

Most of the more persistent man-made structural assets that surround us in everyday life as well as their reliable structural services are normally taken 'as a law of nature' by the general public. Compared to consumer products the service levels of structural assets are extremely high. Bridges with a structural failure rate comparable to that of normal office printers would be considered completely unacceptable, while a tunnel would never be built if they had a service life expectancy comparable to the most long lasting functional products such as (certain) washing machines or Hi-Fi-systems. The same holds for all build structures, including houses, public and commercial buildings.

Meanwhile these structural assets together exceed in financial terms the balance of any global financial institution, or the yearly budget of e.g. the Dutch government many times. Thus, the importance and impact of the broad field of science and engineering related to the built environment - which includes architecture, architectural engineering, civil engineering, process management and policy - is not to be underestimated, both economically and socially.

Notwithstanding the evident importance of the Built Environment sector, the public perception of this sector is not that positive, a trend that has been developing in the past few decades. The public perception of the sector often leans towards non-innovative, somewhat clumsy, disorganized and conservative.

It is often forgotten that inventions and innovations from any field of science and engineering are finally applied in the context of the built environment. Developments with respect to e.g. energy comfort, new building materials and systems are spectacular. For instance, no other innovation has increased life expectancy of people as much as the broad application of developments in sanitary engineering. It is even so, that the difference between developed and developing countries can be largely attributed to the quality of public sanitation systems. Apparently, the development of an adequate and efficient sanitation system requires the effective collaboration within the so-called 'Golden Triangle', i.e. stable and facilitating governments, trained people and innovation originating from educational and scientific institutions and energetic application by these innovations by the market.

PDEng is a two-year professional, post-academic degree, where university graduates work in close collaboration with the industry on an urgent and industrially relevant topic.

Moreover, the environmental impact of the 'building sector' is huge, given the enormous usage of raw materials. Together with the energy sector, the building sector is at the forefront of addressing great societal challenges related to sustainability, scarcity and availability of raw materials as well as the transition towards a circular economic model, based on recycling and upcycling of waste materials and structures.

Another development is the need for true multidisciplinary and cross-disciplinary collaboration on these challenges. Almost every field of science and engineering has found its application in the built environment. Developments within quantum mechanics has led to diverse developments like energy efficient lighting (LED), precise positioning and cutting (laser technologies) and of course to the revolutionary introduction of ICT in the built environment. Developments in (micro-) biology has led to the aforementioned sanitation revolution, whereas new insights in the mathematics of planning and operations research allowed building processes at scales that would have never been possible before.

An effective and multidisciplinary approach faces grand challenges ahead, requiring dedication and collaboration. Therefore the three technical universities decided to collaborate - among others - as 3TU. Bouw Center of Excellence for the Built Environment. The 3TU.Bouw Center of Excellence consists of the Department of the Built Environment at Eindhoven University of Technology, the faculty of Engineering Technology at Twente University, and the faculties of Architecture and Civil Engineering and Geosciences at Delft University of Technology. The overall goal of this 3TU initiative is to promote close collaboration between Dutch universities in order to increase competitiveness in international research and education, and to concentrate research and education efforts to improve efficiency and scientific excellence.

At present 3TU.Bouw concentrates on two major developments: innovation with respect to energy efficiency in the built environment, and providing dedicated professional education programmes to deliver young

professionals that are able to bridge the gap between academia and the market.

The latter is achieved by the so-called PDEng-programme. Within 3TU.Bouw a dozen of these projects have been started in 2014 and a similar number will be initiated in 2015. Industrial partners are always welcome to propose PDEng projects that can be jointly pushed forward within the context of the 3TU.Bouw PDEng-programme.

Bouw 'Lighthouse Projects' aims at promoting and starting up imaginative research projects that are related to the theme 'Energy and the Built Environment'. The 'imaginative' nature of the research as well as the delivery of tangible results (e.g. prototypes, test environments, and so on) distinguishes Lighthouse Projects from other funding schemes.

The preliminary project ideas and results of a series of Lighthouse projects, started only in the second half of 2014, are presented in this publication together with the context of a few of the PDEng-projects started in the same year. It should be noted that success of 3TU.Bouw does not mean that (all) initial project goals are met: a good failure can be a huge success and may generate, in the long run, more impact than a successful project with a more limited scope.

The 'Week van de Bouw' is one of those opportunities where we can stand together; academics and industry, contractors and asset owners, students and experienced professionals. Let's synergise, combine and cross-fertilize our expertise to solve future challenges, while being grateful and proud with everything achieved already by our colleagues of the past generations.

3TU.Bouw
center of excellence for the built environment
www.3tubouw.nl | info@3tubouw.nl

Scientific Director - Ulrich Knaack
Executive Director - Alexander Schmets
Curator - Siebe Bakker

Ambassadors
Delft University of Technology - Architecture: Frank van der Hoeven
Delft University of Technology - Civil Engineering and Geosciences: Jan Rots
Eindhoven University of Technology - Built Environment: Bauke de Vries
University of Twente - Engineering Technology: André Dorée

INFO & CONTACT Lighthouse Projects 2014
Double Face: Michela Turrin - m.turrin@tudelft.nl
Energy Efficient Facade Lighting: Alexander Rosemann - a.l.p.rosemann@tue.nl
Impenetrable Infiltration: Bram Entrop - a.g.entropy@ctw.utwente.nl
Kinemould: Roel Schipper - r.schipper@tudelft.nl
Robotic Driven Construction of Buildings: Henriette Bier - h.h.bier@tudelft.nl
Peter Rem - p.c.rem@tudelft.nl, Theo Salet - t.a.m.salet@tue.nl
Semantic Web of Building Information: Timo Hartmann - t.hartmann@utwente.nl
Sensing Rotterdam: Frank van der Hoeven - f.d.vanderhoeven@tudelft.nl
The LIGHTVAN: Truus Hordijk - g.j.hordijk@tudelft.nl

INFO & CONTACT Lighthouse Projects 2015
PO Lab: Marcel Bilow - m.bilow@tudelft.nl
Polyarch: Eric van den Ham - e.r.vandenham@tudelft.nl
The Leaf Roof: Alexander Rosemann - a.l.p.rosemann@tue.nl
RFID-Sensors: Seirgei Miller - s.r.miller@utwente.nl
Saving Energy Battle: Ana Pereira Roders - a.r.pereira-roders@bwk.tue.nl
Throw in the I-Drone: Bram Entrop - a.g.entropy@ctw.utwente.nl
Understanding the Past: Carola Hein - c.m.hein@tudelft.nl

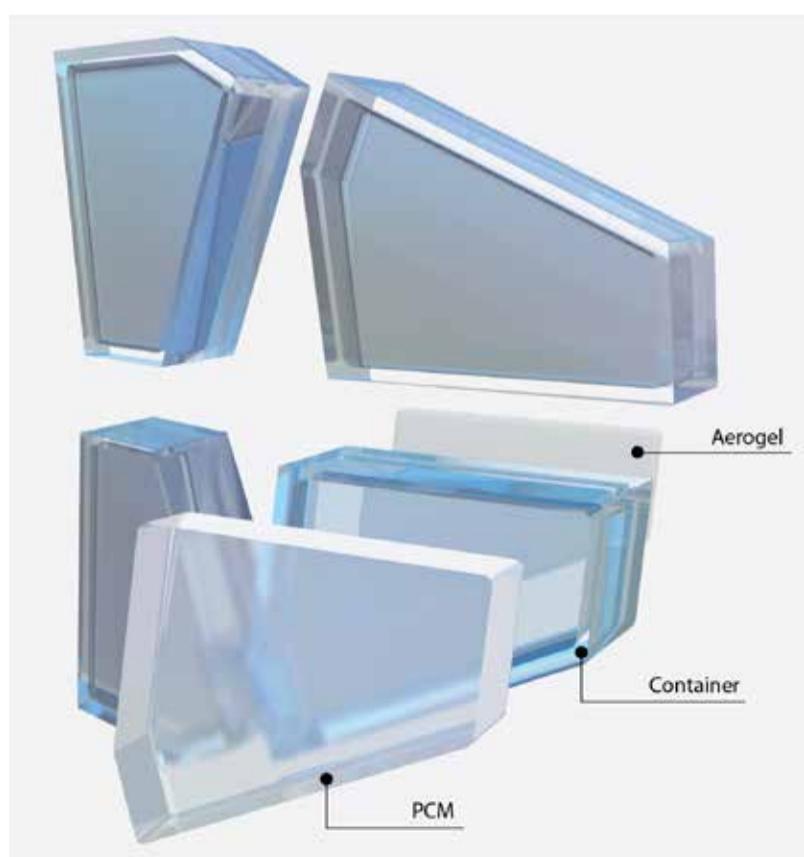
INFO & CONTACT PDEng Projects
Energy Efficient and Healthy Learning 2.0: Stephanie Villegas Martinez - s.villegas.martinez@tue.nl
Geometric Information Provider Platform for Renovation of Building to Lower Energy Costs: Meisam Yousefzadeh - m.yousefzadeh@utwente.nl
A Living Lab: Argyrios Papadopoulos - a.papadopoulos@tue.nl
Luminous Solar Concentrator: Tugce Tosun - t.tosun@tue.nl
A Sustainable Life-Cycle Method: Diruji Dugarte - d.dugartemanoukian@utwente.nl

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graphic design: bureaubakker - Siebe Bakker & studio &J - Anna Karina Janssen
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The DoubleFace project aimed at developing a new product that passively improves thermal comfort of indoor and semi-indoor spaces by means of lightweight materials for latent heat storage, while simultaneously allowing daylight to pass through as much as possible. Specifically, the project aimed at designing and prototyping an adjustable translucent modular system featuring thermal insulation and thermal absorption in a calibrated manner, which is adjustable according to different heat loads during summer- and wintertime. The output consists of a proof of concept, a series of performance simulations and measurement and a prototype of an adjustable thermal mass system based on lightweight and translucent materials: phase-changing materials (PCM) for latent heat storage and translucent aerogel particles for thermal insulation.

The adjustable Trombe wall system leads to an energy reduction of roughly 40%.



Thermal benefits and translucency

The system is based on an innovative approach to thermal principles of Trombe walls. As compared to traditional Trombe walls, the system is about five times lighter than traditional Trombe walls in order to avoid structural overloads in buildings; is translucent in order to benefit from daylight; and is adaptive in order to calibrate the thermal effects. Lightness and translucency are achieved by means of the applied materials. Instead of using heavy and opaque materials like concrete, a novel application of PCM and aerogel is proposed. Several products and technical systems are currently available on the market for applying PCM by integrating them into walls, containers, or ventilations systems or in facades. Double Face proposes a system based on interior design elements, taking advantage of the dynamic behaviour of PCM as well as its appearance. As such, the system is also meant to contribute to aesthetical design criteria in the design of interiors. The elements are translucent; are meant to be located in front of a (full) glass façade, where the largest heat impact from outside happens to be; and can be developed into various design options for new buildings as well as retrofitted into already existing buildings. Additionally, the system is adaptive in order to enhance the thermal benefits. Exposing thermal mass to winter solar radiation (passive heat gain) and protecting it from the summer one (passive cooling) and therefore acting as thermal buffer. This happens by rotating the elements towards the source of incoming heat or the sink for heat release. In winter, the PCM side would face the exterior and be thermally charged during the day by the low winter sun. During night times, oriented towards the interior, it releases the accumulated heat. In summer, during the day in combination with external sun shading, it would store the heat from interior heat loads and during the night release this heat to the outside environment by means of night ventilation, thus acting as a cooling plate.

Ajustable Trombewall

The research process started with a wide inventory of existing PCM; an analysis of their properties; and a consequent short-list of selected materials. For each of the selected PCM, digital simulations

were conducted to analyse the thermal behaviour. They were conducted for single layers of PCM in various thicknesses; and for combinations of two layers, one of PCM in various thicknesses and one of translucent insulation, also in various thicknesses. The translucent insulation was simulated as a layer of Aerogel; and as a system of cavities trapping air within a translucent 3D printed material. Based on the digital simulations, the system of layers was pre-dimensioned for a total thickness of 7cm (5 cm PCM, 1 cm aerogel and 1 cm container wall thickness). Several samples (17x17x7cm) were made for a number of selected PCM. These samples were tested in the laboratory for Building Physics at Eindhoven University of Technology for their thermal behaviour; and at Delft University of Technology for their light transmittance. The measurements allowed for fine-tuning the dimensions as well as for narrowing down the list of selected materials. As a result, PCM thickness was reduced to 4 cm. Furthermore, using the measured properties as input, simulations of the thermal behaviour of a standard room equipped with this Trombe wall system were run in DesignBuilder to study several variations including PCM layer thickness, insulation layer thickness, extra cavities and percentage of holes in the wall. These simulations showed that an opening percentage of roughly 10% was ideal for this Trombe wall system. Because of the limitations of simulating the rotation of the wall panels, a new simulation model was developed in Matlab/Simulink. These new simulations, which included the rotation, showed that the adjustable Trombe wall system leads to an energy reduction of roughly 40% as compared to the 'no Trombe wall situation'.

Exposed technical systems

Parallel to the research, a number of design alternatives were drafted, based on the thermal principles. For this project, one design option was chosen to be developed and prototyped. The option shows the potential of exposed technical systems contributing to aesthetical design criteria within interior design, while remaining within feasibility constraints in order to realize a prototype within the time-line of the project. To realize the prototype, the translucent container



prototype container resin-perspex



for the layers of PCM and insulation, additive manufacturing was considered initially, in order to cope with the complexity of the form. A number of tests were made by 3D-printing translucent PLA and PET via the rather cost effective filament fused deposition modelling (FDM) method. However considering the challenge of obtaining translucent parts that have high structural strength and maximum light transmittance without the need of falling back to expensive 3D printing techniques (like Stereolithography), additive manufacturing was later used only to produce moulds to cast transparent resin, in order to get a more glass-like appearance. An option for a laser-cut transparent sheet of Perspex was developed, leading to satisfactory results as well.

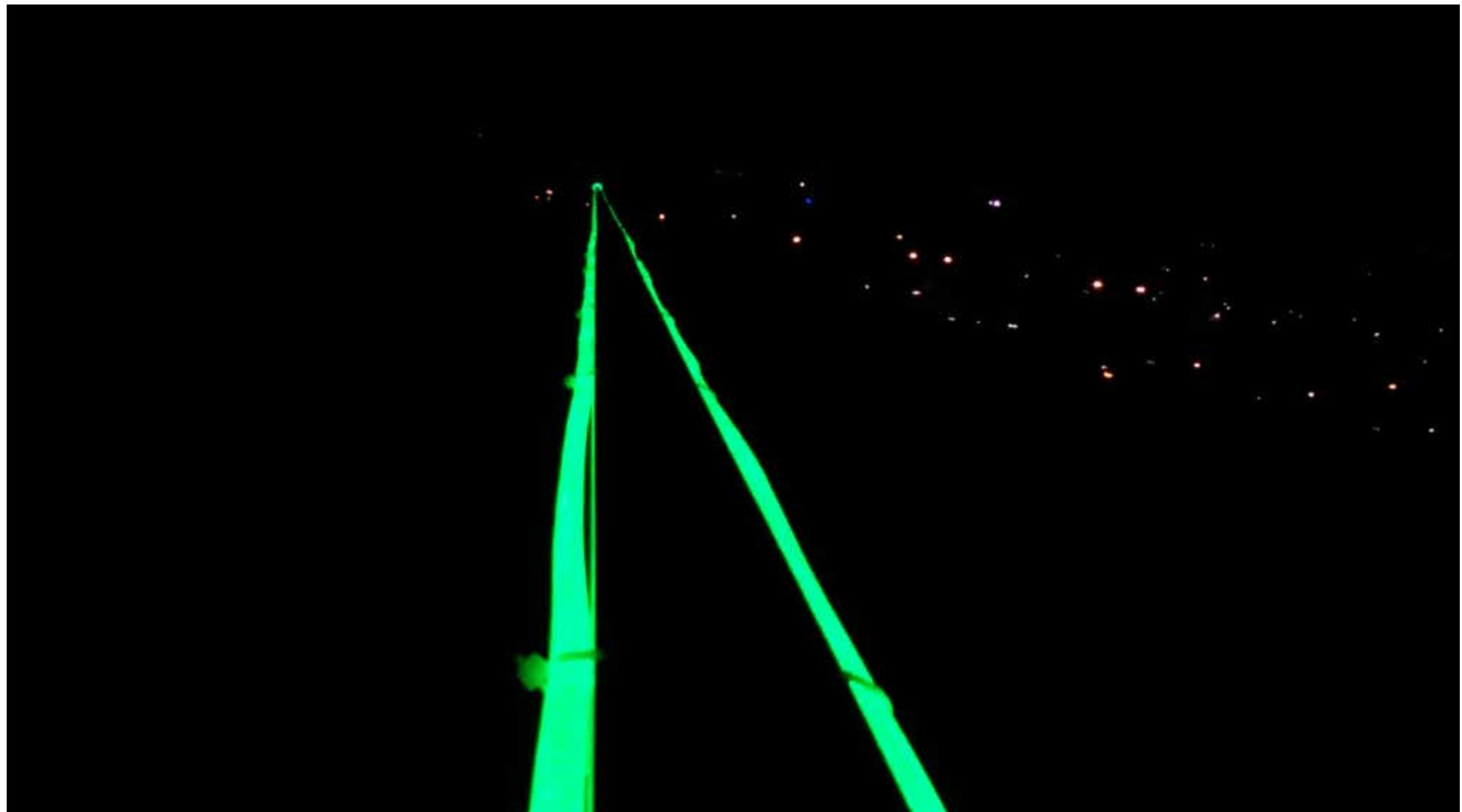
Contingent conditions

The thermal behaviour of the prototype is now being measured using heat-flow sensors and thermocouples at Delft University of Technology. Additionally, further performance simulations are being run in order to model the behaviour of the modular and adaptive system under different climate conditions and in various room environments. Current simulations include fine-tuning of the rotation schedule of the elements in order to orient the insulation according to contingent conditions (day/night – winter/summer). The ambitions of the team include tuning this prototype and exploring other design alternatives, for which further development and testing are intended. A number of companies have been contacted during the process especially regarding existing PCM and their architectural applications.

Delft University of Technology
dr. Arch. Michela Turrin
dr. ir. Martin Tempierik
ir. Paul de Ruiter, ir. Winfried Meijer
dr. ir. Willem van der Spoel
Carlos Alfredo Chang Lara

Eindhoven University of Technology
Dipl.-Ing. Florian Heinzelmann
prof. Dr.-Ing. Patrick Teuffel
ing. Wout van Bommel





The project set out to proof that a conventional optical fibre lighting system for highlighting the structure of a façade can be operated more energy-efficiently through the substitution of the projector using a metal halide reflector lamp by a laser. This is investigated by looking into the photometric assessment of such systems as well as the electric power draw during operation. In preparation for a potential exterior demonstration installation, an additional focal point of the research was the design and testing of a weatherproof case that provides protection to the laser and the ballast. The final stage brought the different aspects of the research together and resulted in a temporary experimental setup (pilot installation) in order to showcase the validity of this novel approach.

The investigated system is an adequate energy-efficient alternative to conventional fibre lighting systems, resulting in savings of at least 80%.



Throughout the project there was active communication between the partners. Meetings took place in Eindhoven, Delft, and Den Haag. At the TU/e two students were recruited to participate in the research project, and at both universities the possibilities for demonstration projects were explored. During the discussions, ideas for details on the overall approach and the setup were developed. The brainstorming continued with the students at their regular project update meetings. They developed the research questions and mapped out their approach in a measurement plan. The student project results were presented at an intermediate workshop and to the project partners.

The weather proofing of the box is being tested for its performance under various exterior conditions, using a climate chamber, by measuring: the interior temperature in the box, the humidity in the box, and the protection against simulated precipitation (snowfall and rain).

After energy performance determination, the photometric assessment focused on two main sets of measurements; illuminance measurements indicating the relative luminous flux coupled out from the fibre and luminance measurements under different observation angles.

The illuminance measurements were carried out along the fibre as well as around the fibre. This produces an indication over the attenuation of the extracted light and also the uniformity of the light extraction. The illuminance at a defined and constant distance is a measure for the relative luminous flux leaving the fibre. In addition to that, the luminance from different observing directions was recorded to evaluate the expected brightness perception. The photometric assessment was done for three laser types: red ($\lambda = 655 \text{ nm}$), green ($\lambda = 532 \text{ nm}$), and blue ($\lambda = 447 \text{ nm}$).

