urban Physics Schools organised in 2011 and 2012.

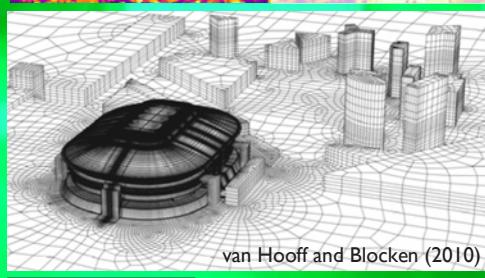
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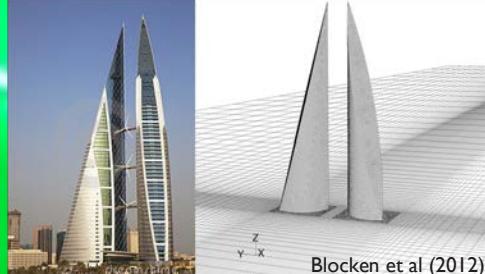
van Heijst (2012)



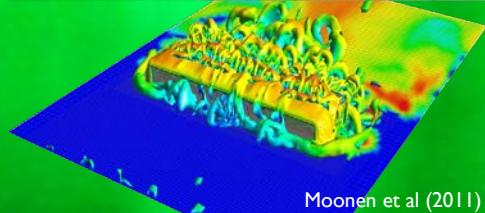
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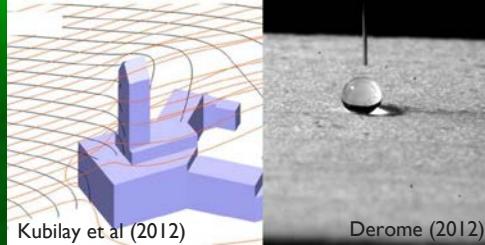
van Hooff and Blocken (2010)



Blocken et al (2012)



Moonen et al (2011)



Kubilay et al (2012)

## REGISTRATION

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**October 13-18, 2013—Nikiti Chalkidiki, Greece**

[www.urbanphysics2013.org](http://www.urbanphysics2013.org)

## THEME

**URBAN PHYSICS:  
multi-scale, multi-phase and  
multi-disciplinary:  
from macro-scale meteorology  
to human thermophysiology**

## INVITED SPEAKERS

**Prof. Janet Barlow**

University of Reading, UK

**Prof. Bert Blocken**

Eindhoven University of Technology, The Netherlands

**Prof. Jan Carmeliet**

ETH Zurich, Switzerland

**Prof. Hein Daanen**

TNO & University of Amsterdam, The Netherlands

**Prof. Dominique Derome**

EMPA, Switzerland

**Dr. Catherine Gorlé**

von Karman Institute for Fluid Dynamics, Belgium

**Prof. GertJan van Heijst**

Eindhoven University of Technology, The Netherlands

**Dr. Twan van Hooff**

Eindhoven University of Technology, The Netherlands

**Dr. Maarten Hornikx**

Eindhoven University of Technology, The Netherlands

**Dr. Peter Moonen**

ETH Zurich, Switzerland

**Dr. Marina Neophytou**

University of Cyprus, Cyprus

**Prof. Christoph Schär**

ETH Zurich, Switzerland

**Prof. Ted Stathopoulos**

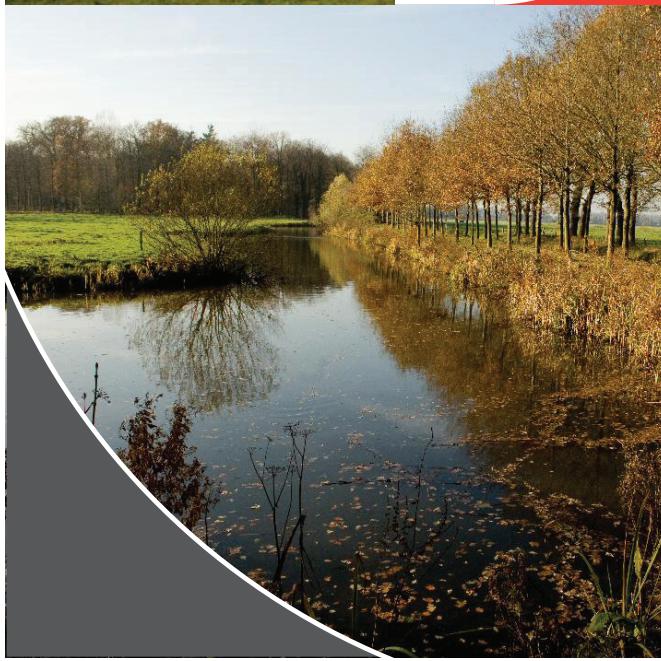
Concordia University, Montreal, Canada

Participants can register by sending an e-mail to [a.khayrullina@tue.nl](mailto:a.khayrullina@tue.nl). The school fee is 950 euro per person and covers course registration, course material, accommodation (6 nights: Sunday to Saturday) and full board (breakfasts, lunches, dinners). Instructions on the payment will be sent after registration via e-mail. A letter of confirmation will be sent to the registered participants after the payment has been received.

The number of participants is limited to 50 persons. The positions will be filled on a first-come, first-served basis.



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# Studying Abroad

## Finn Vossen

'Someday I want to live abroad for a while'. As long as I remember, that is what I told everyone. I thought I would go to England (London) and learn to speak very British, but I stayed in the Netherlands. I started my education at the TU/e and before I realized I was ready to start my master thesis in the combined master Architecture and Physics of the Built Environment. I felt too young and inexperienced to start my master thesis and meanwhile the thought of going abroad never left my mind, so I started to look for the possibilities to combine my studies with my dream. Unfortunately our school did not have an Erasmus contract with a university in London, so I broadened my view and started to look for other destinations in Europe.