Power consumption measurements
A BL Innovative Lighting fiber is connected to a metal halide (MH) lamp of about 190 W; either on one or two sides of the fiber. Currently, the

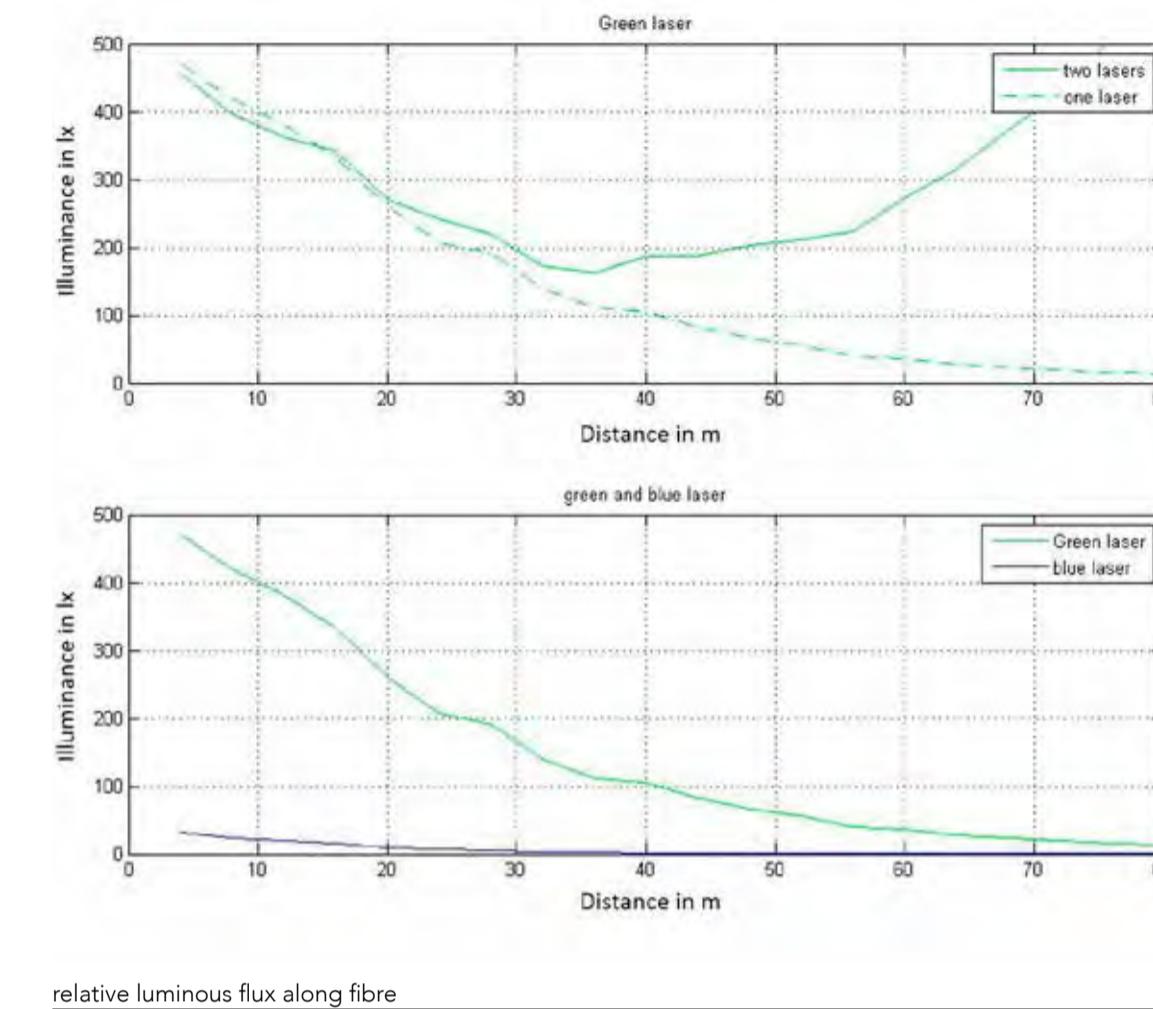
maximum commercially available length of this fiber is 80 meters, and would require at least four MH lamps to light the full fiber length, with a total energy consumption of 764 W. However, if a MH lamp were to illuminate the fiber from a single end the maximum length would be about 13 meters (including visible light loss). With the laser installation, the power consumption over the first 15 minutes after starting the laser was recorded. The results for the three laser types tested are showing a stabilized power draw for the red, green, and blue laser of 59 W, 71 W, and 54 W respectively. The difference in power consumption of the least efficient laser system (2*71 W) compared to a system lit with MH lamps over a comparative fiber length of 80 meters would be five times lower (142 W vs. 764 W), resulting in a savings of approximately 80%.

Photometric measurements

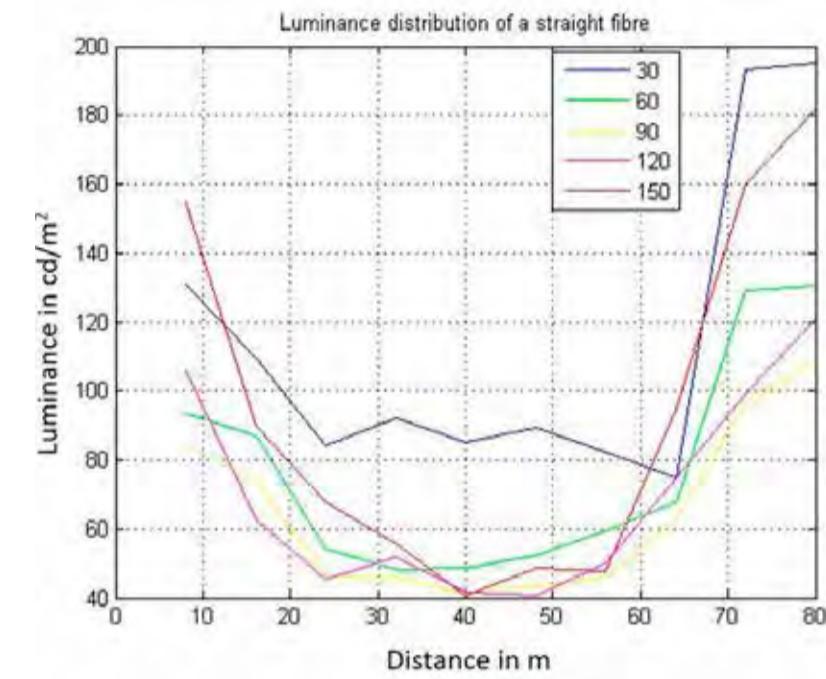
The illuminance was measured at a constant distance from the fibre. This was achieved through the use of a device that was designed and built for this purpose. It can wrap around the fibre and holds the photo element in place. The measurement distance was approximately 1 cm to get the maximum dynamic range. The illuminance measurements are an indicator for the relative luminous flux leaving the fibre. Luminance measurements have been taken under different observation angles around a measurement point. The results give an indication on the brightness perception when viewing the installation from different positions. As a rule of thumb, differences in brightness occur when the luminance difference is approximately one order of magnitude.

Measurement along the fibre

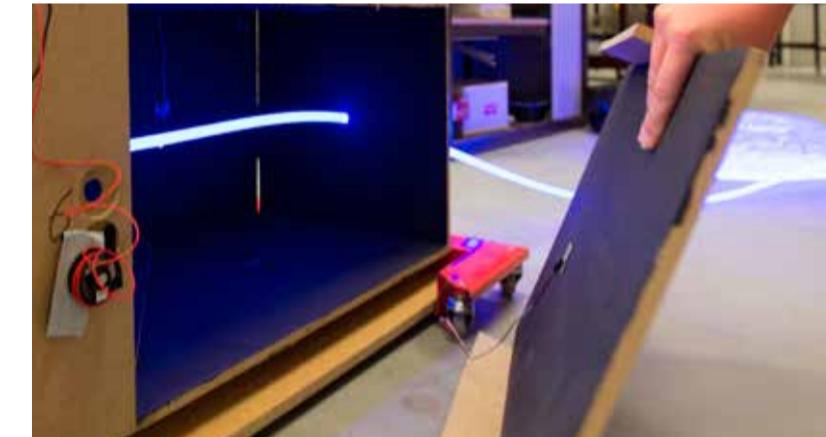
The measurements along the fibre show that the relative luminous flux coupled out is attenuating over the length of the fibre. The data for a system fed by one laser shows that the relative luminous flux drops by one order of magnitude at a distance of approximately 55 m. A fibre system that is fed by two lasers shows the expected symmetric behaviour. The minimum occurs in the middle of the fibre. There the relative luminous



relative luminous flux along fibre



Luminance along the fibre



flux is approximately 40% of its initial value. The measurements for a one-laser system can be mirrored to calculate the relative luminous flux along the fibre. The calculations results match the measurements very closely.

Measurement around the fibre

As a measure for the uniformity in all directions, the illuminance was measured on the four spots around the fibre every 8 m along the fibre (0°, 90°, 180° and 270°). The most noteworthy non-uniform light extraction can be observed at the beginning of the fibre. This is likely caused by slight misalignments of the laser axis and the axis of the fibre that are believed to cause non-uniform light losses at the beginning.

Luminance measurements

The luminance measurements were taken for two situations: the fibre being fed by one laser and the fibre being fed by two lasers.

As expected, the luminance drops along the length in a similar manner as the relative luminous flux. This effect is reduced in a system fed by two lasers. The luminance is relatively similar for all viewing angles (ranging from 30° to 150° with 90° indicating the surface normal). For a two-laser setup, the minimum luminance drops from approximately 200 cd/m² to approximately 40 cd/m². This drop is not leading to a perception of brightness difference according to the rule of thumb mentioned earlier. The laboratory measurements indicate that no visible difference along the fibre system would be noticed.

Temperature dependence

According to the manufacturer's data sheets, the laser systems consisting of a power supply box and the laser module itself need to be operated in ambient temperatures between 10°C and 35°C. A few experiments investigated the influence of the ambient temperature on the light output. The first measurement series looked at the system's performance when ramping up the ambient temperature slightly beyond the upper boundary of the recommended temperature range and

letting it cool down afterwards. The illuminance measurements indicated the impact on the overall light output. The ambient temperature in the upper part of the recommended temperature range has no significant impact on the light output. Normal operation within an enclosure can often lead to a fluctuating ambient temperature. Such a temperature profile was simulated in the laboratory and also leads to no significant changes in light output. After the lighting system is stabilized, the illuminance values ranged between 55 lx and 56.5 lx which corresponds to a maximum variation of 1.1%.

Pilot installation

A working prototype of the laser/fibre system has been demonstrated on the roof of the Vertigo building on the TU/e campus in December 2014. The 80 m long fibre was installed along the inside and outside of a roof rail resulting in a 40 m long light installation that could be seen from the building as well as from the ground.

80% Reduction of energy consumption

The results of this project show that the fibre system fed by lasers is a feasible technology to highlight facades of buildings. The photometric data shows that the system can be operated in such a way that no noticeable brightness differences can be sensed along the fibre. The energy consumption of the lasers are much lower compared to the conventional solution, resulting in a savings of at least 80%. This means that the investigated system is an adequate energy-efficient alternative to conventional fibre lighting systems.

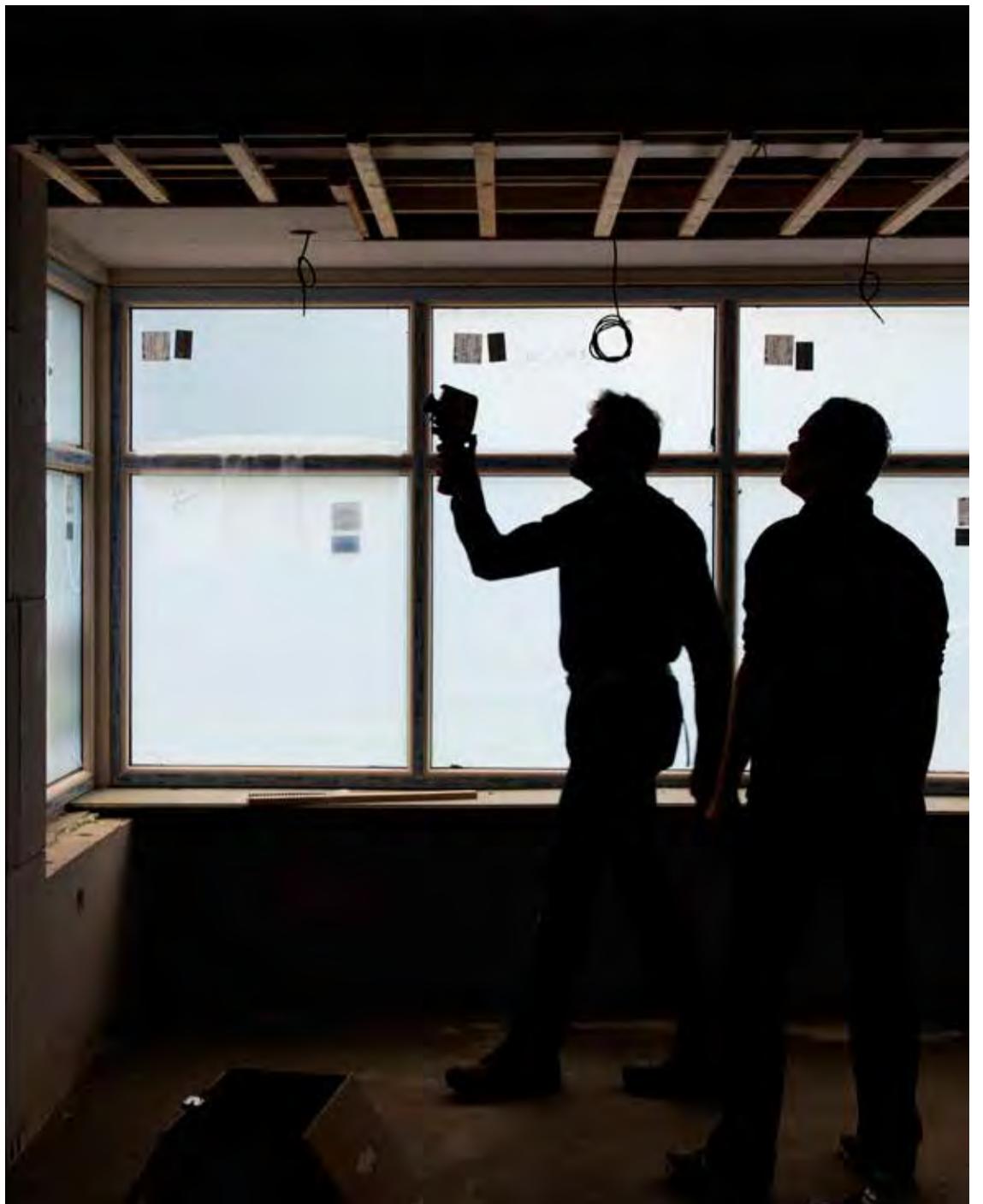
Recommendations for the future include following technology developments to see if such laser systems can be reduced in size for a better integration into the overall system. The current laser system was not developed for a fibre lighting system but rather for measurements/experiments on optical benches. Some of the features and requirements that are currently part of the product may not be required for usage in combination with fibre optics. This can lead to a reduced size and cost for a laser system that would positively impact the economics of real installations.

Eindhoven University of Technology
dr. Myriam Aries, prof. Dr.-Ing. habil. Alexander Rosemann
Wies Westerhout, Mitchel Hoos

Delft University of Technology
assoc. prof. dr. Truus Hordijk

Lighting designer
ing. Rienk Visser

BL Innovative Lighting - Vancouver
Betty Lou Pacey



Het is wenselijk dat gebouwen beschikken over voldoende en de juiste mogelijkheden om te ventileren. Buiten de benodigde ventilatievoorzieningen is het echter de bedoeling een gebouw zo luchtdicht mogelijk te maken ten einde comfortklachten en onnodig energiegebruik te voorkomen. In het Bouwbesluit zijn eisen met betrekking tot de luchtdoorlatendheid – het tegenovergestelde van luchtdichtheid – opgenomen. Met betrekking tot een heel gebouw wordt in Art. 5.4 lid 1 het volgende geseist: De volgens NEN 2686 bepaalde luchtvolumestroom van het totaal aan verblijfsgebieden, toiletruimten en badruimten van een gebruiksfunctie is niet groter dan 0,2 m³/s. De Universiteit Twente en de Technische Universiteit Eindhoven hebben samen met het bouwbedrijf SelektHuis gewerkt aan de uitvoering van het onderzoek "Impenetrable Infiltration". Dit onderzoek naar de luchtdoorlatendheid van woningen kent drie onderdelen, namelijk:

- A. Een veldonderzoek waarbij luchtdichtheidsmetingen worden uitgevoerd op vrijstaande woningen om zo te bepalen tegen welke keuzemogelijkheden luchtdichtheidsmeters en uitvoerende bouwondernemingen aanlopen om de luchtvolumestroom te beïnvloeden;
- B. Een deskstudie waarbij rapportages van luchtdichtheidsmetingen worden bestudeerd om zo te bepalen wat de huidige stand van zaken is betreffende de luchtdichtheid van woningen;
- C. Een vergelijkend praktijkonderzoek naar het bepalen van de luchtdichtheid, waarbij drie partijen de luchtdichtheid van dezelfde duurzaam gebouwde vrijstaande woning zullen vaststellen.

Om de veldstudie en het praktijkonderzoek uit te kunnen voeren, is de nodige apparatuur aangeschaft. Er is gebruik gemaakt van een blower door, een ventilator en een digitale manometer. Tevens is er tijdens de metingen gebruik gemaakt van twee dataloggers om de luchtdruk, binnen- en buitentemperatuur elke minuut vast te leggen. Er werd een anemometer gebruikt om de windsnelheid op locatie te bepalen. Om inzicht te krijgen waar eventuele lekken zich bevonden, werden een rookmachine en een infraroodcamera ingezet.

Veldstudie

De veldstudie heeft betrekking op negen verschillende cases, welke in 2014 zijn opgeleverd. De omvang van de thermische schil en het netto vloeroppervlak van deze woningen zijn vastgesteld aan de hand van de EPC-berekening.

Resultaten metingen

Voor het bepalen van de luchtvolumestroom is, in lijn met EN 13829, het gemiddelde van twee meetseries genomen; één op onderdruk en één op overdruk. Het drukverschil over de gevel liep hierbij op van 20 tot 90 Pa. Elke meetserie bestond uit het bepalen van een baseline met tien meetwaarden vooraf, twaalf debietmetingen en tot slot een baseline met wederom tien meetwaarden achteraf. Vervolgens is met deze meetwaarden teruggeremd naar een luchtvolumestroom bij een drukverschil van 10 Pa. In totaal zijn zestien metingen uitgevoerd op de negen cases. De gemeten luchtvolumestroom (q_{v10} in dm³/s) is gedeeld door het netto vloeroppervlak (in m²) van de woning om zo tot de karakteristieke luchtvolumestroom ($q_{v10,car}$ in dm³/(s·m²)) van de woning te komen, welke kan worden vergeleken met de bij de vergunningaanvraag gespecificeerde ambitie in de EPC-berekening. Bij vier cases is er een tussentijdse meting en een eindmeting uitgevoerd.

Analyse meetresultaten

Het Bouwbesluit eist een luchtdoorlatendheid die kleiner is dan 200 dm³/s en een EPC van maximaal 0,6. Een dergelijk lage EPC wordt bij deze woningen bereikt door onder andere een $q_{v10,spec}$ te behalen van 0,625 dm³/s per m².

vloeroppervlak. Van de negen gemeten cases in de veldstudie, voldeden alle woningen aan het Bouwbesluit. Alleen Case 2 en 5 voldeden niet aan de ambitie, zoals aangeven in de EPC-berekening. Van de negen cases voldeed één woning, Case 5, vlak voor oplevering nog niet aan de in de EPC-berekening gestelde ambitie van 0,625 dm³/s per m² vloeroppervlak. Case 2 nadert op het moment van meten nog niet de oplevering, maar de stap om van 1,10 naar 0,625 dm³/(s·m²) te komen, is nog wel vrij groot. De aansluiting van het dak op de muurplaat verdient in de meeste woningen nog enige aanvullende aandacht.

Bij Case 1, 3, 4 en 5 is een tweede meting uitgevoerd om te bekijken wat het effect is geweest van de gegeven feedback aan de uitvoerders. De eindmetingen vonden rond de oplevering plaats, nadat de uitvoerders de tips uit de feedback ter harte hadden genomen. Na navraag te hebben gedaan bij de uitvoerders en zelf vier cases te hebben gecontroleerd, bleek 71,7% van de tips daadwerkelijk opvolging te hebben gekregen. In het geval van Case 1 is de gemeten luchtvolumestroom gereduceerd met 67%, waarbij notabene ten tijde van de eindmeting het niet mogelijk was om het ventilatierooster van het dakraam boven de hal te sluiten. Voor Case 3 is de reductie 22%. Bij Case 4 en Case 5 was de reductie respectievelijk 41% en 65%. Dat is dus voor deze vier cases een gemiddelde reductie van 49%. Bij Case 6 is eveneens een tweede meting uitgevoerd, maar ditmaal door een andere partij. Deze meting gaf een resultaat van 0,45 dm³/s per m² oftewel een verbetering van 24%. Bij deze tweede meting werd het ventilatiesysteem echter niet ter plaatse van de dakdoorvoer met

opgeblazen ballonnen afgesloten, maar ter plaatse van de ventilatieopeningen in de woning. De blower door werd daarnaast in de voordeur geplaatst in plaats van één van de twee tuindeuren aan de achterzijde van de woning. Deze twee veranderingen in de uitvoering van de meting zullen enige invloed hebben op het verschil.

Deskstudie

Er zijn in het verleden door het toenmalige SenterNovem in kader van het E'novatie programma al veel luchtdichtheidsmetingen uitgevoerd. Na circa twee decennia zijn het nu steeds vaker de opdrachtgevende en uitvoerende partijen zelf die om de zogenaamde blower door tests vragen om de luchtdichtheid van gebouwen te testen. Deze partijen zijn via email, oproepen op websites en oproepen in vaktijdschriften benaderd om de meetrapporten die zij in bezit hebben te delen met de Universiteit Twente en de Technische Universiteit Eindhoven. Deze oproepen hebben er toe geleid dat een database kon worden opgesteld met daarin de meetresultaten van meer dan 300 recent gebouwde woningen.

Deze respons overtrof onze verwachtingen, waardoor het invoeren van de woningen langer duurde.

Praktijkonderzoek

Op 2 en 3 februari zijn onafhankelijk van elkaar drie luchtdichtheidsmetingen uitgevoerd op een duurzaam gebouwde vrijstaande woning in Sterksel. De wijze van meten en de resultaten van de metingen zullen met elkaar worden vergeleken. Op deze manier verwachten we meer inzicht te krijgen in hoeveel de resultaten van

luchtdoorlatendheid van Nederlandse woningen



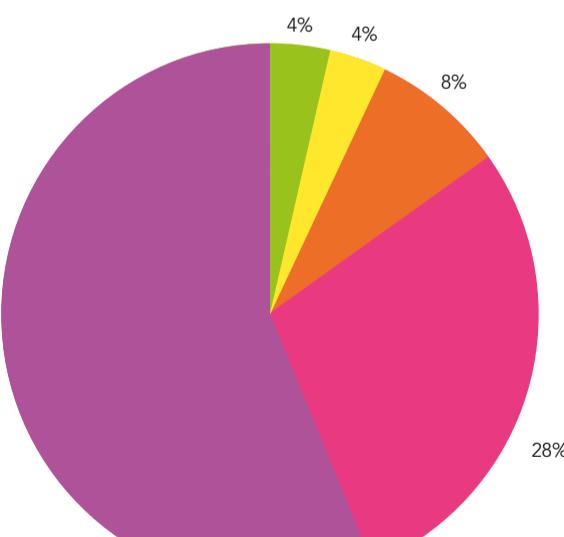
warmte opnames case study woningen

	Case nummer en locatie	Datum meting	Netto volume (m ³)	Netto vloeroppervlak (m ²)	Gemeten luchtvolumestroom (dm ³ /s)	Karakteristieke luchtvolumestroom (dm ³ /s·m ²)
1	1. Radio Kootwijk	06-12-2014	682	2056	290,28	1,09
2		06-12-2014			95,83	0,36
3	2. Doorn	28-10-2014	451	171	194,58	1,14
4		28-10-2014			188,75	1,1
5	3. Rijssen	28-10-2014	391	156	134,03	0,86
6		28-10-2014			94,58	0,63
7	4. 's-Graveland	22-12-2014	339	135	95,97	0,71
8		22-12-2014			56,81	0,42
9	5. Soest	22-12-2014	482	191	40,56	2,26
10		22-12-2014			234,31	1,23
11	6. Brummen	08-12-2014	509	196	150,56	0,79
12		08-12-2014			115	0,59
13	7. Teteringen	01-12-2014	622	217	133,06	0,61
14		01-12-2014			129,17	0,6
15	8. Waddinxveen	18-12-2014	550	215	113,19	0,53
16	9. Brielle	18-12-2014	646	260	158,47	0,61

resultaten van luchtdoorlatendheidsmetingen in het veldonderzoek

Case	Datum meting	Q _{ext} (dm ³ /s)	Ordeel Bouwbesluit	q _{v10,car} (dm ³ /(s·m ²))	Oordeel ambitie EPC berekening
1	06-12-2014	95,83	Voldoet	0,36	Voldoet
2	28-10-2014	188,75	Voldoet	1,1	Voldoet niet
3	17-12-2014	94,58	Voldoet	0,61	Voldoet
4	08-12-2014	56,81	Voldoet	0,42	Voldoet
5	22-12-2014	35,26	Voldoet	0,29	Voldoet
6	01-12-2014	115	Voldoet	0,59	Voldoet
7	01-12-2014	129,17	Voldoet	0,6	Voldoet
8	18-12-2014	113,19	Voldoet	0,53	Voldoet
9	18-12-2014	158,47	Voldoet	0,61	Voldoet

beoordeling resultaten van luchtdoorlatendheidsmetingen



verdeling woningen naar bouwjaar in de rapporten voor de deskstudie

University of Twente
dr. ir. Bram Entrop

Eindhoven University of Technology
prof. dr. ir. Jan Hensen, dr. ir. Marcel Loomans

Nieuwenhuis Groep
ing. Ron Brons

SelektHuis Bouwgroep
ing. Alex Veldhoff, ing. Jan Averink



Developing a flexible mould will encourage industrial companies to manufacture complex geometries in a cost efficient way.

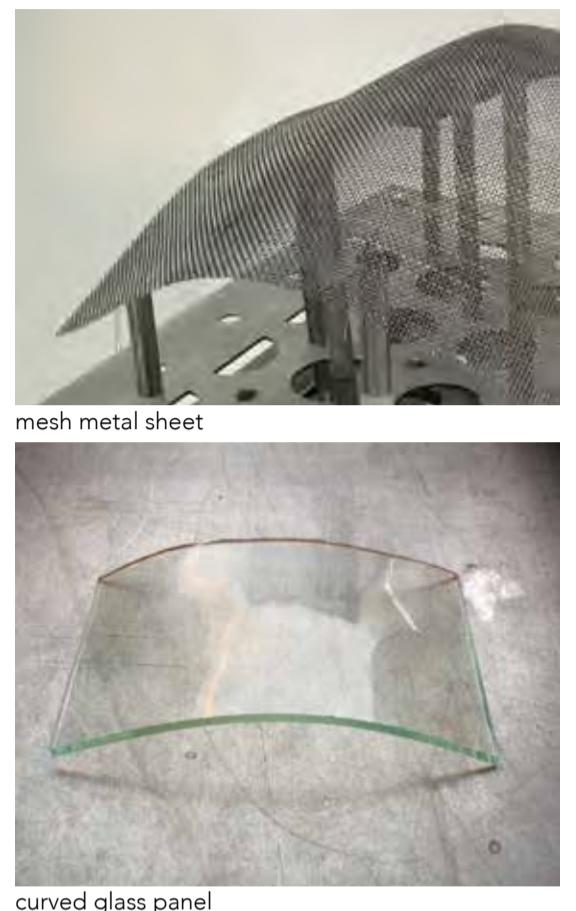
The Kine-Mould is a development that makes it easier to manufacture building elements with complex geometry. Since June 2014 the team has been working on a range of solutions and prototypes. Various building materials have been investigated such as concrete, glass and plastic composites. In a joint effort of TU Delft and TU Eindhoven the following prototypes were designed and built:

1. One for thermoplastic polymers;
2. One for concrete elements;
3. One for glass elements;
4. Several for inflatable mould surfaces.

Students carried out a significant part of the work. Companies were involved in the manufacturing process of the prototypes and application of the results.



fluid mould concept



Prototype for thermoplastic polymers

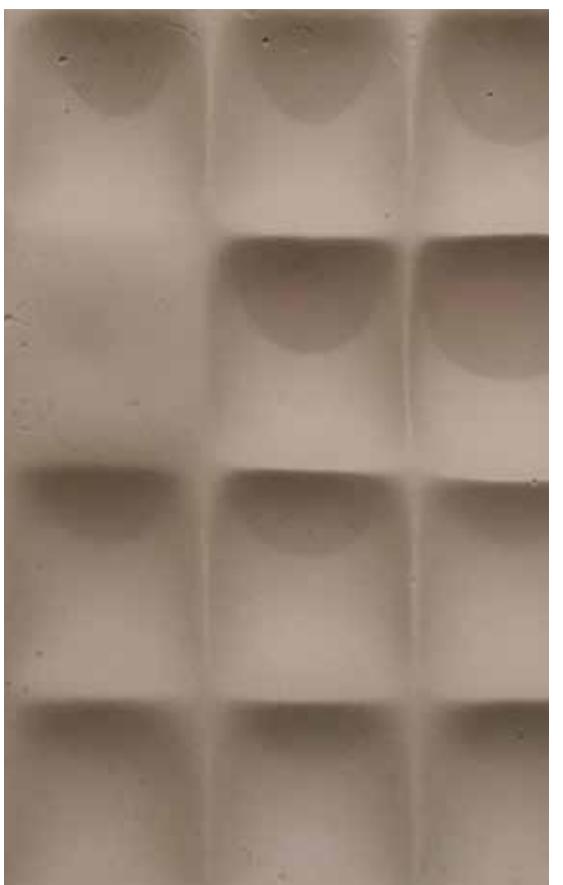
If a thin polymer plate can be thermoformed into the correct geometry, this plate can be used as formwork for concrete or directly as a façade cladding panel. A closed two-face mould with closed edges is needed when using it as formwork. After hardening the concrete, the polymer plate can be removed and recycled. Two principles for deformation were investigated; thermoforming with gravity and with vacuum. For thermoforming a thermoplastic panel edge is clamped by flexible edges on which actuators are attached. After heating the thermoplastic polymer above its glass transition temperature, the edge can be deformed by setting the actuators at desired height. The middle section of the panel is supported by a flexible layer, which can be manipulated by applying various tensions. The second principle relies on vacuum forming of thin acrylic plates. Here an air pressure difference is used after heating the thermoplastic to the proper temperature to control the exact edge shape. After cooling down to room temperature a two-face mould is constructed in a frame of edges, which can be filled with concrete. Since very thin plastic sheets are used, fluid or particles are needed to support the sheets under the concrete pressure.

Prototype for glass

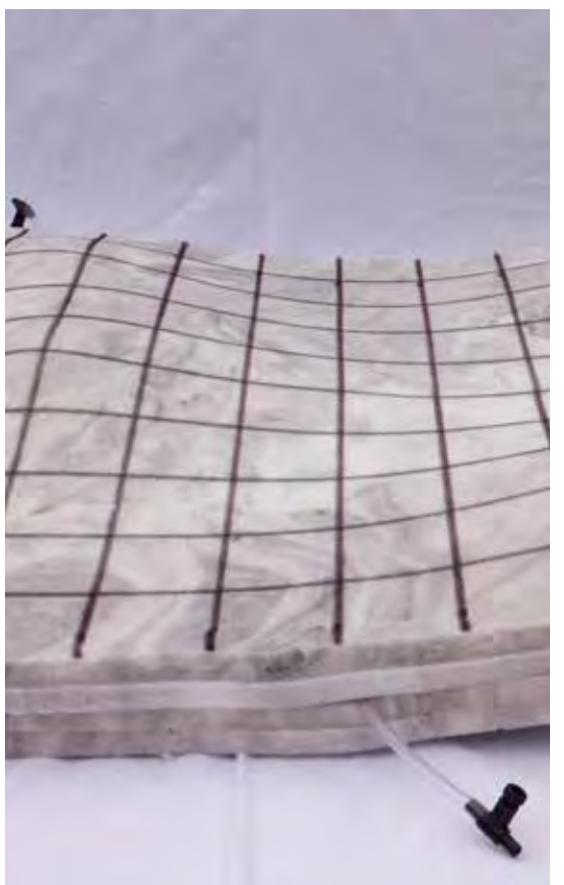
The wish to create curved architectural glass elements has a history at both universities. At Delft, Dr. Karel Volders was one of the first to succeed in manufacturing double-curved glass for architectural applications with a forerunner of the current flexible mould. At Eindhoven, Arno Pronk has been working on this topic for several years. In an earlier TU/e project students had already investigated the option to construct a small glass dome of double curved double glass units, joined together with vacuum-infused structural resins. This research projects presented the opportunity to align forces and knowledge to develop a state-of-the-art prototype and analyse the process in a more detailed manner.

The forming of curved glass is as challenging as it is promising. If successful, it opens a wide range of promising possibilities: imagine shell structures consisting of load-bearing glass elements or think of hybrid building envelopes consisting of partially glass and concrete elements. Challenging however since glass is a brittle material and residual stresses after deformation to a large extent influence the

flexible mould system opens up wide range of possibilities



concrete result and inflatable mould alternatives



concrete result and inflatable mould alternatives



Simple, robust and easy to repair solutions are key to the success of the mould.



concrete prototype



Delft University of Technology
ir. Roel Schipper, MSc Peter Eigenraam, MSc Matteo Soru,
dr. ir. Steffen Grünewald, Ivan Gavran, Matthias Michel

Eindhoven University of Technology
ir. Arno Pronk, Dick Erirkveld (SolidRocks), Hisham El Ghazi,
Mitchell Janmaat, Tobi Lusing, Erwin van Rijbroek, Niek Schuijters,
Martijn Verboord, Robin Versteeg

finished prototype was transported to a concrete factory in order to gain more experience in the production process. Based on these experiences a design for a professional version is made which will be used for first projects in practice.

The principle of deformation after casting brings along questions regarding the concrete: What is the right moment of deformation? What is the effect of the deformation? How can the concrete be reinforced? Apart from the design and assembly of the larger prototype, these aspects have been investigated as well in the PhD research of Roel Schipper that will be finished shortly. Finally, also a computational model has been worked out to predict the effect of certain parameter choices, such as actuator spacing, strip thickness and elasticity, etcetera. This work is on going and will need further development.

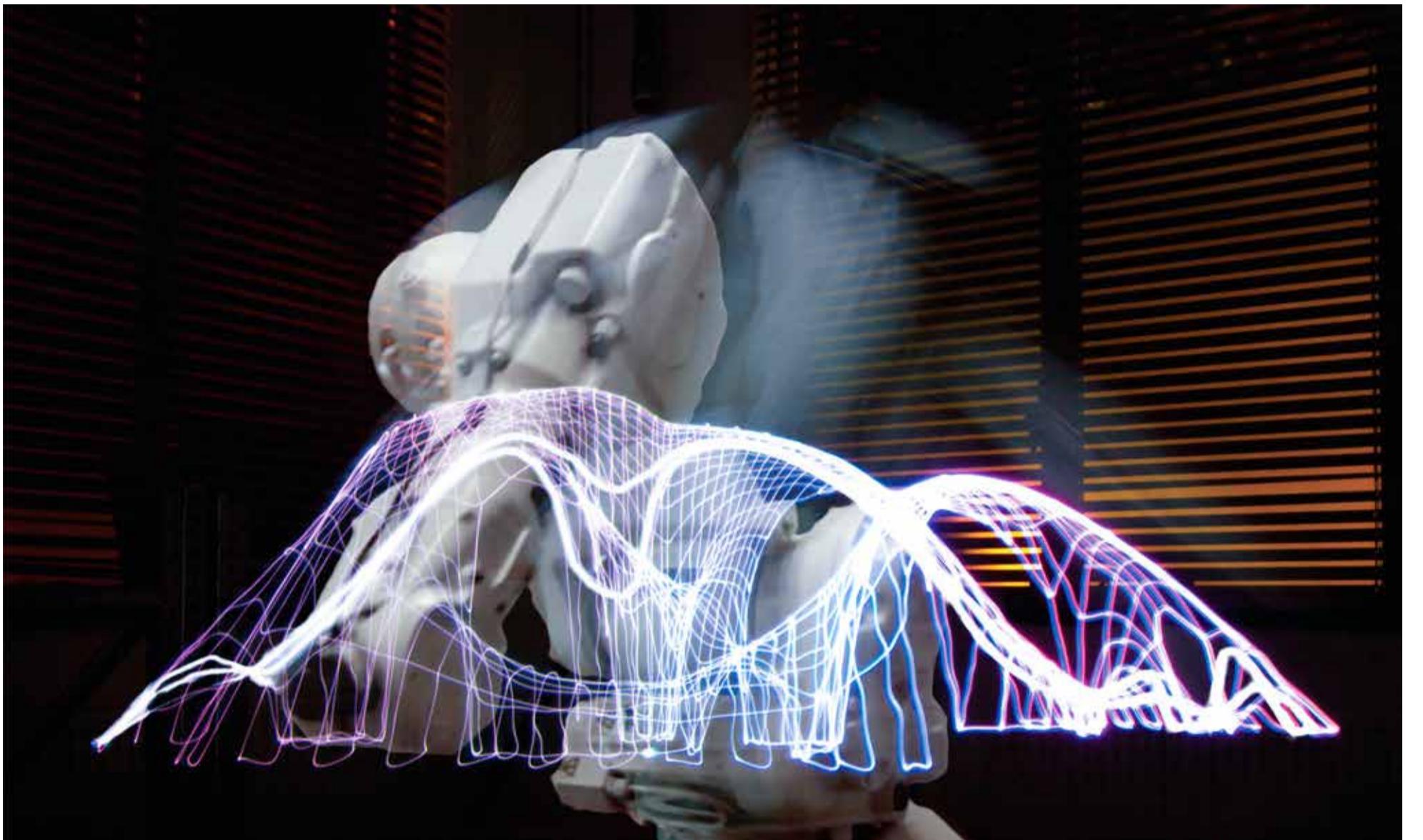
Inflatable mould

Instead of realizing a smooth interpolation surface, additional shape control or play with element texture could be realized by making parts of this surface inflatable very locally. This could result in architecturally interesting textures, and furthermore could lead to a technology that opens new possibilities. In his Master's thesis project that was already on going at the start of the 3TU Lighthouse project, Mitchell Janmaat now had the chance to carry out some experiments with various inflatable mould surfaces. Figure 8 shows some results of this work.

Prototype for concrete

Before the start of the 3TU Lighthouse project, a small-scale prototype existed of the flexible mould for concrete, using a grid of flexible strips as interpolating surface. This prototype showed very promising results, but the team was curious to investigate scale effects and also manufacture larger concrete elements. A new and bigger prototype for the flexible mould therefor was designed and built in order to investigate the behaviour of the mould on larger scale (Figure 7). On a small scale effects like buckling of the strips in the interpolating surface are not likely to occur. For larger surfaces, though, this effect could potentially become more significant. The smoothness of the final panels is influenced by small details in the design of the mould. Dimensions and connections needed to be designed carefully to obtain accurate results. Apart from accurate the mould has to be robust to function well within a concrete factory environment. Simple, robust and easy to repair solutions are key to the success of the mould. A

The 3TU Lighthouse project "Kine-Mould: material efficiency using a flexible kinematic mould system" has resulted in a range of coherent prototypes that demonstrate the feasibility of this manufacturing method for various architectural building materials. At the "Week van de Bouw" in February 2015, the prototypes will be shown. In the summer of 2015, more results and also elements produced with the moulds will be presented at the IASS2015 conference and exposition (see IASS2015.org Scientific publications will be written to give more in-depth descriptions of the results, including validation and testing. The work will be continue since many new ideas and possible solutions are waiting for further exploration as well as cooperation with industry. Further industrial partners are invited to contact us and discuss the possibilities.



Robotically Driven Construction of Buildings (RDCB) is an exploration into holistic/integral design to production solutions for robotically driven construction of buildings by involving the disciplines of architecture, robotics, materials science, construction and building technology, and structural design. The team integrates knowledge from the individual disciplines in order to develop new numerically controlled manufacturing techniques and building-design optimizations for adding creative values to buildings in a cost-effective and sustainable way.

This project is in line with Europe's aims for improving material sustainability and energy efficiency of buildings and construction processes. Robotically driven construction and customized building material systems have the potential to realize this in a cost-effective way and at the same time reduce accidents and health hazards for workers in the building sector. In order to achieve this RDCB is distributing materials as needed and where needed. This requires exploration of a variety of techniques and implies working with customized materials while finding the best methods of applying materials in the logic of for example specific force flows or thermal dissipation patterns. RDCB advances multi- and trans-disciplinary knowledge in robotically driven construction by designing and engineering a new building system for the on-demand production of customizable building components. The main consideration is that in architecture and building construction the factory of the future employs building materials and components that can be on site robotically processed and assembled.

At the Delft University of Technology (TUD) two groups of researchers and students have explored possibilities of implementation of robotics in architectural design and building material systems. While at the Civil Engineering Department the focus was to study the production of suitable recycled fine aggregates to be used in robotically aided construction processes, for the Hyperbody group at the faculty of architecture at TU Delft, the focus was on developing a robotic setup as an integrated design to production system for Additive Manufacturing supported by customized Computer Aided Design procedures.

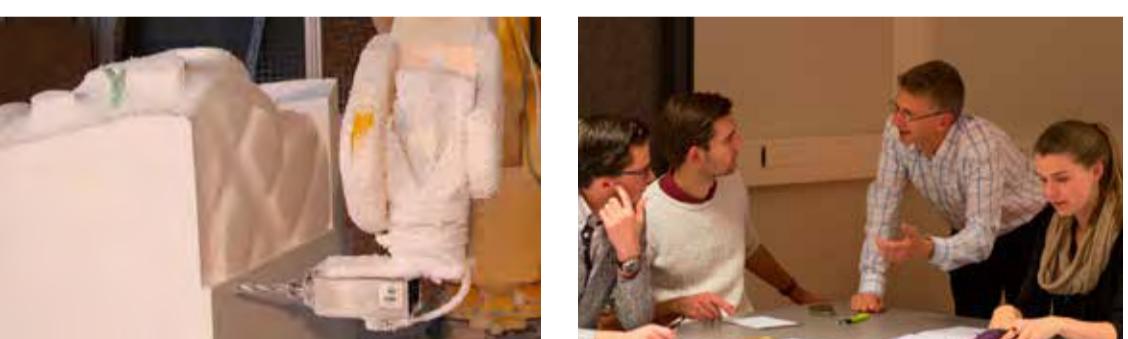
The aim of the project at Eindhoven University of Technology (TU/e) was to create knowledge about robotically construction methods and possible applications of this methods. The process was divided into different stages: brainstorm sessions, design meetings and the realization of the product. It has been done with a team of students with different backgrounds: Structural Design (SD), Building Technology (BT) and Construction Technology (CT).



Robotically Driven Construction of Buildings is distributing materials as needed and where needed.