With only three demands, soon a lot of destinations were skipped. I wanted to go to a well recommended university where there was the possibility to join both architecture and buildings physics and sustainability courses; I wanted to go to a country where people speak proper English and I wanted to go to a nice (student)city. And then there was Scandinavia. Encouraged by two architecture students who already went there I ended up at the Chalmers University in Gothenburg, Sweden. So, here I am, for 5 months, with my thick clothes and always accompanying laptop.

During this semester I joined 3 studio's, which are comparable with the project work we do in Eindhoven. It's very common to do a lot of group work here. So from Monday till Friday, from 9 till 5, we are all sitting together in a big studio to work on our projects and attend different lectures. Sweden has a strong culture of equality, which you can see in the school system as well. The students are encouraged to work



together and help each other so that the best result can be accomplished together, this leads to a very nice atmosphere among students. But of course studying abroad, is not only about studying. You meet a lot of people from all over the world who soon become your friends and family (since we all came here alone).

Culture and language differences lead to a lot of funny situations but with our 'Erasmus'-English (real English, mixed up with words from languages all over the world) we manage to understand each other. And during the weekend it's time to explore the city and its surroundings. The Dutch played a large role in the development of the city, so thanks to the canals it feels a bit like the Netherlands. Furthermore there is a lot of nature: there are beautiful islands along the shore and parks and forests

in the middle of the city. Then there is time to have Fika (coffee and the typical pastry of Sweden: kanelbullar), go to after work on Friday (eat together in a café after school), go to a sauna and dive into a frozen lake, visit an ice-hockey game, have international dinners, go to Oslo, Stockholm, Copenhagen etc.

So, time flies because there is no time to be bored. There is only 1 months left for me to stay here, and I already regret to go home (even though I miss the hagelag on my sandwiches). In short, I could recommend everyone to spend some time abroad!

Hejdå

# The human body as sensor for thermal comfort control

D.R. (Derek) Vissers

Supervisors:

Prof. ir. W. Zeiler (TU/e)

Ir. G. Boxem (TU/e)

Dr.ir. M.G.L.C. Loomans (TU/e)

## INTRODUCTION

One of the primary objectives of a Heating, Ventilation and Air-Conditioning (HVAC) system is to provide a thermally comfortable environment for the building occupants. The satisfaction of the occupants with their thermal environment determines the success of the application of HVAC systems. A lot of effort has been taken to design energy efficient HVAC systems. However, in practice the intended comfort level of these HVAC systems is not achieved, resulting in more sickness absence and lower productivity of the occupants. This is mainly due to the fact that the control paradigm for HVAC systems has remained unchanged, namely regulating indoor environmental variables such as air temperature without including the thermal state of the individual occupant in the control loop.

Recently, individual controlled HVAC systems were proposed, which can cope with the individual differences such as body fat and clothing behaviour between office workers. In addition, these systems focus on the body parts (hands, feet and head) which mainly dictate thermal discomfort in mild cool/warm office conditions (see Figure 1). This research proposed a new control strategy for automatic regulation of personalized radiant heating in mild cool office environments, by including the human body as sensor in the control loop. The upper-extremity and facial skin temperature, both remotely sensed by infrared thermography, were proposed as feedback control parameters (see Figure 2). The objective of this control strategy is to save energy, while maintaining thermal comfort of the individual building occupant.

## THEORY

The human body can regulate heat flow to the environment by increasing or decreasing the skin blood flow. During mild cool exposure vasoconstriction is the most important thermoregulatory effector, which can be clearly observed in the upper-extremity

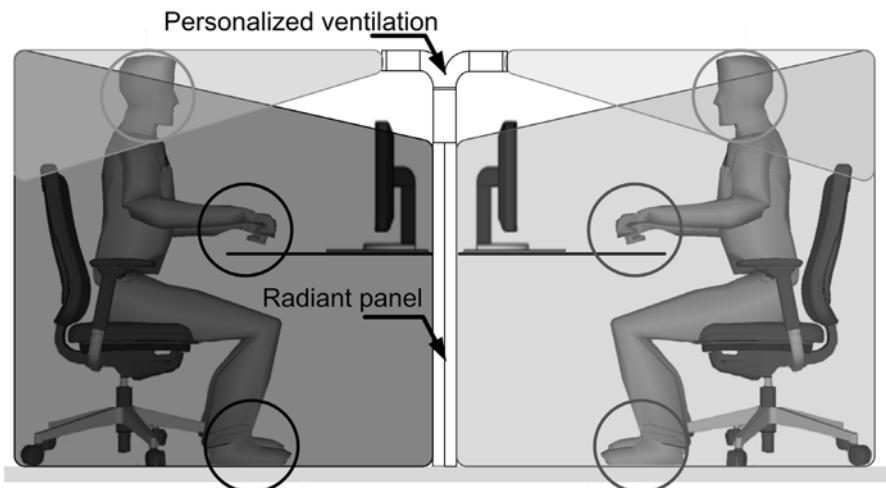


Figure 1 An individual controlled task-ambient conditioning system consisting of radiant panels for heating/cooling and a personalized ventilation device.