RDCB has profited from the support of:
Delft Robotics Institute (DRI)
Department of Architectural Engineering and technology (AE&T)
100% Research
C2CA EU-Project (Recycling of concrete to cement and aggregate)
Mebin (HeidelbergCement)
StudioRAP (production of the mold for TU/e)
ENCI B.V. (concrete composition and production for TU/e).

exploring on-demand building components production



Delft University of Technology
Dr.-Ing. Henriette Bier, M.Arch. Sina Mostafavi, ir. Ana Anton, ir. Serban Bodea, Berend Raaphorst, Guus Mostart, Hans de Jonge, Jeroen van Lit, Jan Paclt, Kasper Siderius, Marco Galli, Michal Kornecki, Mohammad Jooshesh Oana Anghelache, Perry Low, Radoslaw Flis, Rob Moors, Rutger Roodt, Ruth Hoogenraad, Stef Hoeijmakers, Steph Kanters, Thijs Uperlaan, Prof. dr. Peter Rem, Somayeh Lofti, Eleonora di Domenica

Eindhoven University of Technology
prof. dr. ir. Theo Salet, Jordy Vos, Adrie van der Burgt, Bas van Wezel, Christiaan Voorend, Chiel Bekkers, Iris Rombouts, Luc Gerlings, Marieke de Vries, Marijn Bruurs, Rob Wolfs, Siert Saes, Tim Span, Wout Rouwhorst

Interdisciplinary brainstorm

The first meeting introduced the purpose of this project: a robotically created product for the building industry. Because of the variation in building industry disciplines the TUE group was divided into brainstorm teams with the specializations SD, BT and CT. Every discipline explored what they could do with robots within their own specialization. The directive given was: think about possible design-optimizations in order to improve for example sustainability, durability, material-usage and space-usage. In this process the students created their own visions about the new design possibilities considering different robot construction methods. This resulted in three different ideas with common points: building design adaptability, unique shapes (greater design freedom) and effective integration of different disciplines in construction components. The team of TUE continued with studio RAP a design and fabrication studio focusing on robotically controlled fabrication methods within the building processes, to design the possible scenarios for realization of the prototype with the robot.

At Delft, the process of experimentation with robotic arms started in the beginning of the project to inform the design processes at the very early stages to establish a direct link between design and production. This way the team was not only able to explore different design variations and possibilities to be produced only by robotic 3D printing, but also was able to adjust, customize and develop the required design tools to production system, considering both material behaviours and the evolving design outcomes.

Design development

At each university objectives and ideas behind making the prototypes are: TU/e:

- A façade of a building with a segment of a floor.
- optimizing the geometry based on structural behavior.
- Open parts of the optimized topology of the façade to be used as 'windows'.
- The floor-construction is inspired from a leaf's shape, and thicker parts in the floor can be used for tubes and installations.
- Using robotic subtractive methods of production to create complex moulds to cast the designed parts in concrete

 TUD:

- Developing and establishing proper computational design methods for a compression-only structure considering the innate characteristics of the material.
- Translating the results of design and material distribution analysis into robotic motion paths for material deposition.
- Making a part of the designed pavilion with the developed robotic 3D printing system for extruding clay ceramics.
- considering porosity of material in different scales ranging from Macro/scale of architectural elements like openings and building envelop) to Micro (scale of material distribution or material architecture).

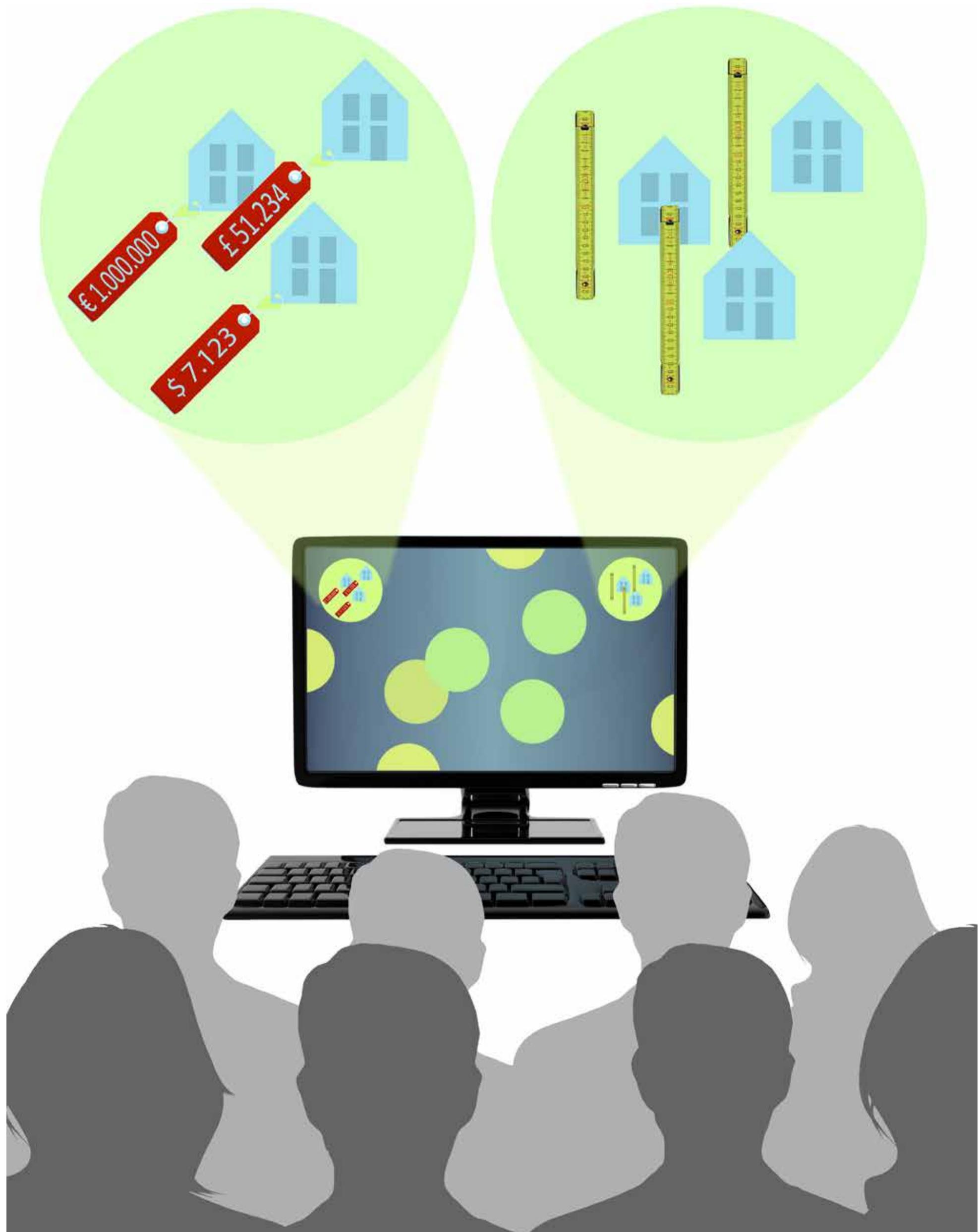
Results, prototypes and future steps

The results of the RDCB project can be discussed at two levels of fundamental and applied research, which are realized through making the prototypes by each university. Researchers at the civil engineering department of TUD have made studies on recycled concrete as well as studies on the use of possible natural materials on a fundamental level. The applied research of the Hyperbody group can provide the required supporting knowledge for further improvement of application of robotic additive manufacturing in the building industry. In combination, the results of on the one hand material based research as the development of computational and parametric design strategies can bridge the gap between early stages of design and production process.

At TU/e, analysis of the experienced design to fabrication process, using a robotic subtractive manufacturing method can lead to a comparison between CNC milling methods with robotically supported manufacturing techniques to specify the advantages of application of robots or robotization in some parts of building industry.

Using robotically driven tools enhances design adaptability, greater design freedom and effective integration of different disciplines in construction components.

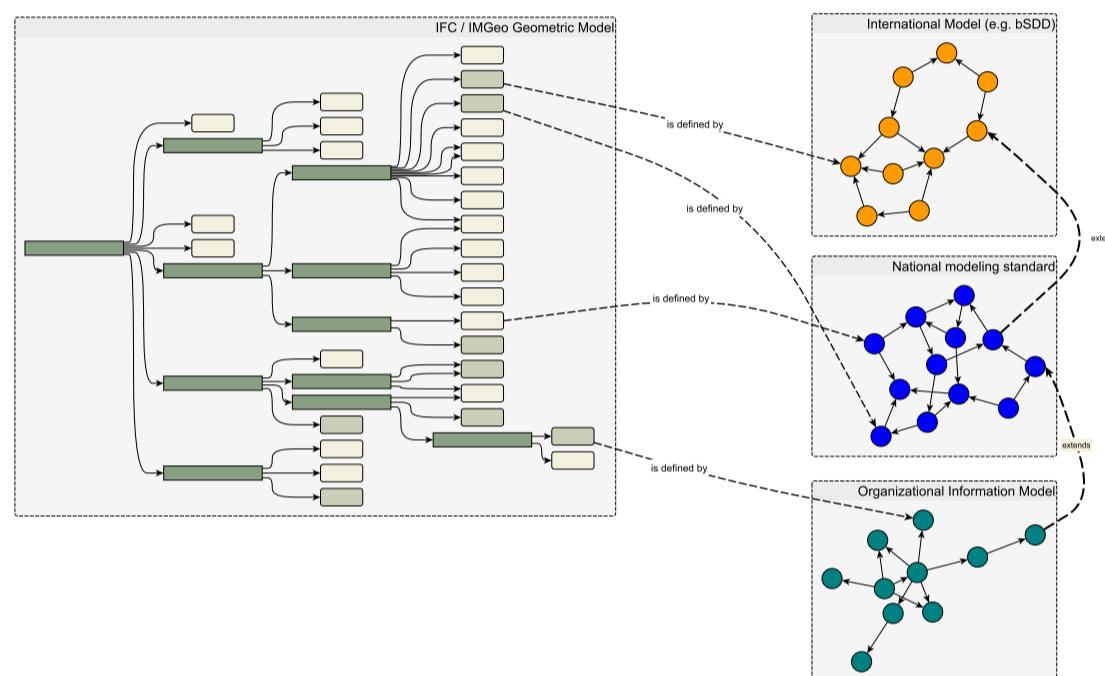
Eventually both series of experiments and prototypes - the casted concrete components of TU/e in robotically produced moulds and porous robotically 3D printed building prototypes of TUD in ceramics – specify to a certain degree what is possible and what is not and can define the future roles of robotics in building industry. In this context the next step for future explorations and prototyping can focus on simultaneous and/or sequential combination of these processes, supported by multiple robots to illustrate and define some of the characteristics of future programmable building factories.



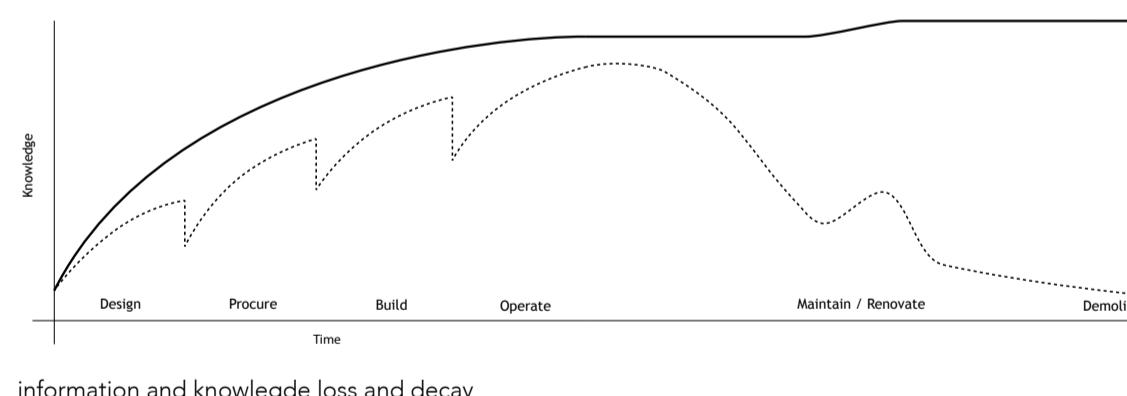
Information required by practicing architects, engineers, construction managers, building operators, asset managers, owners, and users becomes more and more distributed, detailed, and richer. BIG DATA is on the rise and this trend will not stop. We rather expect that this trend will further accelerate in the upcoming years as;

- more and more sensor technologies will become widely available to access existing conditions in the built environment,
- more and more information streams will be combined for various purposes, e.g. mobile data access information to space use in order to evaluate wireless infrastructure performance but also to establish building use patterns in post-occupancy evaluations,
- advanced design tools will allow for more detailed data-driven simulation of an increasing number of design alternatives in shorter time spans, and
- participatory efforts will involve an ever larger number of specialists and non-specialists that all provide information that needs to be accounted for during design and construction planning.

Humans will no longer be able to ensure the consistency of information and, more importantly, find the - for them - relevant data.



Semantically enriched building models with linked structured vocabularies and data sets



information and knowledge loss and decay

The availability of the above described BIG DATA will mean that data sources in the future will be based upon an increasing amount of standards, information models, and semantic dictionaries. Additionally, data sources will become increasingly distributed across the web. Practitioners need to be supported in finding, combining, and acting on this distributed information. Already posing a problem for engineering practice today, in this changing world, humans will no longer be able to ensure the consistency of information and, more importantly, find the for them relevant information.

To this end, semantic web technologies are required that allow machines to readily interpret information and can perform much of the tedious and time consuming work involved in working with distributed BIG DATA repositories. After all, computers can support humans in indexing and searching data. We expect that this will be one of the most important and prominent areas for research in the upcoming years. In this lighthouse project we made a number of first important steps to enable such research:

3TU BIM Data Repository

We set up a repository structure for storing building related information within an archive. This archive will allow us to collect all data that students at the 3TU's developed in the last years and will develop in the years to come. In collaboration with the FP7 EU project 'DURAARK', a repository for the sustainable long term preservation of digital building information in different formats, including the Open Industry Foundation Classes (IFC) has been created and will be filled over time. The repository, made available in the Amazon cloud by project partner Microsoft, can then be used by researchers to develop indexing and search solutions and to empirically test them. We also expect that the repository can grow into a benchmark for testing developed indexing and search algorithms with respect to their performance in terms of speed, completeness, and stability.

Data format, standard, and dictionary map

We also made a first start for establishing a map of the available data formats, standards, and dictionaries to describe building related data. The map will provide an overview of the ontological spectrum within the field of civil engineering. The spectrum, in turn, will allow researchers to start developing different translation mechanisms between the different existing data formats, standards, and dictionaries to arrive at homogeneous indexing and search solutions in the long term.

Information use and exchange processes

A start was made to understand and develop future information use and exchange processes that assume a widely distributed information environment. This part of the research is important to provide the basis for developing practically applicable indexing and search workflows.

Automated indexing methods

A first step was made into exploring possibilities for automatically indexing the semantic information available within the large amount of existing data formats, standards, and dictionaries. Based on a selected number of case projects, first indexes have been extracted and explored according to their utility to support engineering work.

The above summarized four steps, even within the quite early stage of development they are in, provide a strong foundation for semantic web research at the 3TU in the years to come. The steps provide a platform and an initial research framework for academic research at the Bachelor, Master, and PhD level.

University of Twente
dr. Timo Hartmann, prof. dr. ir. Arjen Adriaanse

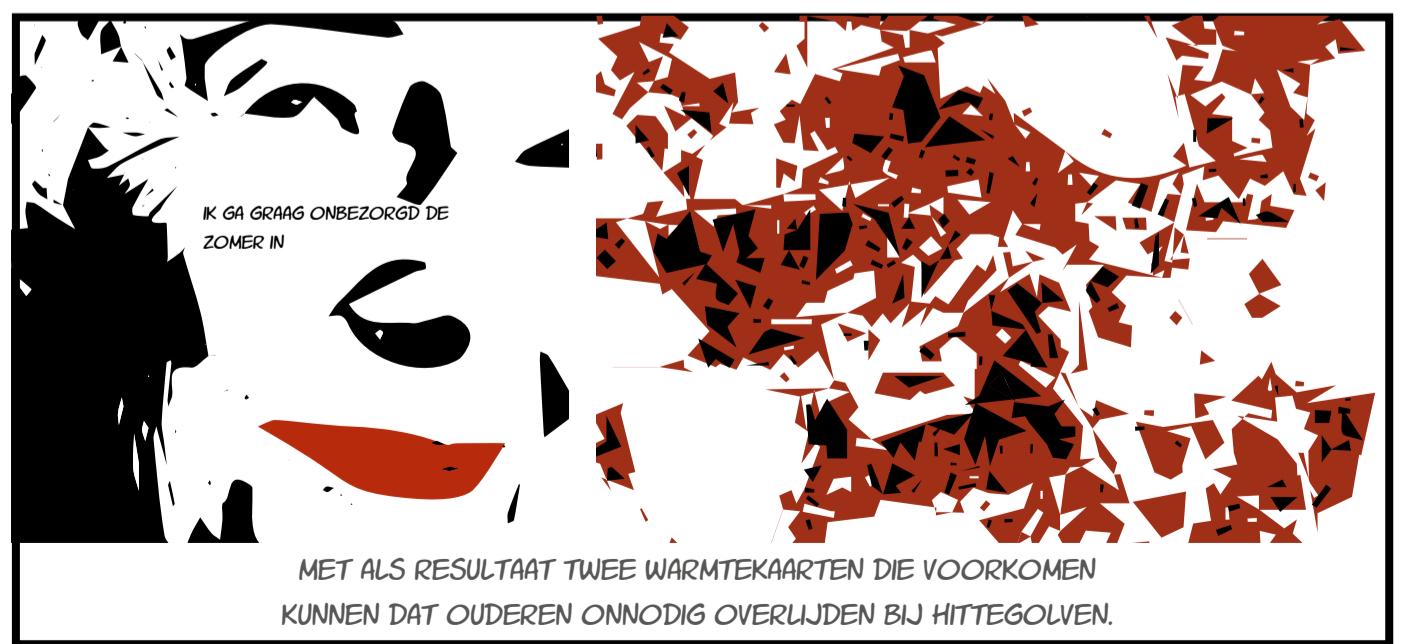
Eindhoven University of Technology
dr. Dipl.-Ing Jakob Beetz, ir. Thomas Krijnen

Delft University of Technology
dr. ir. Alexander Koutamanis

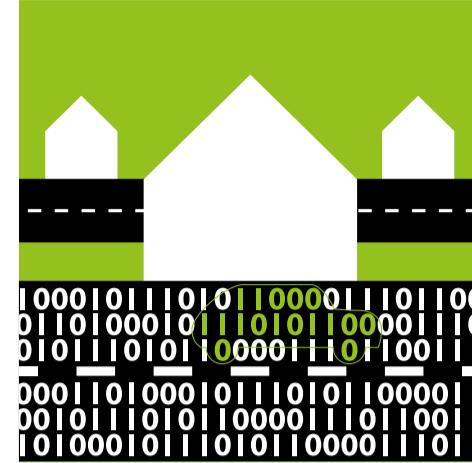
Balast Nedam, Microsoft Netherlands



crowd sensing - inwoners meten warmte in Rotterdam



DE TOEKOMST WORDT GEBOUWD



PERCEPTIE & ACCEPTATIE: DE MENSELIJKE MAAT

Bouwen gaat in de eerste plaats over mensen van alle leeftijden, met verschillende culturele achtergronden en sterk uiteenlopende behoeften. Ze hebben behoefte aan beschutting, ontmoeting en samenzijn, maar ook aan vrijheid, herkenning, concentratie en rust; dit alles in een veilige en gezonde leefomgeving. Tegelijkertijd wordt hun leefomgeving steeds complexer. De wereld digitaliseert, de mens individualiseert en wordt ouder dan voorheen. Er worden hogere eisen aan burgerschap en persoonlijk initiatief gesteld. Daarnaast worden stedelijke gemeenschappen pluriformer en is opleiding een voorwaarde om mee te doen.

Hoe kunnen ingrepen in de gebouwde omgeving bijdragen aan het leven van de mens als individu en als onderdeel van een gemeenschap?

Alle ontwikkelingen in Nederland vinden plaats in een volledig door de mens gecreëerde omgeving die identiteit en herkenning verschaft, of juist gevoelens van onbehagen en achterstand doet ontstaan. Nederland blijkt een redelijk gelukkig land te zijn, maar toch wordt er steeds meer hinder ervaren van medeburgers, van bouwactiviteiten en van verkeer; fijnstof, stank, lichtvervuiling en geluidshinder. Hinderbeperking en flexibel bouwen worden belangrijker.

Door maatschappelijke trends zoals vergrijzing en veranderingen met betrekking tot wonen, zorg, pensioenen en multi-culturaliteit neemt de aandacht voor de wensen en behoeften van eingebuurkers en de vraag naar comfort, gemak en maatwerk toe.

De focus op techniek verandert naar een focus op de mens: de techniek socialiseert. De gebouwde omgeving moet niet alleen praktische en esthetische, maar ook ecologische en sociaal-maatschappelijk doelen dienen. Gebruikers moeten meer betrokken worden in processen in de bouw, co-creatie, om daarmee tegelijkertijd legitimiteit en acceptatie te borgen.

Daarnaast is het zaak dat de eindgebruiker professionaliseert, eventueel met digitale ondersteuning, om optimaal gebruik te maken van de levenscyclus te bereiken. Er ontstaan nieuwe vraagstukken wat betreft privacy, de gebruiker mede-verantwoordelijk maken voor de openbare ruimte en het optimaliseren van de voordelen van dicht op elkaar wonen. Onderzoek is nodig naar passende ruimtelijke oplossingen en nieuwe voorzieningen, met een focus op de mens.

Nederland is het resultaat van een eeuwenlang bouwproces, Nederland is het resultaat van maatwerk gedurende vele eeuwen. Er is land gewonnen, er is land verdedigd tegen het water, er zijn steden en dorpen gebouwd, er is infrastructuur gebouwd: van wegen en dijken, van polders en luchthavens. Mensen beleven het land, de ruimte, het (binnen)klimaat van gebouwen, en hebben verbinding met anderen via fietspad, spoor, snelweg, digital highway, water uit de kraan, vuil naar het stort en waterzuivering, elektriciteit voor levensbehoeften en luxe, droge voeten, veilige havens - een greep uit vanzelfsprekendheden die mede mogelijk gemaakt zijn door de bouw en civiele techniek.