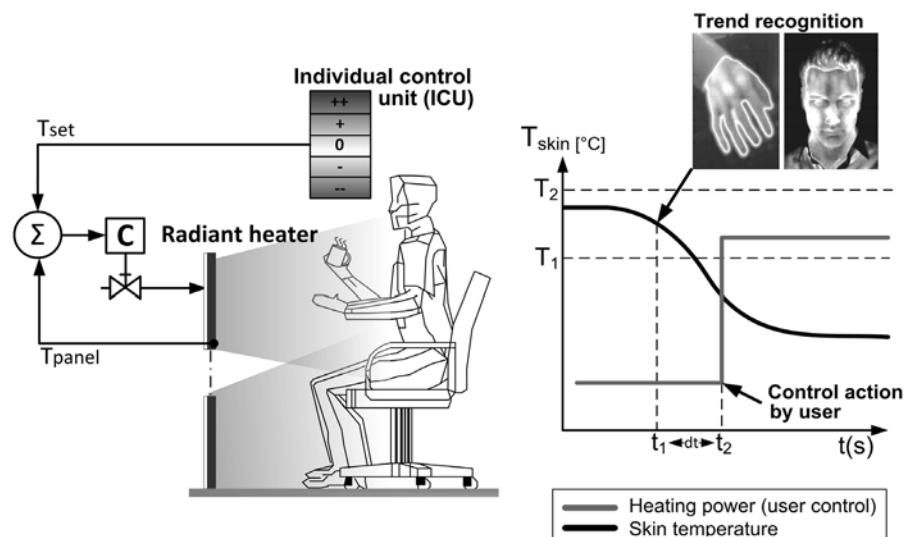


Figure 2 The human in the loop control strategy based on actual thermo-physiology of the upper-extremities and face.

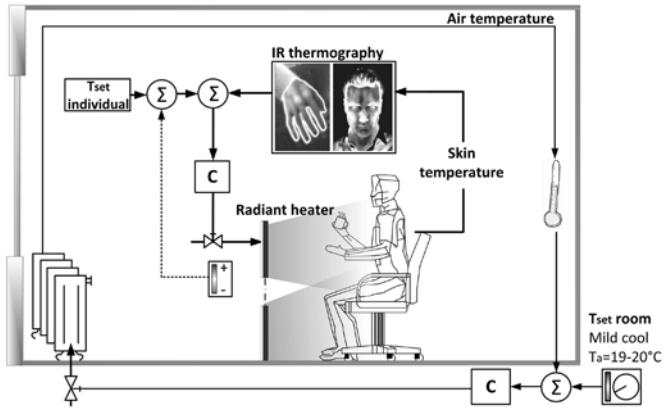


Figure 3 User-controlled experiments in which the user had the ability to influence the local thermal environment by the radiant panels.

region. In addition, the variations in facial skin temperature may also indicate if a person is getting warmer or cooler.

The challenge for automatic control of radiant heating is to detect the turning point from a neutral thermal state to a cooler thermal state before the occupant perceives any cool thermal sensation. The fact that the skin temperature can fluctuate within a range of temperatures without producing any temperature sensation (i.e. the neutral zone) is highly useful in this.

#### EXPERIMENTS I: USER-CONTROL

A number of user-controlled experiments were performed in mild cool office conditions ( $T_a=19-20^\circ\text{C}$ ) to determine if a decreasing trend in skin temperature of the hands or face was observed, before the user performed any heating control action (see Figure 3). Two human subjects participated several times in this research. The results 'proof-of-principle' demonstrated that the 3rd finger skin temperature was a critical performance indicator of the

body thermal state in the cooling region. To test whether the finger temperature was actually useful as control signal, the experiments were reversed: from user-control to automatic control.

#### EXPERIMENTS II: AUTOMATIC COMFORT CONTROL

The 3rd finger skin temperature, measured by infrared thermography, was used as feedback control parameter for automatic regulation of a radiant hand-heating system (see Figure 4). Different bandwidths were applied as set-points for the control loop; the bandwidth is defined as a range of temperatures in which the finger temperature was controlled. By controlling the finger temperature in a small bandwidth ( $T_{sk}=29-31.5^\circ\text{C}$ ), it was possible to feed-forward respond to the thermal preferences of the subjects (i.e. before cool discomfort occurred), while the basic room air temperature was lowered from 22 to  $19.5^\circ\text{C}$  (see Figure 5). The local- and overall thermal sensation of the subjects were maintained at neutral or slightly higher level, and

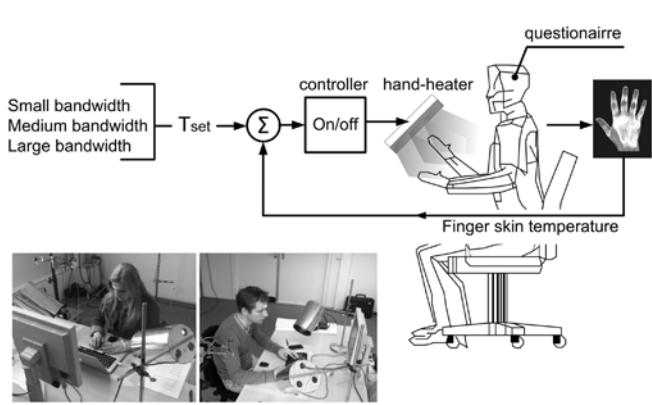


Figure 4 Automatic thermal comfort control using the 3rd finger skin temperature as feedback control signal for regulation of the radiant hand-heater.

the subjects did not prefer any environmental control action. By modeling the preference that arises from the interactions with the user, this small bandwidth might be applicable to other individuals.

#### ENERGY SAVINGS

The energy saving potential results from the fact that the basic room air temperature set-point can be lowered from 22 to  $19.5^\circ\text{C}$  when local heating is applied. This means that less energy is needed to condition the entire space. A simulation, using a whole-building model programmed in the MATLAB HAMBase environment, was performed to calculate the energy saving potential. A typical state-of-the-art office building in the Netherlands was chosen as case study. The simulation results showed an energy saving potential of 17% for heating by decreasing the set point of the indoor air temperature from  $22^\circ\text{C}$  to  $19.5^\circ\text{C}$ , and taking into account local radiant heating of 98W per occupied workplace.



# Studytrip 2013

## Ho Chi Minh City Vietnam

### REGULATIONS IN PARK 23

#### 1. FOR VISITORS :

1. No dogs, pets and alcohol. Eat good healthy snacks and fruit. Fingers without littering and measure the vehicle in dimension.
2. Not allowed to bring weapons anywhere. Additionally substances into the park. Not allowed to drink beer, spirit, play football and smoke weed and any cigarette or cigar. Bring the park's decree. Not allowed to break or steal flower and do not damage trees.
3. Not to speak, sing, whistle, participate in below silence and other noise in the park. Not allowed to bark and catch birds. Both having animals and no bring pet dogs into park. Keep public morality.
4. Children under 10 years have to sit. Must not add the seats.
5. Prohibited to bring alcohol to the park.

#### regulations

6. The park opens on regular days from 06:00 until 18:00.

#### II. FOR THE PARTY'S EMPLOYEES :

This year s.v.b.p.s. Mollier organized a study trip to Ho Chi Minh City in Vietnam. This is a city of commerce and tradition that has influenced the entire country with its endless energy. The Metropolitan area is populated by more than 9 million people and the population is expected to grow to 13.9 million in 2025. This means a grow of new dwellings, offices and industry. Enough reasons for 15 students and 1 supervisor to sign in for this study trip.

#### SUNDAY 28 APRIL

After weeks of organizing, planning and packing it was finally time to leave Eindhoven and start our study trip to Ho Chi Minh City. With almost a complete group we gather at Eindhoven station to take the train to Düsseldorf International Airport. Without any trouble we get to the airport where we still have more than 3 hours to get through all check-ins. The flight to Dubai will take about 6 hours, enough time to get some sleep.



Visit at the International University

#### MONDAY 29 APRIL

Early in the morning we arrive at Dubai Airport, where we have a transfer of more than 3 hours to wander around in the impressive terminals. Our trip is continued by another flight of about 7 hours to our final destination: Ho Chi Minh City. Once we arrive in this metropolis it is dark, hot, humid and the traffic can be considered as rather chaotic. Imagine: 9 million inhabitants having at least 2 motorbikes per person and an infrastructure which is underdeveloped. The result? A huge amount of smog, traffic jams and locals wearing facemasks. For us as foreigners it is a fascinating and amusing sight but for the locals it is the harsh everyday reality. After being dropped off at the backpackers district, we are guided through narrow and lively alleys to our hostel where we receive a kind welcome from the owner. We enjoy the air-conditioned and nice rooms for a moment and head off to a local restaurant to taste the, sometimes indefinable, Vietnamese food for the first time.

#### TUESDAY 30 APRIL

With our first night behind us, we start the day with exploring the China town of Ho Chi Minh City. The first challenge is getting there. The China district (Cholon area) is roughly 7 kilometres away from our hostel. We decide to spare our feet and travel by public transport.

When arriving at the destination we quickly decide that it would be easier to split the group in two. Once that was done we start to explore. First stop is the Cha Tam Church followed by several other churches and pagodas. China town is truly amazing. It is not just the temples that amaze us, the everyday life of the Vietnamese has our interest as well.

reference point many times after this visit. The market is indoors and there are T-shirts, souvenirs, watches, bags and jewelry for sale, but also food and drinks. The next highlight of the tour is the fine arts museum which shows a lot of paintings and sculptures of Vietnamese artists.

The most impressive moment of the tour is without doubt the War Remnants Museum. This museum is dedicated to the Vietnam War and primarily contains exhibits relating to the American phase of the Vietnam War. The museum has left a great impression on the students.

The last highlight of the day is the reunification Palace, but unfortunately we are too late and it is already closed. The reunification Palace and the pagoda will be visited another day. The walking tour gives a lot of reference points to find the way and gives a lot of information about the culture and history of Vietnam.

#### THURSDAY 2 MAY

Today we go to the International University of Ho Chi Minh City. We get off the bus a few bus stops too early, but we eventually are on time with the help of some Vietnamese people.

When we arrive at the university, a group of 6 students is waiting for us and brings us to a class room. In this class room there is an introduction given about the International University. After that presentation, Mike presents about the Eindhoven University of Technology and s.v.b.p.s. Mollier.

When the introduction ends, there is a traditional performance of the students of the International University of HCMC. One of the student sings a

Street scene of Ho Chi Minh City





Preparations for the building site visit

Vietnamese song and another student sings Price tag, a popular pop song of Jessie J. The acts are not what we expected, but are very impressive. The following part of the program is the question time about the Vietnamese culture and student life.

**A**fter the question time, there is a campus tour. The students give us a guided tour in the school building. We could see the canteen, the library and the laboratory. During the guided tour we can ask the students questions and learn some Vietnamese sentences. Because at the end of the afternoon there is some time left, we go back to the Reunification Palace and to the pagoda.

**I**n the evening we are invited by mister Pichel to come to the Water Club. During this meeting different guests tell something about the abundance of water in the Mekong Delta. The speakers tell about their research and discuss the results.