LEEFBAAR & EFFICIENT: SMART CITIES

Over de hele wereld en ook in Nederland trekken steeds meer mensen vanuit landelijk gebieden naar de stad, er ontstaan nieuwe metropolen en mega cities. Daarnaast hebben demografische trends, zoals vergrijzing en kleinere huishoudens, een grote invloed op de stedelijke omgeving en haar samenstelling. Om steden leefbaar en toekomstbestendig te houden is een transitie van de stad noodzakelijk. Maar, de stad is een complex systeem dat niet met louter korte termijn maatregelen te veranderen is. Hoe ziet de stad van 2050 er uit en hoe kunnen wij hier naartoe werken?

De stad is een samenspel van sociale, economische en ecologische factoren, die met elkaar in balans dienen te zijn. Problemen die momenteel urgent worden voor steden zijn een ongezond stedelijk klimaat, onveiligheid, wateroverlast en overlast door verkeer. In steden is ruimte nodig voor duurzaming en vergroening, maar ruimte is schaars in Nederland. Anderzijds komen er steeds meer kantoort- en fabrieksgebouwen leeg te staan. Welke nieuwe technologieën zijn beschikbaar om hier een oplossing aan te bieden? Het smart city concept biedt hier vele mogelijkheden.

Smart cities zijn gebaseerd op nieuwe technologieën, zoals elektrisch vervoer, straatverlichting met sensoren en mobiele netwerken. Er is echter nog veel onderzoek nodig naar de toepassingsmogelijkheden van deze nieuwe technologieën in de gebouwde omgeving. Dit onderzoek vraagt een samenwerking tussen stadsbewoners, stadsbestuur, onderzoeksinstellingen en de bedrijfsleven. Daarnaast moet nieuw kennis ontwikkeld worden met betrekking tot stedenbouw en bestuurlijke instrumenten zowel voor de lokale als globale schaal tot nieuwe oplossingen te komen.

Het is belangrijk dat zoveel mogelijk belanghebbende partijen betrokken hierbij worden en dat de resultaten van het onderzoek zichtbaar en tastbaar worden gemaakt. Zonder gericht onderzoek loopt Nederland als één van de dichtstbevolkte landen ter wereld het risico om aan leefbaarheid in te boeten, zolang problemen als toenemende verdichting, onveiligheid en een ongezond leefmilieu niet aangepakt worden.

Duurzame bereikbaarheid in snel verdichtende en qua vervoer dichtslibbende urbane regio's blijft een constante uitdaging. Hierin kunnen nieuwe geavanceerde verkeerssystemen een rol spelen om een optimale reistijd te laten samen gaan met maximale veiligheid en geringste hinder. Tenslotte is het noodzaak te streven naar 100% emissieloos transport.

INFRASTRUCTUUR & VEROVER: SMART MOBILITY

De logistiek van grondstoffen, producten en personen is het belangrijkste fundament onder de economische ontwikkeling van een samen-leven: Nederland heeft zijn huidige welvaart er grotendeels aan te danken. Kenmerkend voor mobiliteit en logistiek zijn twee verschillende aspecten: enerzijds de modaliteit, zoals auto, trein, schip, vliegtuig of pijp- of kabelleidingen, en anderzijds de onderliggende infrastructuur, zoals wegen, bruggen in tunnels, spoor, water-wegen en havens en luchthavens.

Modaliteit en infrastructuur dragen heel verschillende kenmerken, qua investering, levens-duur en innovatiesnelheid. In het afstemmen van ontwikkelingen en beperkingen van beiden schuilt een grote maatschappelijke opgave.

Infrastructuur aanleggen vergt veel planning, grote investeringen en anticiperen op ontwikkelingen voor lange tijdsperiodes, soms langer dan 100 jaar. De structurele eigenschappen van deze infrastructuur zullen door gebruik en externe omstandigheden verouderen, terwijl veilig gebruik gewaarborgd moet worden. Hierdoor is er behoefte aan nieuwe monitoringstechnieken die op elk moment de gezondheidstoestand van een object kunnen weergeven en onderhoud- en ver-vangingscycli kunnen aansturen.

Door de dichtheid van de netwerken zal aanleg, onderhoud en vervanging steeds complexer en duurder worden, terwijl de acceptabele last en barrièrewerking voor de omgeving geringer zal moeten worden.

Dit vraagt om nieuwe processen, contractvormen, tot multifunctioneel ontwerp en nieuwe in-place recycling en upgrading strategieën.

Daarnaast veranderen de kenmerken en infrastructurele behoeften van vervoersmodaliteiten snel, terwijl de eisen met betrekking tot veiligheid, geluidshinder en uitstoot vervuiling steeds strenger worden. De interface tussen de modaliteiten en hun infrastructuur wordt ook belangrijker: de uitdaging om goed functionerende multimodale knoop-punten te verwezenlijken. Verder zal de rol van de bestuurder door voortgaande ontwikkelingen op het gebied van sensoring en ICT steeds kleiner worden. Vervoersmiddelen digitaliseren snel, en zullen gaan interacteren met de omgeving.

De ontwikkeling van de samenleving en de technologie vragen voortdurende aanpassing van de fysieke leefomgeving. Voorspelingen over de gevolgen van klimaatverandering zoals zeespiegelstijging, de noodzakelijke transitie naar decentrale, duurzame energieproductie en de noodzaak tot een gesloten kringloop voor grondstoffen, maken een versnelde ontwikkeling en toepassing van innovaties in de gebouwde omgeving van groot belang, voor de huidige generaties, en alle die volgen.

INFORMATIE & INTERACTIE: INTELLIGENTIE IN DE BOUW

De bebouwde omgeving bepaalt in belangrijke mate ons gevoel van welzijn. In een wereld van toenemende automatisering neemt het gebruik van robotica en ICT ook in de bouw toe. Dit leidt tot een virtuele infrastructuur die verschillende partijen en processen met elkaar verbindt, en bovenal een enorme hoeveelheid data en informatie produceert. Dit zal de manier van bouwen, de bouwplaats en daarvan gekoppelde processen ingrijpend gaan veranderen.

De digitalisering van de bouw staat nog in de kinderschoenen. Met technologische innovaties en het beschikbaar komen van steeds meer informatie, zal op het gebied van het bouwproces, ketensamenwerking en -integratie nog veel winst te behalen zijn.

Ontwikkelingen zoals BIM, 3D-printing, sensors en drones zullen talrijke mogelijkheden bieden voor constructie en duurzaam beheer van onze leefomgeving. De integratie van verschillende informatie systemen en real-time data communicatie leidt momenteel echter nog tot veel problemen.

Daarnaast ontstaan nieuwe vraagstukken over de balans tussen openbaar en privé. De beschikbare hoeveelheid data gerelateerd aan de bouw is al enorm, en zal naar verwachting blijven groeien? Welke informatie hebben we nodig, en hoe wordt die informatie gedistribueerd uit data-sets? Welke data zijn er in de toekomst nodig, en kunnen we daar nu al op anticiperen? Hoe gaan we de informatie delen, binnen bouw- en beheerprocessen, met beleidsmakers en eindgebruikers?

Data science is daarom bij uitstek een kennisgebied dat de toekomst van de bouw en het beheer van de (openbare) ruimte gaat bepalen. Momenteel ontbreekt het nog aan informatie en inzicht over de kansen en toepassingen van ICT ten behoeve van bijvoorbeeld het klimaat in gebouwen, comfort, gezondheid, welzijn en bovenal de menselijke interactie met technische systemen in gebouwen. Een sterke kennispositie over de inpassing van systemen innovaties in de gebouwde omgeving en effectieve toepassing van ICT in de bouw, zal de concurrentiepositie van Nederland blijvend kunnen versterken.

INTEGRATIE & ORGANISATIE: SMART CONSTRUCTION

Opdrachtnemers en projectmanagement in de bouw worden in toenemende mate complex. In alle projectfasen, vanaf initiatief en ontwikkeling tot aan realisatie en beheer, zijn multi-disciplinaire, multi-stakeholder en multifunctionele processen geen uitzondering meer. Voor de 'license to operate' zal de bouwsector haar opdrachtnemers, omgeving en ketenpartners meer betrouwbaar en reëller tegemoet moeten treden. Verder is er een beweging richting meer zelfbouw en meer bouw op kleine schaal. Daarnaast wordt de bouwsector meer bipolaar, met enkele grote spelers, en vele kleintjes.

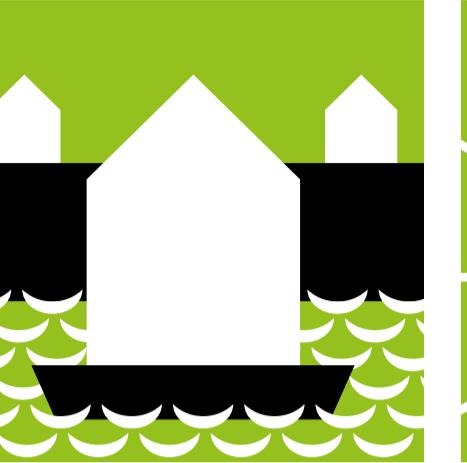
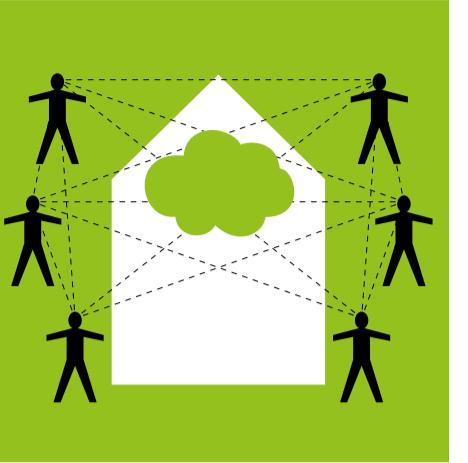
Door de economische crisis is een ontwikkeling in gang gezet richting een veel kleinschaliger bouw. Economische groei moet nu gezocht worden in iets anders dan enkel het bouwvolume. Hiervoor zullen onder andere nieuwe marktpartijen en financieringsarrangementen nodig zijn. Er kan gedacht worden aan andere business modellen zoals huren in plaats van kopen, of financiering door middel van crowd funding. Daarnaast wordt transparantie van beleid en besluitvorming steeds belangrijker en wordt in toenemende mate waarde gehecht aan creativiteit en waarde creëren.

In een circulaire economie worden de belasting op het milieu en de kosten van beheer van de gehele levensduur van producten meegenomen en wordt gekeken hoe materialen en energie (ewig) hergebruikt kunnen worden met hetzelfde kwaliteitsniveau. Deze circulaire aanpak verschift de focus van nieuwbouw naar hergebruik en richt zich op een omschakeling naar een bouwsector die geen afval meer produceert. De uitdaging is om voor zeer lange gebruikspériodes te ontwerpen, met inherent functionele flexibiliteit van de bouwwerken. De implementatie van nieuwe, circulaire processen als de basis voor een duurzame bouw is echter uitermate ingewikkeld.

Een andere trend is de netwerk benadering ten aanzien van infrastructuur; er worden immer hogere eisen gesteld aan betrouwbaarheid van netwerken en voorzieningen. Verder liggen er grote uitdagingen met betrekking tot onderhoud en beheer. Voortgaand wetenschappelijk onderzoek is nodig naar nieuwe aanbestedings- en contractvormen, regelgeving, juridische kaders en financieringsmodellen. Hoe kan Nederland een gidsland worden op het gebied van lange termijn samenwerking en waarde creëren?

De mogelijkheden voor het produceren van hernieuwbare energie en duurzame materialen zijn nog maar ten dele bekend. Daarnaast is er ook veel onderzoek nodig op procesniveau: nieuwe werkprocessen, aanbestedingsprocedures, business modellen voor levensduur benadering of building with nature. Tenslotte zal het energielandschap veranderen van grootschalige installaties, naar decentrale productie. Kortom, de noodzakelijke energietransitie zal vergaande consequenties hebben voor de gebouwde omgeving.

thema's voor de Nationale Wetenschapsagenda



Nederland is het resultaat van een eeuwenlang bouwproces, Nederland is het resultaat van maatwerk gedurende vele eeuwen. Er is land gewonnen, er is land verdedigd tegen het water, er zijn steden en dorpen gebouwd, er is infrastructuur gebouwd: van wegen en dijken, van polders en luchthavens. Mensen beleven het land, de ruimte, het (binnen)klimaat van gebouwen, en hebben verbinding met anderen via fietspad, spoor, snelweg, digital highway, water uit de kraan, vuil naar het stort en waterzuivering, elektriciteit voor levensbehoeften en luxe, droge voeten, veilige havens - een greep uit vanzelfsprekendheden die mede mogelijk gemaakt zijn door de bouw en civiele techniek.

De ontwikkeling van de samenleving en de technologie vragen voortdurende aanpassing van de fysieke leefomgeving. Voorspellingen over de gevolgen van klimaatverandering zoals zeespiegelstijging, de noodzakelijke transitie naar decentrale, duurzame energieproductie en de noodzaak tot een gesloten kringloop voor grondstoffen, maken een versnelde ontwikkeling en toepassing van innovaties in de gebouwde omgeving van groot belang, voor de huidige generaties, en alle die volgen.

Desondanks kampt de bouw met het imago conservatief en versnipperd te zijn. Echter, de constructieve zekerheid van producten van de bouwsector zijn formidabel (voor infrastructurele objecten als waterkeringen is 100 jaar een absoluut minimum), de ontwikkelingen in de afgelopen decennia ten aanzien van energiecomfort en -zuinigheid, nieuwe, slimme bouwmaterialen zijn spectaculair te noemen. De bouwsector is bij uitstek de omgeving waarin de innovaties uit talrijke vakgebieden in geïntegreerde vorm hun uiteindelijke toepassing vinden. Zo heeft bijvoorbeeld geen enkele innovatie zoveel kwaliteitsjaren aan het leven van de mens toegevoegd als adequate sanitatie in zijn leefomgeving. Publieke sanitatie is een goed voorbeeld van een historisch, en 'ongoing', project dat alleen tot stand kon komen door effectieve werking van de gouden driehoek wetenschappelijk en onderzoek. Op basis van deze thema's zijn vragen geformuleerd voor de Nationale Wetenschapsagenda, welke in de volgende pagina's gepresenteerd worden.

Daarom heeft het samenwerkingsverband van faculteiten van de drie Technische Universiteiten in Nederland, 3TU.Bouw, in nauwe afstemming met de bouwsector en de hele bouw gerelateerde onderwijsketens, een 8-tal thema's geaggregeerd die richtinggevend zullen zijn voor toekomstig wetenschappelijk en onderzoek. Op basis van deze thema's zijn vragen geformuleerd voor de Nationale Wetenschapsagenda, welke in de volgende pagina's gepresenteerd worden. De toekomst wordt gebouwd!

Samenstelling op basis van bijdragen medewerkers Technische Universiteit Delft - Architecture & Civil Engineering and Geosciences, Technische Universiteit Eindhoven - Built Environment en Universiteit Twente - Engineering Technology; ondersteund door Bouwend Nederland.
redactie:
Alexander Schmets met Siebe Bakker, Ulrich Knaack & Lisa Kuijpers

De meeste innovaties uit diverse wetenschappelijke disciplines vinden hun toepassing in de gebouwde omgeving: in woningen, kantoren, fabrieken, bruggen, wegen, vliegvelden en hun installaties. De hoeveelheid aan ontwikkelde innovaties is enorm. Tegelijkertijd is het mogelijk dat bestaande optimale situaties weg-geïnnoeerd zijn: vervangen door iets nieuws dat niet noodzakelijk beter is. Wie kan dit allemaal overzien? Hoe meet en weeg je het belang van een ontwikkeling alvorens deze grootschalig toegepast is en er langdurig ervaring mee is opgedaan?

Ontwikkelingen die lange termijn voordelen bieden, die zich uitstrekken voorbij de sterfelijkheidshorizon van individuen, kunnen grote impact op de mensheid hebben. Maar de economie van de vrij markt is (nog) niet ingesteld op voordelen en cash flows in een verre toekomst. Hoe kun je in het hier en nu bepalen of een technologie of beleidskeuze op zo'n lange termijn voordelen biedt? Verder blijven of een technologie veelbelovende technologieën 'op de plank liggen'. Alleen grootschalige toepassing gedurende langere tijd kan aantonen of een nieuwe technologie echt werkt, wat vervolgens de mogelijkheid geeft tot door- en uitontwikkeling en tot optimalisering van voordelen.

Dit vraagt echter om partijen die grootschalige risico's willen en kunnen dragen, partijen die vooroplopen en sturen. Zijn dat de overheden, internationale verbanden, NGOs?

De uitdagingen van vandaag zijn te groot om alleen maar door technische oplossingen beslecht te kunnen worden. Er zal een zeer breed gedeeld gevoel van noodzaak moeten ontstaan, er zullen snelle resultaten nodig zijn om het momentum te houden en te vergroten.

Er zal sturing moeten plaatsvinden, naar kennisbehoefte, de 'fog of information' over de prestatie van diverse alternatieve innovaties zal moeten optrekken. Innovatie vraagt om toepassing, testen in de praktijk, verwerpen of evolutionair verbeteren. Het vraagt intense samenwerking om technieken en processen verdergaand te integreren en te versimpelen. Dit gebeurt allenaar door mensen: hoe bereid je mensen in onderwijs en inspiratie voor op zo'n gezamenlijke uitdaging?

Extreme omstandigheden vragen ook om nieuwe ontwerpstrategieën en materialen voor wegen, bruggen en tunnels. Deze dienen robuust en betaalbaar te blijven functioneren. Dit alles vraagt niet alleen om het vergroten van de voorbereidbaarheid van het gedrag van materialen, constructies en systemen, maar ook van het weer en andere natuurfenomenen, zoals aardbevingen en vulkaan-uitbarstingen. Zelfs als de vermeende oorzaken van klimaatverandering in de komende decennia volledig kunnen worden weggenomen, dan nog zullen de gevolgen zich lang merkenbaar zijn.



Een van de uitdagingen voor de gebouwde omgeving is dat er een sterke reducție van het energieverbruik nodig is. Daglicht heeft vele mogelijkheden om een goede energiebron te zijn wanneer sommige problemen, zoals verblinding en oververhitting, kunnen worden voorkomen. Naast een goede energiebron is daglicht ook nodig voor het biologische systeem van het menselijk lichaam, het hormoon systeem en het slap-waakritme. Dat betekent bijvoorbeeld dat bij een goede daglichtomgeving kinderen beter kunnen presteren op school en senioren beter kunnen slapen en minder depressieve gevoelens zullen hebben.

Praktische daglichtonderzoeken worden meestal gedaan met proefpersonen die al op universiteiten en laboratoria aanwezig zijn, zoals de studenten en de medewerkers. Het is de vraag of conclusies getrokken uit dit type studies geschikt zijn om bijvoorbeeld goede basisscholen en senior woningen te kunnen ontwerpen en bouwen. Onderzoekers verwachten dat de ontwerpregels volledig kunnen verschillen voor deze specifieke gebouwen en hun gebruikers, omdat de zintuigen van mensen en de verwerking in de hersenen eerst op jonge leeftijd een ontwikkeling doormaken en later bij het ouder worden ook weer veranderen. Zo blijkt bijvoorbeeld dat senior ogen vier keer zoveel licht nodig hebben als die van jongeren en dat problemen met verblinding anders ervaren worden. Jonge kinderen en ouderen hebben vaak geen mogelijkheden om naar universiteiten te komen om proefpersoon te zijn bij laboratorium testen. Als we willen dat daglicht gebruikt wordt als een goede, gezonde en goedkope energiebron, dan moeten we gebouwen ontwerpen die visueel comfortabel zijn voor de gebruikers. Dat vraagt om meer specifiek onderzoek met ouderen en kinderen als proefpersonen.

LIGHTVAN

Recent is een multifunctioneel mobiel lichtlaboratorium gebouwd in een transport auto, de LIGHTVAN. Deze LIGHTVAN heeft een tweeledig doel: Met dit rijdend lichtlaboratorium kunnen we naar de leefomgeving van specifieke groepen mensen gaan, de kinderen en de senioren, zodat zij proefpersoon kunnen zijn bij specifieke leeftijdsafhankelijke lichtonderzoeken. In dit rijdende laboratorium is daartoe meetapparatuur aanwezig en ook een tafel en stoelen voor de diverse proefpersonen. Testen over luminantie- en kleurcontrasten zijn mogelijk, evenals 'licht en schaduw' patronen. Zelfs kleine oogtesten kunnen worden uitgevoerd. Daarnaast is de achterzijde van de bestelauto aangepast zodat bij geopende deuren allerlei innovatieve gevallen getest kunnen worden. De LIGHTVAN kan naar verschillende locaties worden gebracht en gericht op diverse zon richtingen. Diverse passe-partouts zijn aanwezig voor verschillende maten van gevallen, zodat bouwfysische metingen gedaan kunnen worden en proefpersonen hun voorkeuren betreffende comfort en gezondheid voor gevallen kunnen aangeven.

Als we willen dat daglicht gebruikt wordt als een goede, gezonde en goedkope energiebron, dan moeten we gebouwen ontwerpen die visueel comfortabel zijn voor de gebruikers.