### FRIDAY 3 MAY

**T**oday we visit the first company in Ho Chi Minh City. After the university yesterday which started very early, today we have some more time for breakfast. We again use public transport to get to the office of Royal HaskoningDHV. Fortunately for us, we can find the office without many problems. We are welcomed by Roel Philippa who is a project manager of Royal HaskoningDHV Vietnam. They arranged two presentations for us, one from an engineer and one from a senior architect. The architect was born in Vietnam but studied and worked abroad and he can tell us a lot about the differences between countries. In this presentations and the discussion afterwards it becomes clear that sustainability as we know it, may be a step too far for Vietnam. At this moment they don't have any motivation to save energy or think sustainable. They

probably first have to solve their problems with an instable energy network, no central sewage and for instance building site management before they think about sustainable buildings.

**A**fter lunch Royal HaskoningDHV organizes a trip to one of their building sites. It is a 1 hour drive to the building site of Marigot/Swarovski. They are building a factory for jewelry which means some working halls for about 600 people without any windows and the facilities for eating without any walls. The working halls are remarkably small for the number of people that will work there. There are no windows in these halls because of the possibility of espionage. The dining hall and the changing rooms are contrary open to provide natural cooling. For one of the first times, this building makes use of cavity walls. This time not for keeping the heat inside, but for keeping the heat outside. This means you have to pay attention to the details and for instance put the vapor resistant layer on the right

Marigot Jewellery (Swarovski) building site, managed by Royal HaskoningDHV



side. To make sure that these modern structures are added in the right way, Royal HaskoningDHV also controls the building site. Also to make sure the construction workers know how to meet the international standards. Remarkable are the number of women on the building site. In the Netherlands you actually never see women as construction workers, but on this building site there are many. Our guide tells us that women in Vietnam work more and at higher positions than in most western countries. The number of workers on the building site is very high, that is due to the low labor costs. Instead of investing in machinery they use more people at the building site instead. The building materials are relatively expensive in Vietnam, because they have few local materials. Therefore they must import most building materials from abroad. After this tour we drive back to the centre of Ho Chi Minh City and finish the day together.

### SATURDAY 4 MAY

**T**oday we are going to Can Gio island, also known as monkey island. After a journey of about one and a half hour by bus and ferry, the curious and cheeky monkeys seem excited to meet us. The naive student who has a banana in his pocket is robbed within no time and even uneatable stuff is not safe in their presence. We continue our trip towards a crocodile farm where we get the opportunity to 'catch' a crocodile with a fishing rod. The 'tough men' among us grab their chance and have success for a few times. Afterwards, we get on small speedboats which bring us to the center of the mangrove forests where a former Vietcong base is established. Here we are confronted with the unimaginable and unworthy circumstances in which the Vietnam War took place. The trip is finished after a lovely Vietnamese lunch and a refreshing dive into a salt- and freshwater pool. In the evening we decide to visit one of the famous Water Puppet theatres in Ho Chi Minh City. Water puppetry is a Vietnamese

tradition that dates back as far as the 11th century when it originated in the villages of the Red River Delta area of Northern Vietnam. Since the reviews were hilarious and outstanding our expectations are rather high. During the performance, live music is being played and the 'actors' operate the water puppets manually with the use of bamboo rods from behind a screen. After all, it can be said that it is a very surprising and amusing show!

#### SUNDAY 5 MAY

A trip to the Mekong-delta is planned for today. Arriving at the Mekong-Delta after a three hour trip, we all get on a small boat. The boat is taking us to an island nearby. The small boat trip is refreshing and gave us a chance to escape the heat for a moment. The island is clearly a tourist attraction with several 'authentic' Vietnamese shops, allowing us to buy souvenirs.

**A**t a certain point we get the chance to ride bikes. As true Dutch folk, our passion for riding bikes, is no match for the heat to stop us. Being able to choose your own path, and not being stuck in a bus, it gives us the little freedom we long for. That results in an off-road path, passing by several houses were few tourist arrive. Top attraction is a local elementary school with kids shouting 'Hello!'. After our little bike ride we



Boat trip through the Mekong Delta

go into small boats. We are constantly drinking water to compensate the excessive sweating, while being peddled back to our bus stop.

The Mekong-Delta gives us an empty stomach as we arrive back to the hostel. Longing for a nice dinner, we start looking for a place to eat. With so many restaurants in our so called 'backpackers' district, our search for a place to eat is an easy one.

#### MONDAY 6 MAY

**A**rup is the second company visit. Richard Padfield electrical engineer welcomes us in the office. He starts with an introduction about himself and the company. Arup was founded in 1946 and since 2000 is established in Vietnam. The main difference with Vietnam and western countries is the way of thinking. Words like sustainability, energy neutral are a step too much. The aim is to build as cheap as possible with the Vietnamese standards which



# Start je carrière bij Heijmans

Heijmans is een veelzijdig bedrijf, actief in vastgoed, woningbouw, utiliteitsbouw, installatietechniek en infra. Mensen maken het bedrijf. Met meer dan 8.000 collega's bouwen we aan de ruimtelijke contouren van morgen. Samen maken we mooie projecten van blijvende waarde, voor onze klanten en voor de samenleving. Dat is het succes van Heijmans.

#### Ook deel uitmaken van dit succes?

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Having breakfast in a park



Back to school

are very low. Arup is one of the most expensive companies, but is leader in innovation and new ideas. International companies chose Arup for their innovative approach and the quality they deliver.

**A**rup applies the international LEED standard for big projects in Vietnam. There are several problems with this approach because of the difference in climate. Also sustainable solutions don't work in this climate. Another difference between Vietnam and western countries is the role of the government. Vietnam is a communistic country so the government needs to approve everything. Therefore getting a license to build is hard and gives a lot of difficulties. Arup has succeeded in getting the confidence of the government and so there are a few high rise buildings in Vietnam which are design by Arup. One example is the Time Square, an L-shaped building with

three basement levels. A very impressive skill of Arup is top down building. While one layer is built underground, four layers can be built on top. This results in a six layer cellar and a lot of cost saving. This is also applied in the Time Square.