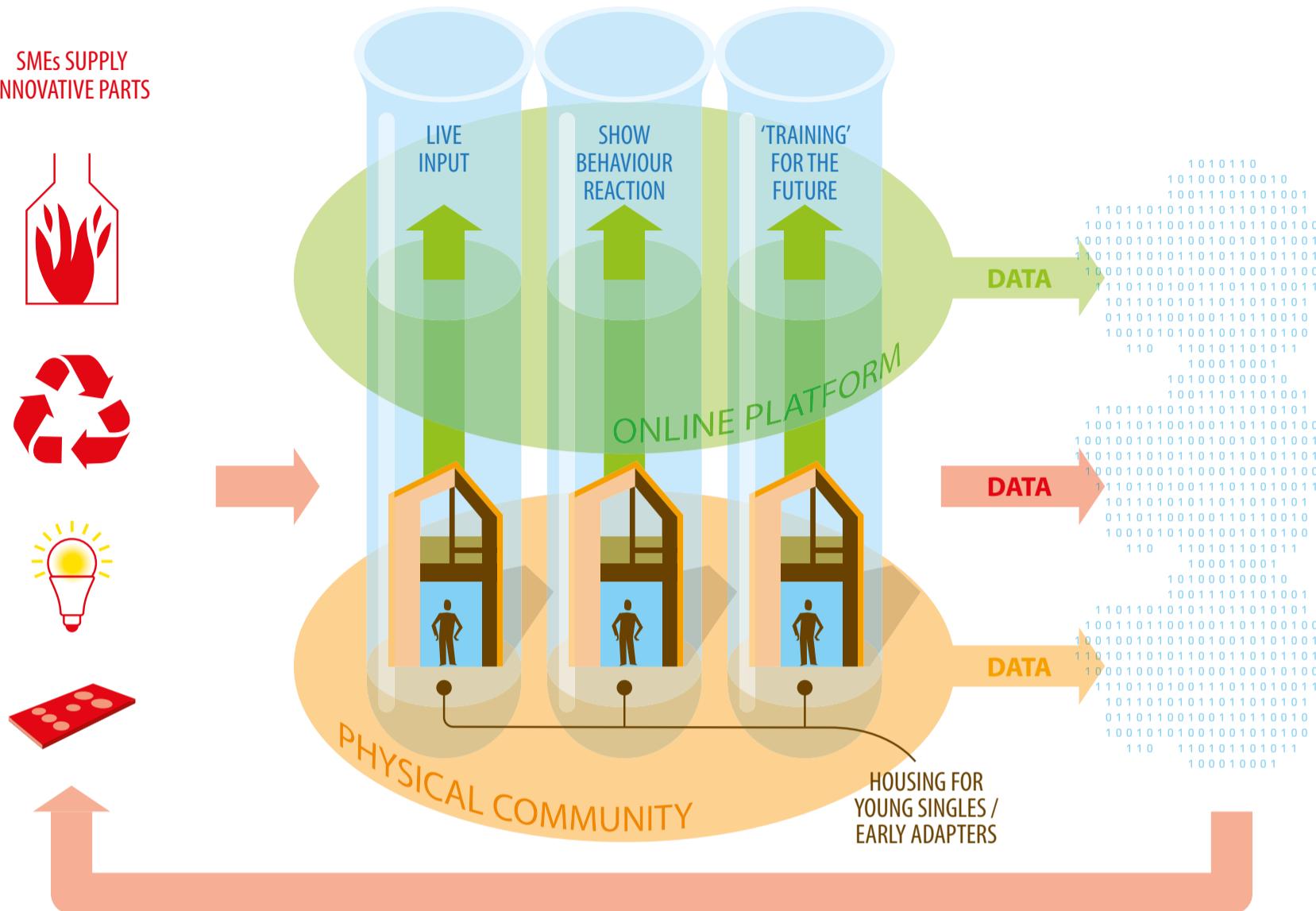
Mobiel lichtlaboratorium

De bouwfysica groepen van de Technische Universiteiten van Delft en Eindhoven hebben in een eerder stadium van onderzoek al pilotstudies in scholen, seniorenwoningen en verzorgingshuizen uitgevoerd, met bouwfysische metingen en vragenlijsten voor de gebouwgebruikers. Met het mobiele lichtlaboratorium kunnen we ook laboratoriumproeven en observaties gaan uitvoeren in de leefomgeving van kinderen en senioren, dus met de juiste proefpersonen. Daarnaast kunnen we alle leeftijds categorieën van proefpersonen bevragen over het comfort en hun voorkeuren bij nieuwe innovatieve gevallen. Dat zal meer mogelijkheden en betere onderzoeksresultaten geven.

Met het 'LIGHTVAN' onderzoek beogen we het lichtontwerp voor gezonde scholen en moderne seniorenwoningen en verzorgingshuizen te optimaliseren met betrekking tot het gebruik van daglicht als een goedkope en belangrijke energiebron.

A LIVING LAB

PDENG



A living lab towards an autarchic temporary residential community

This project is focused on providing movable-temporary sustainable housing at derelict locations in cities, for young people / graduates / singles / expats / professionals in the European market. The goal is to act as the missing link between innovative small and medium enterprises in the sustainability and energy efficient sector (SME's) and their target audiences i.e. residences. It is a new housing concept that provides residential solutions and living lab facilities for innovative energy technologies. It is a solid quality solution at affordable rental price, at central locations inside cities providing independent living. At the same time, it provides a low cost living lab facility for field testing, linking to market and showcasing to innovative companies which want to "market test" their products and produce performance data. The ultimate goal is to influence user behavior via water, waste and energy autarchic community, in different levels, than later on the same principles can be applied in other residential, commercial or industrial district arrangement.

A living lab, designed for early-adopters to experience novel technologies, to produce technological performance and user behavior data, through a community of autarchic residences via a water, waste and energy box/hub.

The demand for single person, affordable and private residential housing has been increasing for the last few years. This problem will be intensified as 2020 is approached and the demand for low energy consumption houses is rising. On the other hand, a rapidly growing demand for living labs by innovative small and medium enterprises has been observed which want to test and showcase their proven product. At the current state, an investment for living labs from them may not economically feasible. Finally, a lot of waste is generated in cities that is thrown away unexploited.

This living lab provides a combined solution, introducing an aesthetically pleasing, low production cost temporary house that, through energy production from PV installations, allows for lower rent, making it more affordable for potential customers. Also, innovator companies through a cost effective way will be allowed to test and showcase their new technological solutions while getting reviews and suggestions from the residents concerning the performance of their product. Moreover, they get a first link to the market in an environmentally friendly environment with low risk for their company image if the product doesn't perform well, since the tenants and clients sign a contract where accountability and liability are clearly mentioned.

Two market segments are targeted with a hybrid business which combines a service and a product, in one package. The first target market is young people who just started their career and are not able to buy their own house, they don't want to commit themselves to a permanent residence yet, they demand freedom, quality and independency. The second target market is small and medium companies (SME's) which can benefit from accessing the service offered by living labs. The technologies applied at the living lab are in two different conceptual levels, building and district scale level. The goal is to make the

To conclude, the expected result should be that residents of this housing will have the opportunity to experience and test novel sustainable technologies, and provide feedback to the technological designers through an online community platform. Another problem that can be tackled this way is waste in cities that is not utilized. This way, the people living there are going to co-create the transition to sustainable energy and behavior, "trained" to comprise the future "Net-not generation".

PDENG

Goal: interoperability

Context information

The municipality gathers the information from the infrastructure above and underground of a city. The zeros and ones represent the "data" of an asset in the database.

The problem

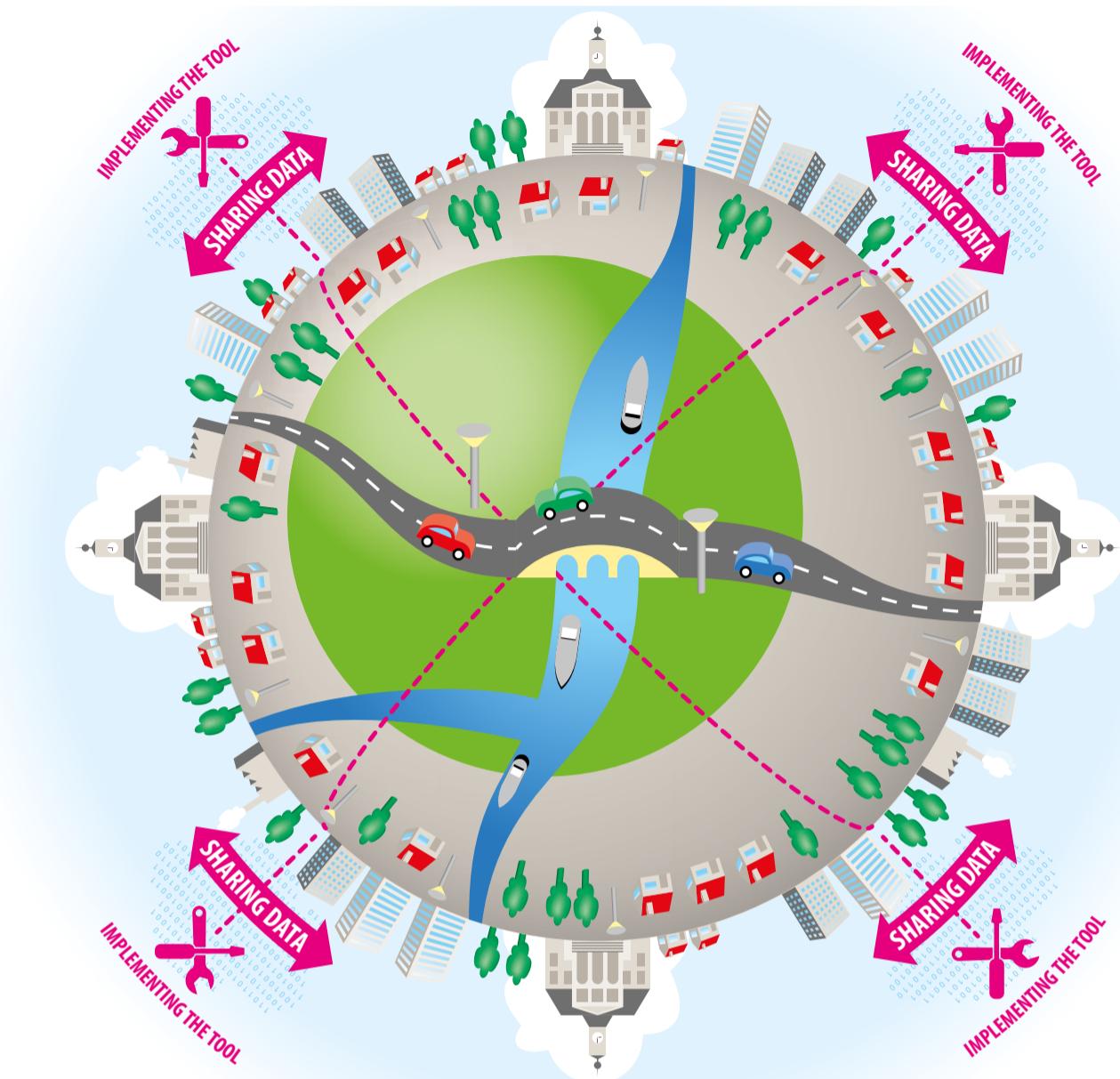
The unawareness of the potential business and common goals a municipality can have with other organization by being in an invisible capsule that block them from this to happen.

The solution

The solution is sharing information.
It doesn't have to be all the information
the organisation possesses, but only the
necessary by implementing the tool.

The tool

The database and the Life-cycle cost (LCC) will throw information to qualify performance, resources and interoperability making them work together smoothly.



payments), its maintenance tasks (i.e. dredging), and its strategic investments (i.e. expansion of channel, addition of servicing infrastructure). To do so, it is required account for with an unified data structure, have one common data base, and integrating standardize life cycle management methods.

To provide an answer to the previous problem, in this project I will develop a BIM tool that enables efficient and effective asset management of the GHT, and that will provide a standardized means for enhancing the interoperability among the different harbors in the Twentekanaal. The goal of this tool is to support strategic decision making

The provinces of Gelderland and Overijssel in the Netherlands are connected by a nautical channel, The Twentekanaal. A nautical channel is a dredged and marked lane of safe travel to vessels transiting that body of water. The Twentekanaal is composed by the nautical channel and six harbors. The water of this channel is managed by Rijkswaterstaat (the Dutch government body responsible for waterways) but the infrastructure of each harbor is in charge of the municipality it belongs to: Lochem, Goor, Almelo, Delden and Hengelo to Enschede. The Twentekanaal is mostly used for the transport of sand, gravel, salt and cattle food but also for recreational function like sailing and fishing.

The current administrative structure of the Twentekanaal is not integrated, making of all of its owners separated entities. As a consequence, issues like maintenance are undertaken by each harbor independently. Moreover, under the current structure, Rijkswaterstaat has a direct but independent relation with each harbor, decreasing the effectiveness and efficiency of decisions that should be taken together.

To improve this situation, the municipalities and governmental instances related to the Twentekanaal have created the 'Gemeenschappelijk Havenbeheer Twentekanalen' (GHT) a company to manage the commercial and recreational function of this channel and to support the future commercial plans for that area. The municipalities will still be the owner of its harbor, but will delegate the management to this new company. This structure will enhance collaboration and allow the integration of asset management decisions, such as execution of maintenance activities.

The project will explore how to unify the management of the different functions of the channel, such as its commercial and administration activities (i.e. managing usage control, unifying toll

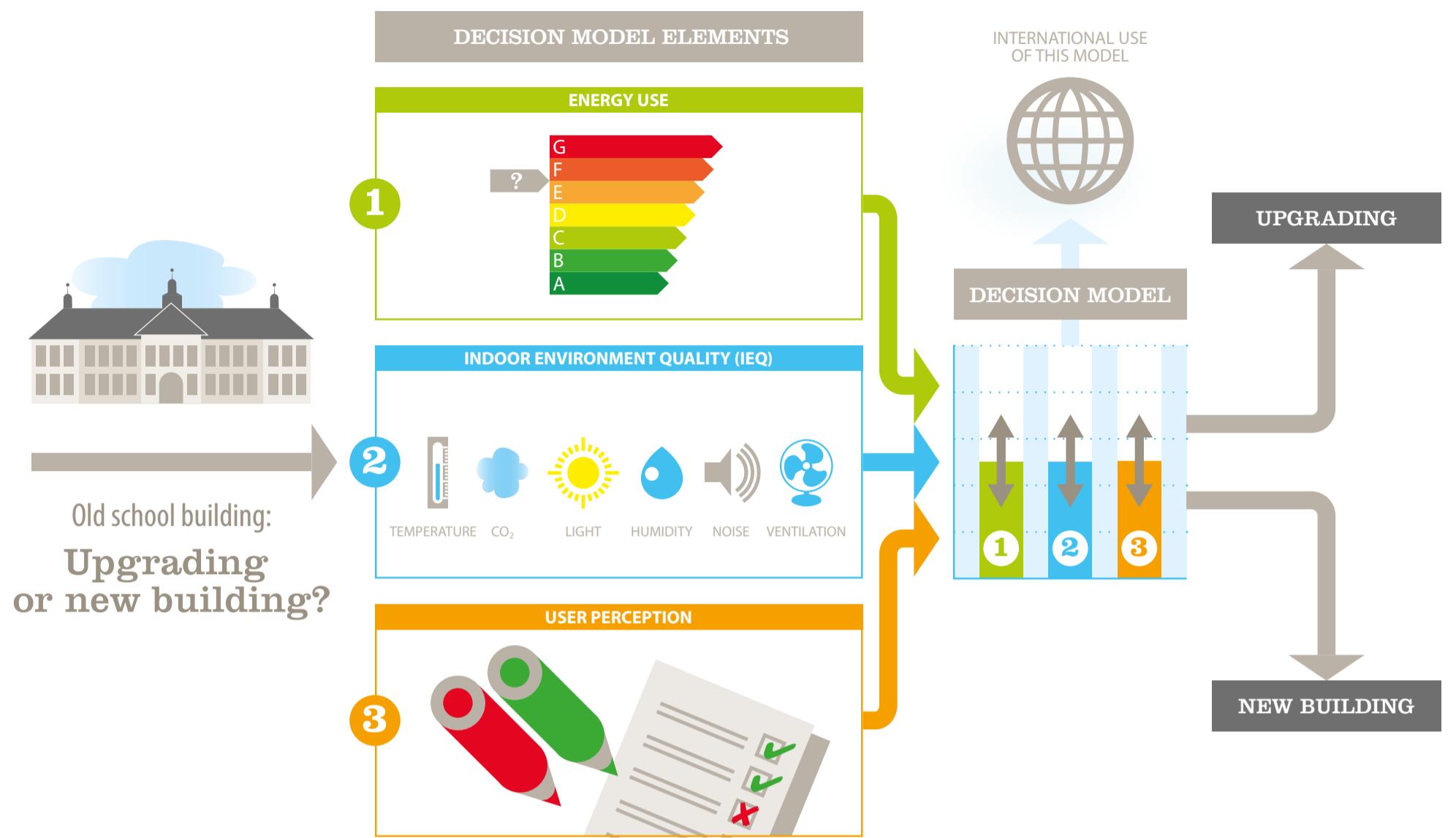
The need for innovative and cost effective approaches for infrastructure maintenance has never been more crucial. In fact, this has been a popular topic in technical reports like the McGraw Hill Construction, the Dutch Cobouw construction magazine and the new multidisciplinary journal "Infrastructure Asset Management" by the Institution of Civil Engineers. The financial status of Industrial Parks (IP) and Business Parks (BP) in the Netherlands, as well as in the rest of the world, has been greatly influenced by the 2007-2008 financial crisis. As a consequence, several IPs and BPs have suffered from infrastructural deterioration that needs to be revitalized. Therefore, one of the priorities facing municipalities nowadays is stimulating companies to invest and redefine such areas with the goal of improving its economic output and optimize the expenditure on its maintenance costs. The different stakeholders involved in the life-cycle management of these parks make strategic decisions based on data that has been gathered over time by its users, either private or public. However, gathering data is becoming more and more complex with time. Infrastructures in these parks are increasingly demanding custom supply of services by the private industry to cope with their technical operations. As a consequence, the level of detail of the assets information is very high. Hence, the digital collaboration and interoperability has become almost mandatory for enabling proper management in construction areas. Interoperability can be described as the ability of making systems and organization work together.

Rijkswaterstaat has a direct but independent relation with each harbor, decreasing the effectiveness and efficiency of decisions that should be taken together.

Iruji Dugarte Arch.
University of Twente
Construction Management and Engineering

Supervisors: dr. Timo Hartmann & prof. dr. André Dorée

HEALTHY LEARNINGS



A good school environment is paramount to the performance and health of the pupils and teachers. However, the quality of school buildings in the Netherlands is in general not so good, with 80% of them not complying with good practices for the indoor environment, while having high energy costs. When tackling these issues, School Boards around the country have two options: building new facilities, or upgrading the existing ones. Although they usually prefer new buildings, municipalities around the country are promoting the alternative. This presents opportunities for the sustainable renovation of potentially thousands of buildings, to make them not only energy efficient, but with a high quality indoor environment as well; Energy efficient schools with good indoor environment are at the heart of the project "Developing a model for the balance of energy use and indoor environment quality in school buildings".

In order to provide the best learning environment, a balance must be struck between energy use and indoor environment comfort and quality.

MSc. Stephanie Villegas Martinez
Eindhoven University of Technology
Smart Energy Buildings & Cities

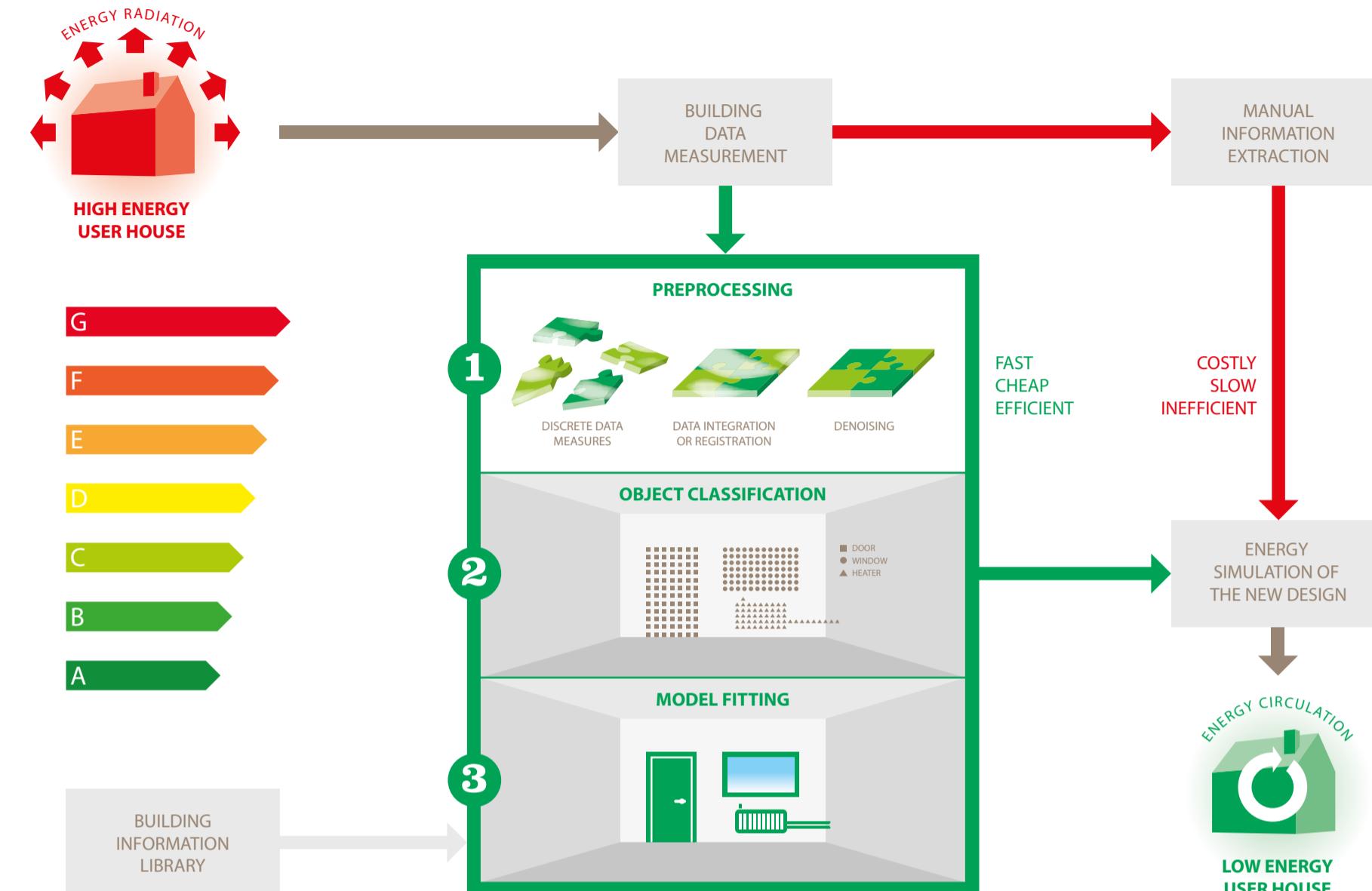
ACADES, Ruimte-OK, Eco KLima

Supervisors: dr.ir. Marcel Loomans, dr. Ad den Otter

PDENG

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GEOMETRIC INFORMATION PROVIDER PLATFORM



For years now, focus has been put in constructing buildings that are energy-efficient and energy-saving; however this comes sometimes at the cost of reducing the comfort and quality of the indoor environment, which translates in unsatisfied users –in a large part, students, teachers and staff-. In order to provide the best learning environment, a balance must be struck between energy use and indoor environment comfort and quality. The project aims at developing a tool that helps make visible to School Boards and Municipalities the interactions between indoor comfort and energy, by providing information related to these two streams. The information presented can be used for comparing the current status of the school buildings with 'good' school buildings, and to find a balance between indoor comfort and energy use. In order to do this, three aspects will be taken into consideration: Energy use, Indoor Environment Quality (IEQ), and the perception of the users. By means of a 'Living Lab' situation, measurements will be taken of the most relevant parameters: For the energy use, it means the current energy consumption of the building; for IEQ, measurements of CO₂ level, ventilation, (operative) temperature, relative humidity, lighting and noise level of the installations; the perception of the end users will be measured by means of questionnaires. All three flows of information will be used for the creation of a model where a balance –if possible– between energy use and indoor comfort will be found. Depending on the performance indicators, and the interest of the different stakeholders, each flow will have a different weight. The relationships between the three flows will influence each other, and recommendations will be given according to what is more important for the key stakeholders.