**R**ichard Padfield tells that life in Vietnam comes with a lot of challenges like working with the government. Also getting a driver license is really hard so it's easier to ride a motorbike as all Vietnamese people do. After the introduction and discussions it's time for Mike's presentation about fire safety. A fire safety engineer of Arup attends the presentation. A very important task has to be done before we leave the office and that is making a group picture.

**A**fter lunch we visit the Bitexco tower. This is the highest tower of Ho Chi Minh City and has 64 floors. We

visit the skydeck and have a great view over the city. The Time Square and the A&B tower stand out because of their height. After taking a lot of photo's the group splits into different groups to buy souvenirs, ride a motorbike or have a massage.

#### TUESDAY 7 MAY

**T**oday we go to the Cu Chi Tunnels, the underground complex of the Vietcong in the Vietnam war. The tunnels stretch from Ho Chi Minh City to the Cambodian border. In the district of Cu Chi alone there are more than 250km of tunnels. The network, parts of which is several storeys deep, include innumerable trap doors, constructed living areas, storage facilities, weapons factories, field hospitals, command centers and kitchens. At first the tour guide shows us the camps above the ground. He shows us also the different booby traps, which are very impressive.

Spelling Mollier in the Bitexco tower



Evening at Ho Chi Minh City



Then the doors of the tunnels have to be found, which is very difficult.

In the afternoon we go to the Cao Daï Temple. This is a temple for the ultimate religion, it is a combination of Buddhism, Confucianism, Taoism, native Vietnamese spiritualism, Christianity and Islam. During the visit there is a prayer service with calm chants. In the temple everywhere you see an eye, this is the official symbol after Ngo Minh Chieu saw it in a vision. Ngo Minh Chieu had founded the Cao Daism.

#### WEDNESDAY 8 MAY

The program tells us that we will visit the University of Architecture today. But unfortunately the university sent us an e-mail just before the departure that this visit has to be canceled. The university didn't have any time to accompany us. Instead of the university visit we decide to go Vung Tau which is a little town at the sea. The trip of about 100 km by hydrofoil takes about one hour. In Vung Tau they have built a statue of Jesus Christ with outstretched arms on the top of a hill. After visiting this statue we had some free time at the beach for lying in the sun and swimming in the sea.

In the evening we decide to have dinner at a local restaurant. Both for us as for the restaurant owners this was a real adventure. The menu was only in



View on Ho Chi Minh City from the rooftop bar on the AB Tower

Vietnamese and in order to communicate with the owners we used gestures and drawings. After finishing dinner we found out that we have eaten frogs, cow tendons and stomachs.

#### THURSDAY 9 MAY

We are lucky to say that we will visit the famous and successful Vietnamese 'Architect of the year 2012' this morning. The architectural

engineering company is named Vo Trong Nghia and specializes in designs fully constructed of bamboo. For Vietnam, which is considered as a developing nation, sustainable design is particularly important since Vietnam tends to rapidly lose its connection with the natural environment and faces a severe pollution crisis. The architect provides us with a brief introduction on



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- Installatietechniek



Last company visit at Tebodin

all the projects which have been developed by his company. The designs are very convincing and sophisticated which makes us extremely enthusiastic to visit one of the projects after the presentation. Therefore we grab a taxi to the projects named 'Bamboo Dome' and the 'Water and Wind café' which are both located at the edge of Ho Chi Minh City. The concept of the Water and Wind café states that the wing shaped design of the building increases the wind speed through the building which reduces the sense of heat for the visitors. Furthermore, the water which surrounds the building will provide additional cooling by means of the conversion of solar heat into the evaporation of the water. In the afternoon we visit Philips which is situated in the AB tower. At the moment, Philips is the main developer and manufacturer of electrical lightning devices in Vietnam.

**W**hen sunset emerges, we head up to the rooftop bar of the AB tower, for which the AB tower is well-known among experts and tourists. In this precious place we enjoy the lovely scenery and see the skyline of Ho Chi Minh City fade slowly in the dark while the streetscapes change from busy market stalls and shops into lively nightlife with cozy bars.

#### FRIDAY 10 MAY

**T**oday we are heading to Tebodin, a worldwide consultancy and engineering firm. Once again we decide to take cabs, as the cab-fees are low. Being welcomed in Dutch by one of the expats, we head to the meeting room. Tebodin starts with their introduction of Tebodin Vietnam. The introduction is followed up by a presentation from our students Jelle Loogman and Robert Snoeren. Unfortunately the planned visit

to one of Tebodin's projects was cancelled. However Tebodin did not let us leave before treating us with a delicious lunch. Including exotic 'delicates' in the soup, such as a chicken head.

**W**ith a gap in our schedule we decide to fill it up by visiting a few stops we skipped during the walking tour earlier. With today being our last full day, some of us added a Vietnamese massage in their spare time. Our last evening takes us to one of the local bars. Sitting on the Vietnamese-sized garden chairs, we celebrate our time together as a group. Drinking the local beer and for some, trying the fried squid, sold by a lady on her bike. Some continued their night in a nightclub, accompanied by new Vietnamese friends. Others took another delicious Mojito's and pray that the fragile garden chairs will hold their weight for another couple hours.

#### SATERDAY 11 MAY

**T**oday is the last day of the study trip. The last chance to buy souvenirs and visit parts of the city we haven't visited yet. A couple of students visit the slum and the free housing which looked more like a ghost building. Other students visit district 7 or visit the local bar. At 17:00 we gather at the hostel and say goodbye to all our new friends. The taxi picks us up and takes us to the airport. When the check in is open, we see that the departure time is changed from 20:30 to 0:00. After checking in we gather in the lounge and get a free meal. After a long wait we finally enter the airplane and leave Ho Chi Minh City.

#### SUNDAY 12 MAY

**A**t 1:30 pm we arrive at Düsseldorf Airport and we go to Eindhoven by train. In Eindhoven everybody goes home with fine memories about Ho Chi Minh City.

Wind and Water bar (wNw), designed by Vo Trong Nghia Architects



# Experiences of a PhD

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After the completion of my master (Physics of the Built Environment) in 2008 at the Unit BPS, I started in July 2008 with my PhD study entitled "Experimental and numerical analysis of mixing ventilation at laminar, transitional and turbulent slot Reynolds numbers". The PhD study was performed as a bi-doctorate between TU/e (supervisor: prof. Blocken) and Leuven University (supervisor: prof. Baelmans), with funding provided by both Universities. Furthermore, during the study there was a strong collaboration with the Department of Applied Physics (prof. Van Heijst). In December 2012 I successfully defended my PhD, and I obtained my PhD at TU/e with honors. Currently, I am working as postdoctoral researcher at the Unit BPS in the Climate Proof Cities research program.

## SUMMARY OF PHD STUDY

My PhD study consisted of two parts, (I) experimental and numerical work on isothermal transitional mixing ventilation in an idealized simplified reduced-scale model; (II) experimental and numerical work on mixing ventila-

tion in a full-scale complex enclosure in an urban environment, driven by both wind and buoyancy. Both parts consisted of a combination of unique measurements, either full-scale or reduced-scale, and state-of-the-art Computational Fluid Dynamics (CFD) simulations. It is widely known that the proper ventilation of buildings and other enclosures such as airplanes, trains, ships and cars is very important with respect to human (thermal) comfort, energy efficiency and sustainability. One of the most commonly applied and studied ventilation methods is mixing ventilation, which is based on the injection of an air jet in the upper part of the room.

In Part I of my PhD research I focused on mixing ventilation at transitional slot Reynolds numbers. The vast majority of previous ventilation studies focused on fully turbulent flows (high Reynolds numbers). Low Reynolds ( $Re$ ) numbers can indicate the presence of a transitional flow regime inside the room, which can be distinguished from turbulent flow by the presence of relatively large coherent structures (vortices).

Several publications have indicated the fact that transitional flow can be present in different types of room airflow, however, only a very limited number of studies has dealt with room airflow at transitional slot Reynolds numbers so far, either experimentally or numerically. In addition, there was no consensus on the capabilities of CFD to predict transitional room airflow. To analyze mixing ventilation driven by a transitional jet we performed flow visualizations and Particle Image Velocimetry measurements in a reduced-scale water-filled setup (fig. 1). In addition, we used these experimental results to assess the capability of steady Reynolds-averaged Navier-Stokes (RANS) CFD simulations. These comparisons showed that certain RANS turbulence models are not capable of accurately predicting the flow pattern in a room when it is driven by a transitional (low- $Re$  number) jet. As a result, differences in the air exchange efficiency predicted by two different turbulence models can be as high as 44%.

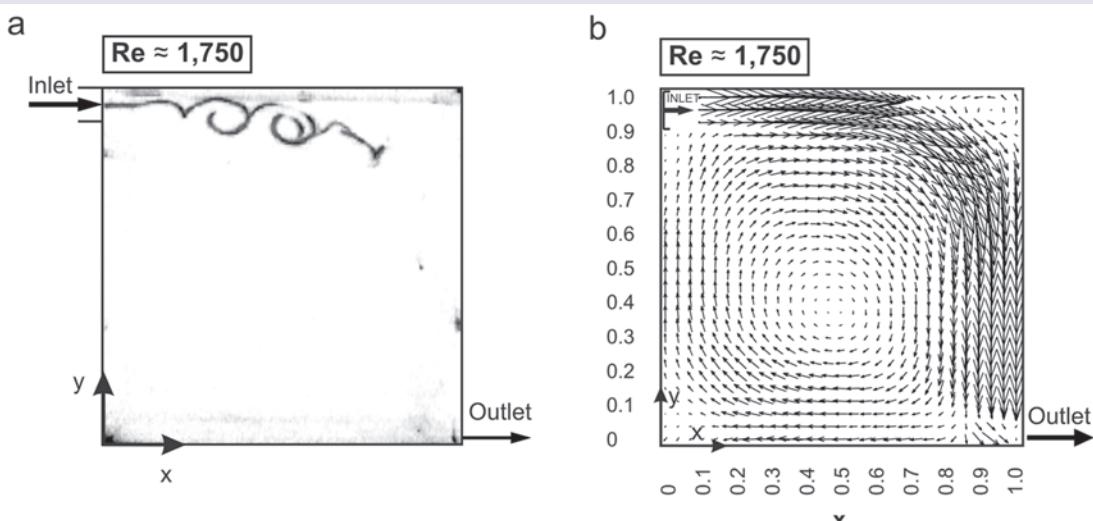


Figure 1 (a) Flow visualization of the flow pattern inside the cubic enclosure for  $h = 0.1$  and for  $Re \approx 1,750$  (instantaneous image). (b) Result of PIV measurements. Time-averaged velocity vectors for  $Re \approx 1,750$  in the vertical center plane of the cubic enclosure