This project is part of a larger initiative, "Energy efficient, healthy learning environment 2.0", which is started by OPTI-school, a Brabant based knowledge centre for optimal learning environments, committed in finding useful

innovations that could be applied to address the issue at hand, namely, the quality of school buildings throughout the Netherlands. The outcome of this project can have a significant, positive impact for the Dutch society: ensuring a good indoor environment for the students while they participate in their academic life, and doing this in buildings that are more efficient in their energy use can only be deemed as very desirable. It results in cost minimisation, a better learning and teaching environment in which performances optimize and absenteeism minimises. Furthermore, during the project there will be direct communication with the end users, and this is an opportunity that can be used to raise awareness among them about the importance of using energy in an efficient manner, and about having a comfortable, healthy indoor environment. They can also spread this awareness among others, like their parents and friends, to encourage efficient energy consumption, and a more responsible behaviour.

In current situation renovation procedure for energy efficiency is too slow and expensive and is not covering market demand. One of the bottlenecks is 3D as-built modelling which is an essential part of the energy simulation. However 3D modelling is a wide field in science with various methods and standards. Energy simulation software, such as Energy plus, requires general geometric information from indoor area of buildings. Area of the floors, position and orientation of walls, position and shape of the openings, position and volume of energy sources would be sufficient information for energy simulation which fits to LOD3. Therefore the problem is developing an efficient system which provides required geometric information.

To obtain a comprehensive picture of the project it is necessary to review current operational tasks. Following are general operational steps of manual procedure:

Measurement: Point cloud measured by laser scanners, topological and thematic maps, metadata measured by local sensors and the history of energy consumption are assumed as input data.

End software: The results of data processing have to become ready for energy simulation and also to be visualized. Therefore the output of the modeling process will be a suitable input for Energy Plus and visualization software.

Building Information Library: a simple library is necessary for facilitating building component selection. Automatic access to the most suitable model is the purpose of having such a library. Thus it is necessary to develop a model selection method which properly connects semantic labels to the appropriated models.

Manual model fitting: 3D modelling of area proceeds through manual model fitting. Expert modellers draw or choose suitable models for building objects. This is the most time consuming task and depends on the skills of modeller and the facilities of the software.

Energy file format: Required geometric information has to be extracted and transformed to a

file format which is suitable for Energy modelling. For instance, to produce IDF files for Energy plus, various geometric parameters have to be extracted from 3D model. Point vertexes for building objects as well as area and volume information are extracted from 3D models. Full automation of this process is quite demanding. However automatic as-built generation for indoor area is in early development steps and still has long way in research. In spite of many developed methods, not any general qualitative solution has verified yet.

A real-time modelling system is a dynamic system which obtains raw data from measurement tools, processes them through mathematical analysis and finally delivers achieved information to the user in standard formats. Thus an automatic system composed of the following sections:

Measurement: Point cloud measured by laser scanners, topological and thematic maps, metadata measured by local sensors and the history of energy consumption are assumed as input data.

Data registration: Individual files have to be integrated to form a unique file for the interested area. This file includes all scanned points in unique ground coordinate system. For this aim Ground Control points are required to register collected 3D points to the ground coordinate system. Registration has to be within determined accuracy level. Any error in control points or lack of overlapping data directly affects registration accuracy.

Model fitting: 3D modelling of area proceeds through manual model fitting. Expert modellers draw or choose suitable models for building objects. This is the most time consuming task and depends on the skills of modeller and the facilities of the software.

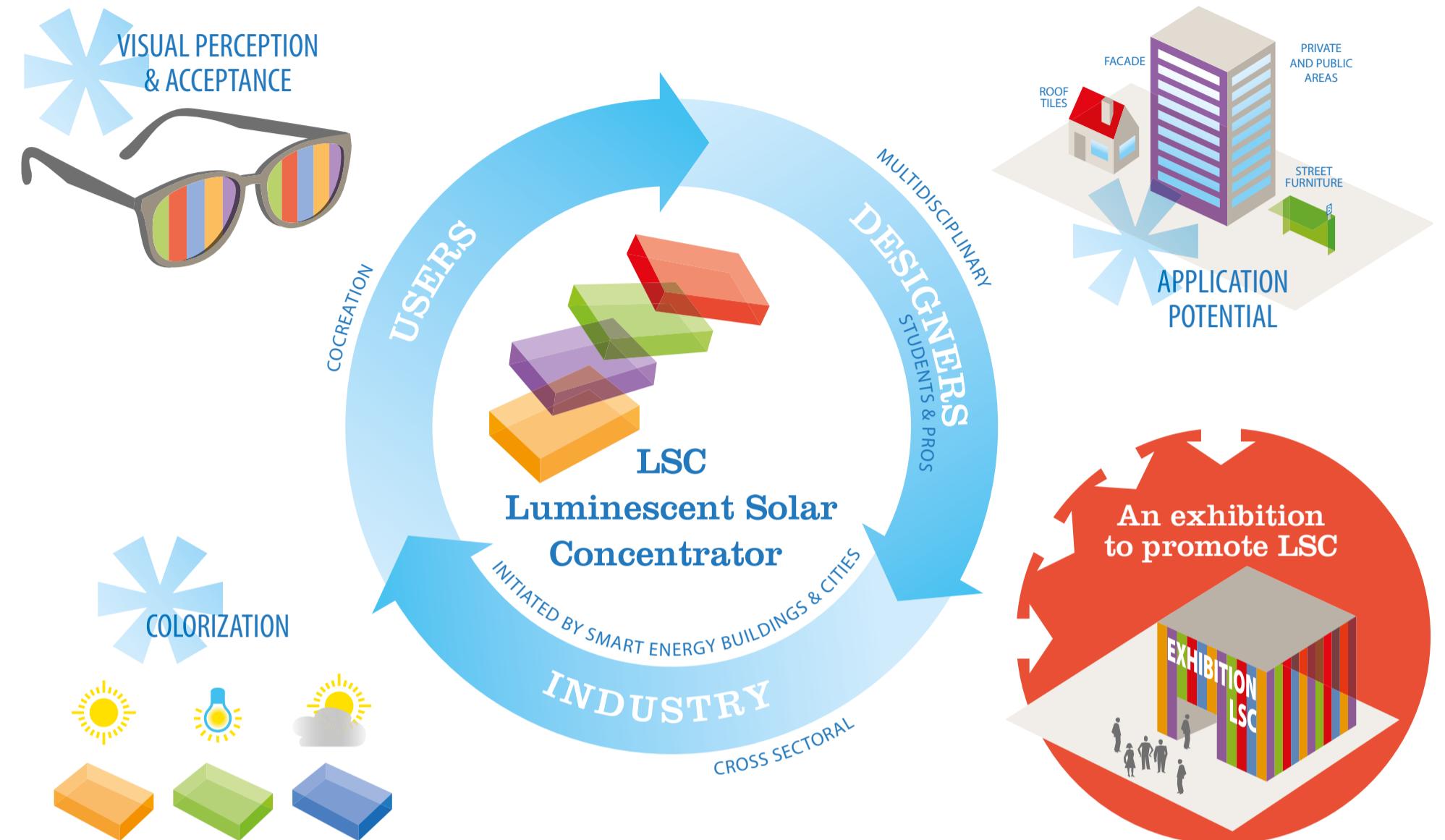
Modelling platform: Development of a reliable modelling process is the main purpose of this research. This section links the measured data to energy modelling and visualization software. Due to the variety in architecture and complexity of data, having a comprehensive automatic process is not yet viable.

Renovation of existing buildings is known as an essential stage in reduction of the energy loss. Considerable part of renovation process depends on geometric reconstruction of building based on semantic parameters. Following many research projects which were focused on parameterizing the energy usage, various energy modelling methods were developed during the last decade. On the other hand, by developing accurate measuring tools such as laser scanners, the interests of having accurate 3D building models are rapidly growing. But the automation of 3D building generation from laser point cloud or detection of specific objects in that is still a challenge. The goal is designing a platform through which required geometric information can be efficiently produced to support energy simulation software. Developing a reliable procedure which extracts required information from measured data and delivers them to a standard energy modelling system is the main purpose of the project.

A real-time modelling system is a dynamic system which obtains raw data from measurement tools, processes them through mathematical analysis and finally delivers achieved information to the user in standard formats.

MSc. Meisam Yousefzadeh
University of Twente
VISICO

3D Geo Solutions



Luminescent solar concentrator (LSC) is a device that has luminescent molecules embedding or topping polymeric or glass waveguide to generate electricity from sunlight with a photovoltaic cell attachment. LSCs can be employed both in small and large scale projects, independent on the direction or angle of the surface with respect to the sun, promising more freedom for integration in urban environments compared to the traditional PV systems. The aim of the SEB&C PDEng project is to investigate the applicability of this innovative technology in the built environment and to bridge the gap of knowledge linking societal, design and technological aspects. The final goal is to exhibit potential application concepts of LSC developed by co-creative methods at SPARK campus which is a hub for open innovation in built environment. Necessity of a paradigm shift towards sustainable and smart cities came into being due to the significant increase in energy demand of the buildings. The challenge is to increase renewable sources in the energy mix while designing aesthetic environments. Thus, building integrated renewable energy technologies represent a great opportunity to help overcome this current challenge. Smart energy, energy efficiency and use of renewable sources are key aspects to be considered nowadays and many innovative technologies need further exploitation to be commercially viable, such as luminescent solar concentrator.

A luminescent solar concentrator (LSC) is a device that has luminescent molecules embedding polymeric or glass waveguide to generate electricity from sunlight with a photovoltaic cell attachment.

MSc. Tugce Tosun
Eindhoven University of Technology
Smart Energy Buildings & Cities

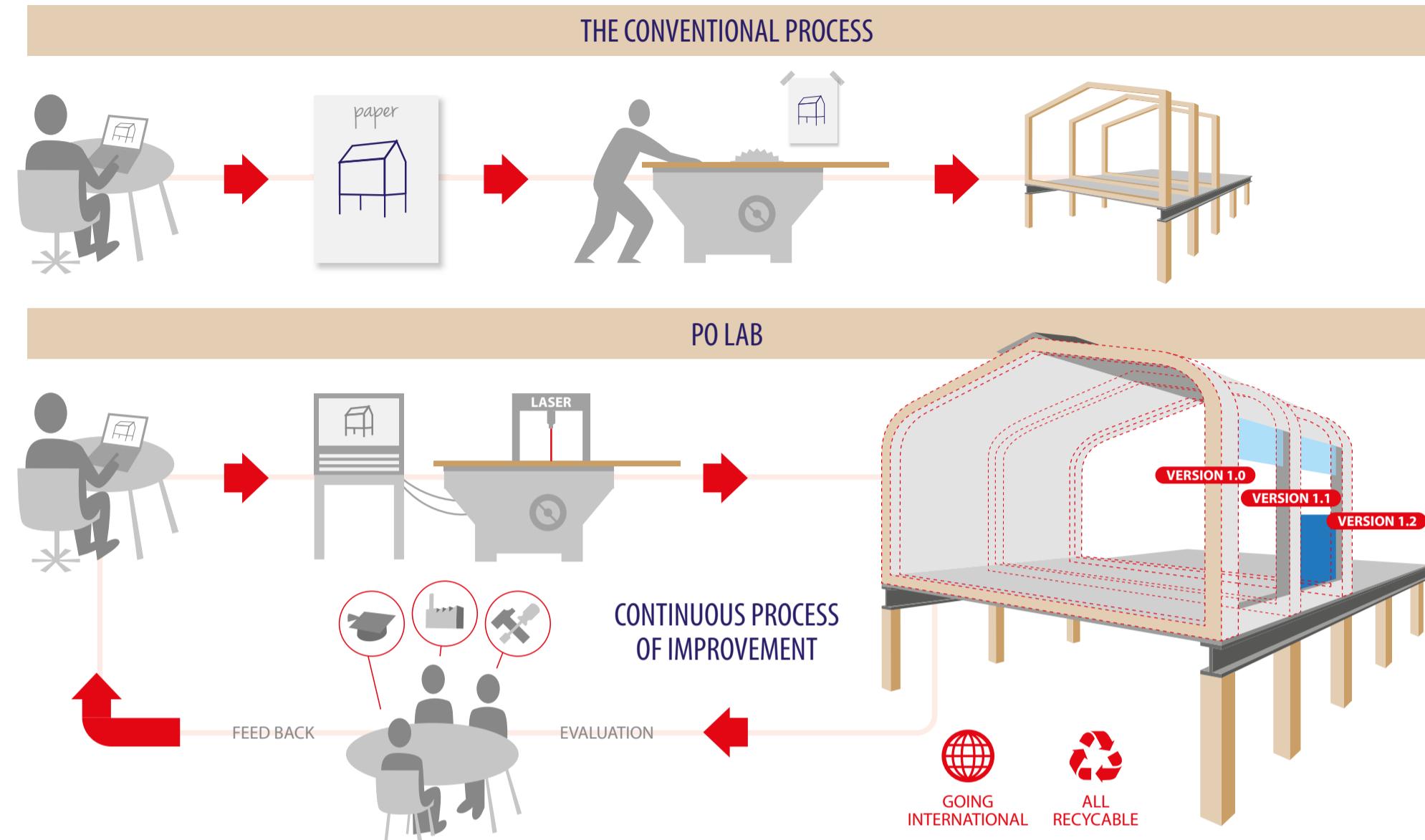
Supervisors: prof.dr.ir. Jos Lichtenberg, dr.ir. Pieter-Jan Hoes

A luminescent solar concentrator (LSC) is a device that has luminescent molecules embedding polymeric or glass waveguide to generate electricity from sunlight with a photovoltaic cell attachment. The result of these co-creative idea generation methods will be later analyzed and it will give us guidance to develop products using the LSC device. Looking at the results gathered so far, it can be stated that, people perceive LSC as a technology that will help integrate renewable energy generation in urban areas. Exterior facade cladding, window glazing, public transportation waiting area, shading device and street lighting are some examples of possible applications proposed by the participants. Once, the question of 'what can be produced using LSC?' is exploited, 'how to produce these products' will be studied. The results of this study will be exhibited at SPARK campus which is a hub for open innovation in the built environment. The exhibition is intended to increase the visibility of LSC while demonstrating different design concepts.

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A participatory approach is being followed throughout the project. People from different fields of expertise are encouraged to involve at the initial product development phase of the project. In particular, co-creative workshops, interviews with experts and an open innovation survey are being executed to gather ideas with different perspectives about the applicability of LSC.



With this lighthouse project a platform will be developed to explore the applications of building sector related product development – the PD Lab. In fact a platform will be developed literally to investigate and test digital production technologies like CNC milled wood connections, but also a platform in its wider meaning to investigate the effects and influences of file to factory production, to explore the potential in the field of sustainability, material use, logistics and the interaction of stakeholders within the chain of the building process.

CNC milled connections with plywood sheet good is invented at the MIT in Cambridge ten years ago. Within this method friction fit connections of plywood sheets can be easily assembled like a puzzle, made possible by the precision of the cutting machine. We attend to use CNC milling technologies that Pieter Stoutjesdijk picked up by himself during his studies at the MIT to increase the quality of the building process and the product itself. It's the question how this method or process can contribute to an economy and ecological advantage for the building sector.

The digital process offers the advantages of modularity, predictability and precision which will be key features on the building site. The digital engineering phase allows a constant overview of material flows, energy consumption, production time and embodied energy. Former problem solving on site will be reduced by the control of the digital design before hand in close collaboration within the design team, this will reduce failure costs.

This technologies deliver accurate precision which allows airtight construction details, an essential key factor to create low energy consuming buildings with a high comfort. Due to this accuracy an easy and fast assembly is possible.

The idea will be based on a prefab system that is set up under a set of to be defined restrictions. The elements of the system can be quickly assembled on site in a precise manner despite poor weather conditions. Insulation, inner and outer layers are already preassembled therefore wall, floor and roof elements will directly perform according code and requirements.

Milling technologies can handle a variety of sheet good, the system will be produced out of

environmentally friendly plywood or natural fibre based plates which comes from waste cycles. The materials will be chosen according to the position and requirements of the different layers. The use of these materials will reduce the embodied energy.

While the use of standardized building components accepts the reuse of the components like Lego blocks, the building itself allows a high amount of flexibility over time. Due to the use of environmental friendly materials the blocks itself can be easily disassembled after its lifetime and brought back into the ecological cycle.

The digital process offers the advantages of modularity, predictability and precision which will be key features on the building site. The digital engineering phase allows a constant overview of material flows, energy consumption, production time and embodied energy. Former problem solving on site will be reduced by the control of the digital design before hand in close collaboration within the design team, this will reduce failure costs.

The current situation on the market asks for smart use of technology and material.

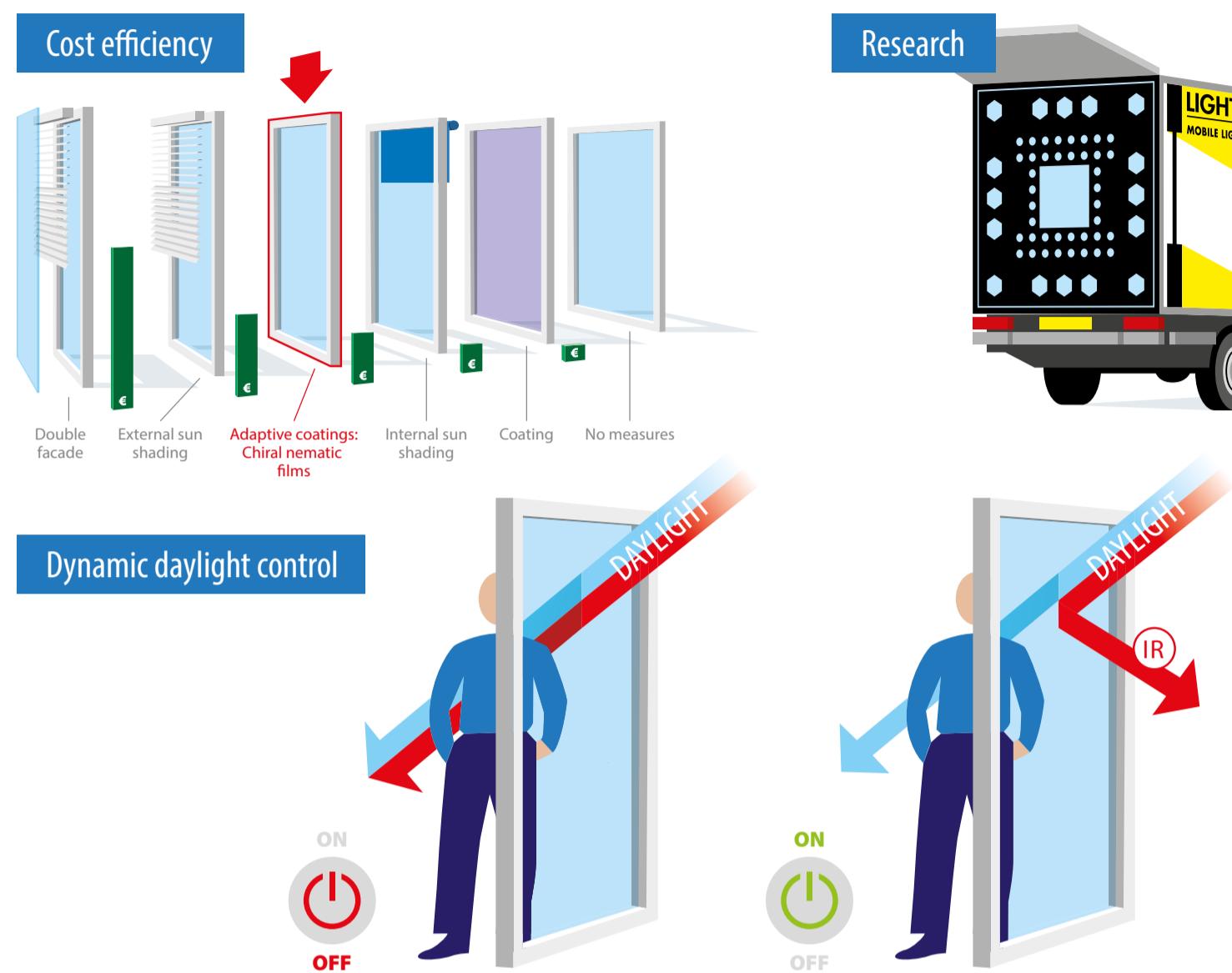
The goals of the team are clear but also demanding. It's not about following a trend, or the fulfilment of an architect's dream. The current situation on the market asks for smart use of technology and material, which adds up together higher than the sum of its parts. It's about testing how far a system has to be developed to create the future of our buildings. Who is responsible, who makes the decision and when do we have to make them, will standards limit us or bring us further. It's about integration of components and functions, but also about the implementation of knowledge that will enhance the building system step by step.