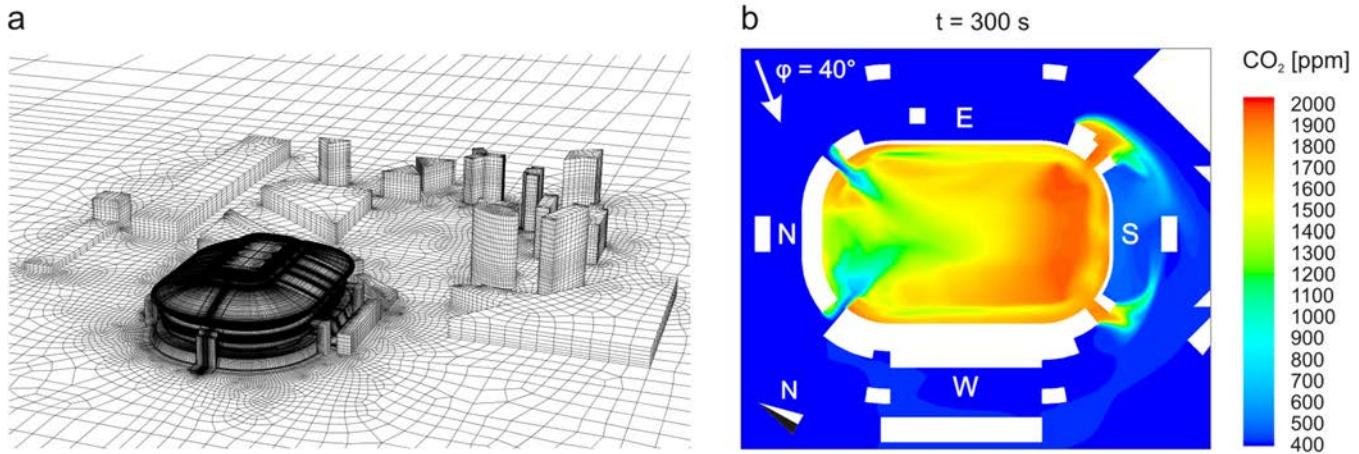


Figure 2 (a) Computational grid on the building surfaces of the Amsterdam ArenA and part of the ground surface: middle grid, 5.6 million cells. (b) Distribution of CO<sub>2</sub> concentration (ppm) in a horizontal cross-section at a height of 4.65 m above the ArenA deck at t = 300 s.

**P**art II of the doctoral thesis contained a case study of natural mixing ventilation in a semi-enclosed stadium (Amsterdam ArenA) in an urban area driven by wind and buoyancy. Full-scale measurements were presented which were used to validate steady RANS CFD simulations of the airflow in and around the stadium. The validated CFD model was used to assess the current and alternative ventilation configurations, and to identify regions with higher pollutant concentrations using simulations of CO<sub>2</sub> concentration decay (fig. 2). Finally, the influence of the urban surroundings and the influence of the wind direction on the air exchange rate was analyzed, showing that very large errors (up to 96%) can be made when neglecting the urban environment in natural ventilation studies.

#### PHD STUDY IN RETROSPECT

**A**t the beginning of my PhD study I thought that four years is a very large time-span. However, in retrospect, the years passed amazingly fast. First of all, this can be attributed to the fact that it was simply a very pleasant and joyful time. Secondly, I was involved in a wide range of activities, which certainly had a very positive effect on my experiences as a PhD student.

**D**uring my PhD period I was not only working on my main research topic. Thanks to prof. Bert Blocken, who encouraged me to participate in a range of activities, I participated in several research projects that were not related to my PhD research. For example, I was involved in the assessment of wind comfort on balconies of high-rise residential buildings in Antwerp using CFD simulations. Furthermore, I worked on the numerical part of the analysis of the Ventec® roof, which was designed by Ben Bronsema to enhance natural ventilation and the wind energy potential of wind turbines positioned inside the roof construction. Based on this study we wrote several journal publications, of which one was granted a Best Paper Award of the ISI journal

Building and Environment. Note that we have a high reputation in our group regarding the Best Paper Award of this journal; in 2009, 2011, and 2012 the award was given to researchers of the group of prof. Bert Blocken.

**B**esides these additional research projects, I have been actively involved in education in the bachelor and master track at the Unit BPS, among others as supervisor of second year bachelor projects and as co-supervisor in seven (partly ongoing) master theses. Being a co-supervisor of bachelor projects has allowed me to step out of the in-depth research activities for half a day in the week, and it has forced me to refresh, and keep up, my knowledge of the broad number of aspects of building physics, but also of general building engineering. Co-supervising master students has also been a pleasant activity for me, it has kept me sharp and has provided me with the opportunity to work with excellent, motivated and enthusiastic master students! It is very good to see that several students I co-supervised in their second year of the bachelor found their way to our Unit as a master student. The same holds for some of the PhD researchers, who I co-supervised during their master thesis and who started their scientific career at our Unit. I think it is very important to keep attracting motivated and talented master students, which in turn can even consider a PhD position, if available and if the student has ambitions in this direction.

**E**nthusiasm for conducting research is probably the most important thing you need when considering to apply for a PhD position. As mentioned earlier by among others Roel Loonen and Miruna Florea, PhD research is not only work, it should also be your hobby, with other words, you should enjoy it! Personally I have never regretted my decision to do perform a PhD study; I went to work every day with great pleasure, and I am still doing so at the moment as a postdoctoral researcher. A job as a PhD

researcher enables you to learn every day, perform in-depth research, have contacts with excellent and enthusiastic students, and researchers worldwide, and enhances your development as a professional, but also as a person. As you might have noticed, I am very positive about my former life as a PhD student. I think my master study at the Unit BPS provided an excellent starting point for my PhD, but I am convinced that it also provides students a very solid academic background for other jobs, either in research or consultancy! This is one of the things we can be proud of at the moment, but it also something we should maintain in the near and far future!

# Hoe lang steken we onze kop nog in het zand?



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