Delft University of Technology
Dr.-Ing. rcel Bliow, Dr.-Ing. Tillmann Klein, prof. ir. Thijs Asselbergs

University of Twente
dr. ir. Bram Entrop, prof. dr. ir. Joop Halman

Eindhoven University of Technology
prof. dr. ir. Jos Lichtenberg

ECOnnect | Fabrication Factory
ir. Pieter Stoutjesdijk



The challenge of the future is to minimize the energy consumption of buildings while maintaining an optimal comfort level in the interior. Controlling the energy streams in and out of the building, and especially daylight management, plays an important role. It deals with many, sometimes conflicting functions of the building: Generally a maximum of natural lighting is desired to reduce the need for lighting energy which in today's buildings accounts for approximately 30% of the total electricity demand. But daylight contains a lot of energy. We need to block sun radiation in summer to prevent overheating, whereas in winter this incoming energy is desired to reduce the need for heating energy.

There are several traditional strategies to control daylight such as metallic coatings, exterior and interior sunshades. The existing daylight management strategies are rather inefficient or they involve considerable constructive effort, high investment costs and high maintenance and cleaning expenditures. On top of that the architectural impact of additional external or internal functional layers is big and they often do not meet the expectations of designers.

Responsive coatings have a great potential on the nanoscale in relation to traditional technologies for daylight management.

Delft University of Technology
ir. Eric van den Ham, assoc. prof. dr. Truus Hordijk,
Dr.-Ing. Tillmann Klein

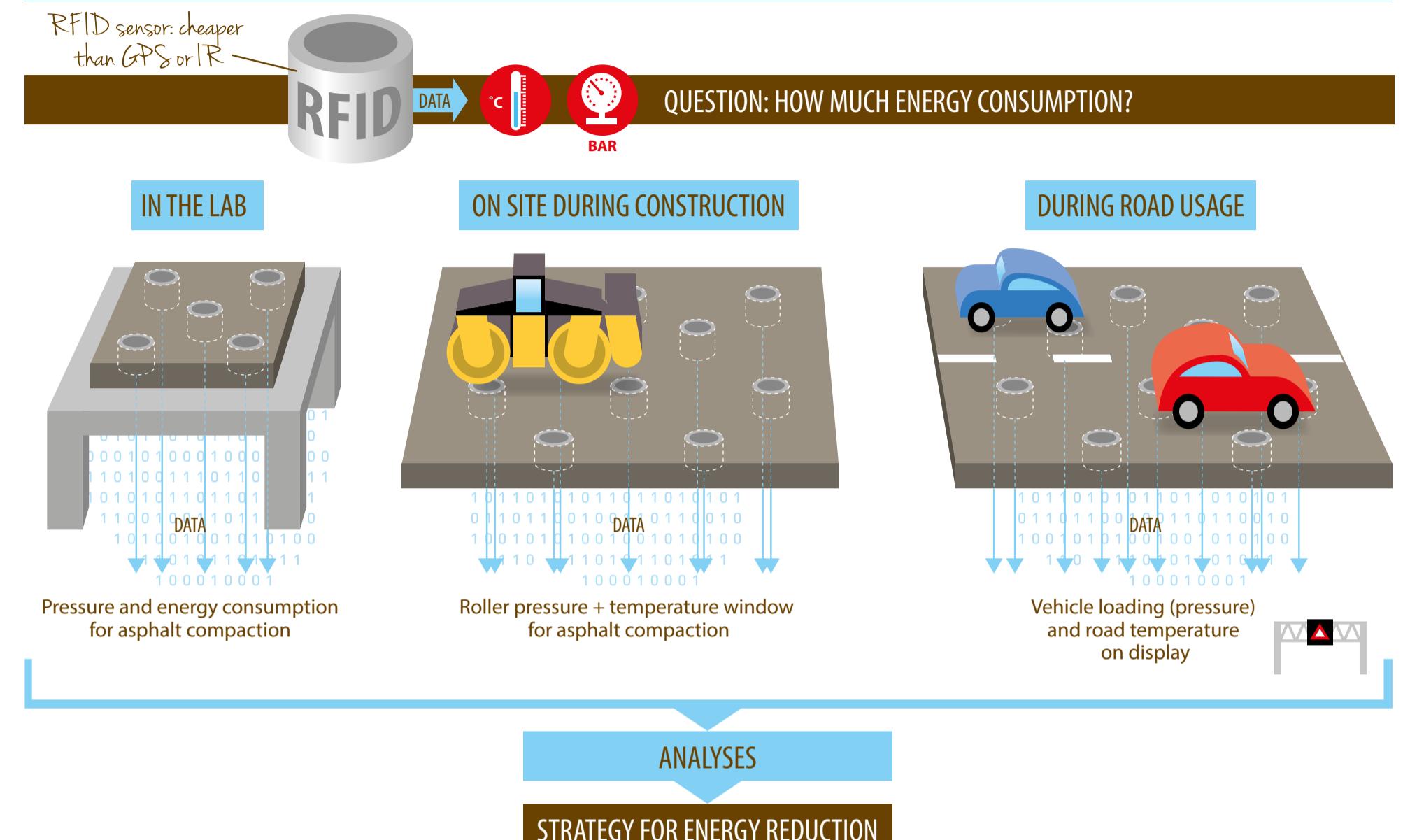
Eindhoven University of Technology
prof.dr.ir. Jan Hensen, prof. Dr.-Ing. Alexander Rosemann,
prof. dr. Albert Schenning, dr. Michael Debije

Our collaborating party, the Department of Functional Organic Materials and Devices at the TU/e is a leader in developing new responsive coatings. With these materials we will be able to switch physical properties such as colour, reflectance and heat transfer. For instance, responsive liquid crystal networks may adapt the degree of reflection. The position of the reflection band in the electromagnetic spectrum can be dynamically shifted in response to temperature or light. Reflection can be shifted in the near infrared part of the spectrum thus controlling heat flux without affecting transparency in the visible part of the spectrum. When applied on a glass window this film determines whether the heating part of sun light is being transmitted or reflected.

Since it is responsive, this technology will potentially deliver a much better performance than current static metallic coatings without the need for additional constructive effort for external sun shading devices. The impact of this new concept on the established building process is low and we can expect a high acceptance by decision making parties. Responsive coatings have a great potential on the nanoscale in relation to traditional technologies for daylight management.

Over the past two years we have been discussing with numerous stakeholders the possibility of applying responsive polymer based technology in the field of building. This has been done in several workshops and individual meetings. In other disciplines, such as LCD screens and automotive industry similar technologies have been successfully applied.

With this proposal we aim at clarifying the energy savings potential as well as identifying the technological challenges that need to be tackled in order to get PolyArch market ready. Prototypes of the product will be displayed and tested in the LightVan, a mobile light laboratory.



Simply put, we will determine energy consumption using Radio Frequency Identification (RFID) sensors. These rather clever sensors are currently experiencing a developmental boom given their potential. Over the last decade or so, RFID tags have been used by the retail and consumer goods to identify and track objects on a very large scale. Also, the last few years has seen much progress in making RFID a reliable, standardized wireless communication medium with the ability to mass produce low-cost RFID tags. RFID uses wireless electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. Whilst many of today's wireless sensor technologies are still very expensive, RFID offers good potential for the development of pervasive sensors. In other words, we can use it to track certain process parameters in the testing and construction of asphalt. By placing these sensors into the asphalt mixture, temperatures and pressures can be measured during laboratory testing and construction, but also during usage and maintenance of the road where additional RFID sensors can be added to measure weather conditions and other long-term parameters.

RFID sensors will be used to monitor: (1) compaction temperature and pressure during the laboratory testing process, (2) compaction temperature and pressure during the asphalt construction process and (3) vehicle load pressure and road surface temperature on the constructed asphalt layer over the long-term in terms of energy and durability.

The main aim of the project is "To measure the energy consumption during asphalt construction using RFID-sensors and to determine the relationship with the asphalt quality (durability) of WMA using laboratory experimentation."

The project activities include:

- Monitoring the energy consumption for different operational compaction strategies in the laborato-

ry and during three field projects;

- Measuring the roller pressure, the number of roller passes and the temperature window for compaction using RFID-sensors;
- Drilling asphalt cores from the constructed road and determining the asphalt quality characteristics, such as resistance to rutting and cracking, in the laboratory; and
- Monitoring and displaying vehicle load pressure and road surface temperature on dynamic display boards.

The energy consumption during construction is focussed on: the roller type and pressure; the number of roller passes and temperature of the asphalt mixture during compaction.

The tangible results of this research project will be:

- Demonstrate the suitability of RFID-sensors in monitoring asphalt temperatures and compaction pressures during asphalt construction projects and laboratory testing;
- Demonstrate the usefulness of RFID technology in the dual role of dynamic data display and long-term data collection instrument;
- Better understanding of the influence of different compaction strategies on asphalt quality characteristics for WMA.

This research starts with monitoring the asphalt temperature and roller pressure during laboratory testing and construction. If successful, the ambition is to use RFID sensors to monitor additional parameters such as ambient temperature, moisture and precipitation during the usage and maintenance of the asphalt road. This may also provide much-needed data for the planning of maintenance strategies and other necessary interventions. Furthermore, the RFID-sensors can be included as measuring instruments in the existing Process Quality improvement (PQI) monitoring framework developed in the ASPARI-network to monitor the on-site construction process of asphalt roads.

The energy consumption problem

Governments, regulatory bodies and road authorities all push for and promote sustainability. Contractors respond with strategies to reduce their carbon footprints. Besides optimising their asphalt production and logistics processes, companies are investing in the development of low energy asphalt mixes. Warm Mix Asphalt (WMA) is such an asphalt mixture produced at lower temperatures, thereby requiring less energy. It has recently become very popular in the Netherlands with various types of WMA products being developed by construction companies. In essence, the asphalt mix is modified to reduce the viscosity and the mixture is therefore more flexible at lower temperatures enabling more time available for a very important part of the construction process viz. COMPACTION. While essential research effort has been put into developing techniques for adjudicating WMA, optimising their composition and rationalising the design; less effort has been put into the operational handling and consequences regarding energy consumption and durability. In short, little is known about actual energy consumption during the asphalt compaction process.

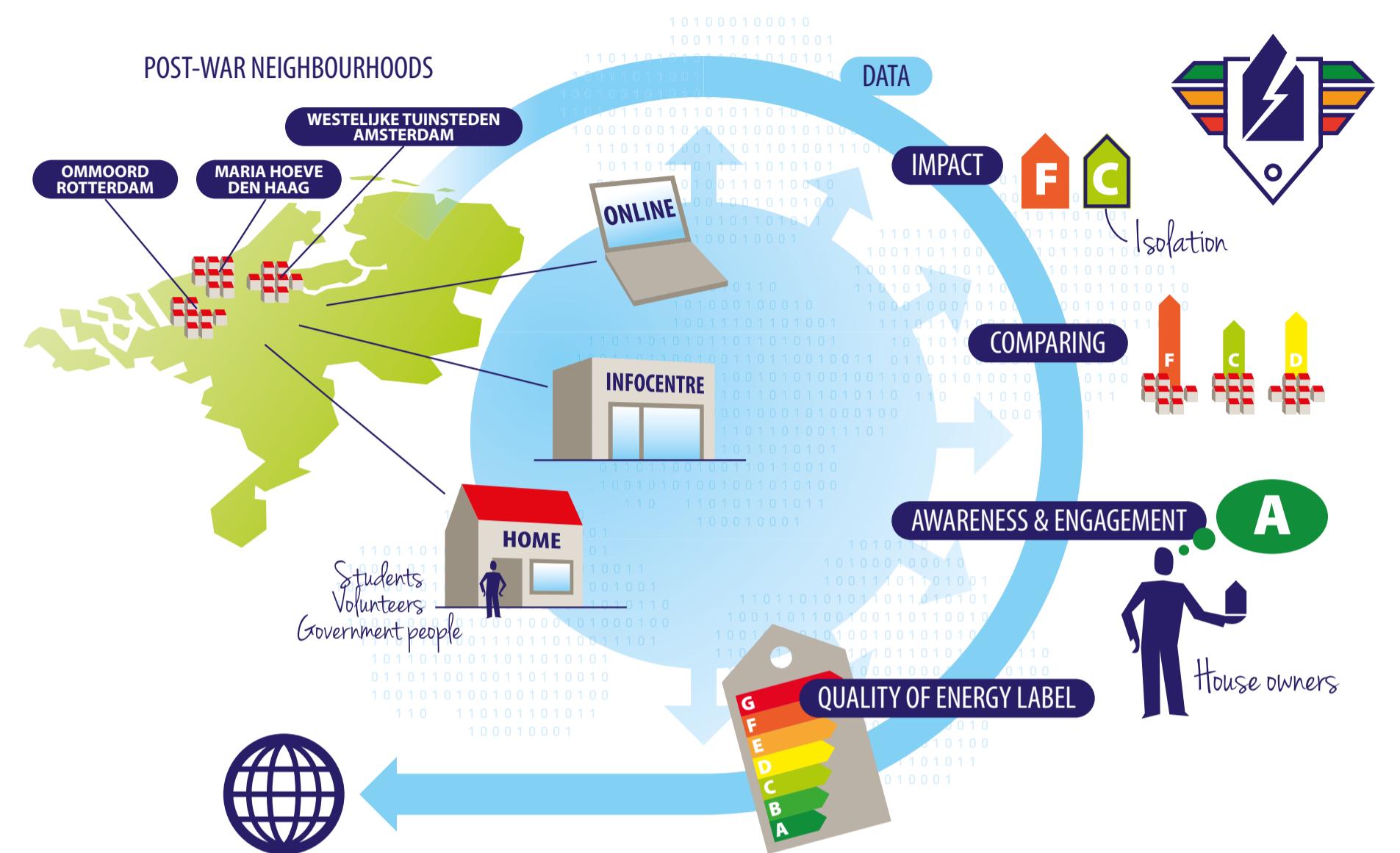
By placing these sensors into the asphalt mixture, temperatures and pressures can be measured during laboratory testing and construction, but also during usage and maintenance of the road where additional RFID sensors can be added to measure weather conditions and other long-term parameters.

University of Twente
ir. Seirgei Miller, Msc. Frank Bijleveld

Delft University of Technology
prof. dr. ir. Sandra Erkens, dr. ir. Kumar Anupam

SAVING ENERGY BATTLE

ELHP2015



3TU Saving Energy Battle (sEB) aimed at charting post-war neighbourhoods in energy saving rankings, and take a first step in a global monitoring tool on resource efficiency. We also tested the new process of energy performance certification, in three post-war neighbourhoods of major Dutch cities: Westelijke Tuinsteden, Amsterdam; Ommoord, Rotterdam; and Mariahoeve, Den Haag.

This monitoring tool and online short courses were developed online. Further, we organized an live event on 28 February 2015, where students and volunteers teamed up to assist building owners with the upload of requested information and photos. The sEB event was a great experience! Den Haag won first place (127), followed by Amsterdam (118) and Rotterdam (62)!

All building owners who succeeded in uploading all needed information have obtained a definitive Energy label issued by Atriensis, free of charge. The research team has their data, to answer their research questions. Public officers and owners can inform transformation decisions on their energy savings. Ministries can compare and determine the contribution of measures as the energy performance certification to boost energy efficiency. Everyone wins!

There is still very little known on the energy efficiency of post-war neighbourhoods, and even less on the contribution of private efforts to raise energy savings through the transformation of their buildings.

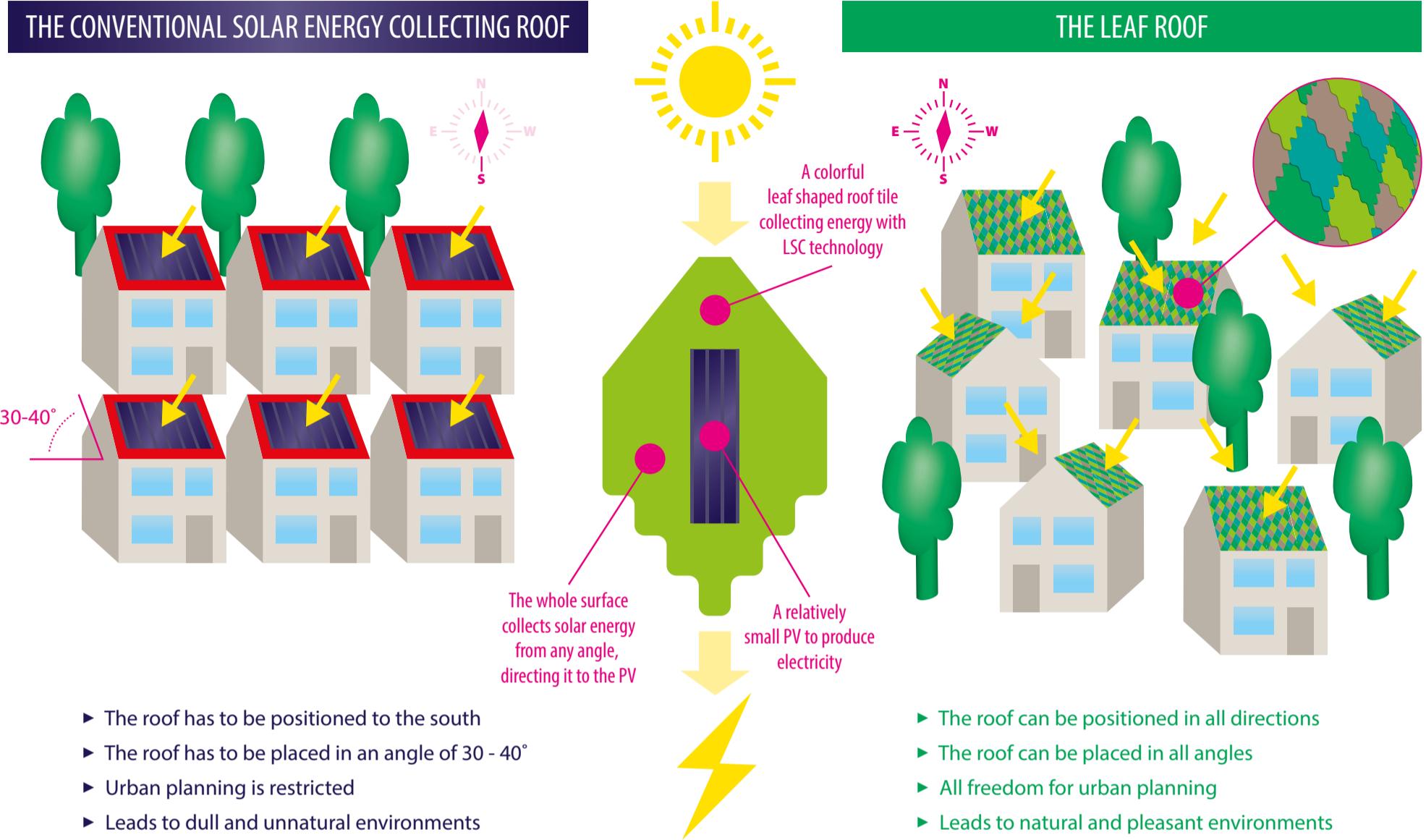
Eindhoven University of Technology
dr. Ana Pereira Roders

Delft University of Technology
ir. Job Roos

Atriensis, Van nut, Videohero, Rijksdienst van Culturele Erfgoed, Rijksdienst voor Ondernemend Nederland, Gemeente Amsterdam, Gemeente Den Haag, Gemeente Rotterdam

LHP2015

THE CONVENTIONAL SOLAR ENERGY COLLECTING ROOF



Energy efficiency is a priority to many cities, with programs being implemented to stimulate energy savings in the built environment. Cities aim to reduce carbon footprint, but also to cut energy costs, one of the biggest expenses of building ownership. That has led to urban renewal developments, where neighbourhoods were demolished and replaced by new neighbourhoods, assumingly more sustainable. Some neighbourhoods built during the post-war period are now under trial for their poor materialization and energy inefficiency. Though, they are also the massive expression of a rising idealism from the 20s and 30s, where public officers and professionals, as urban planners, architects and engineers had the opportunity to give the working class a larger, healthier and greener environment. The demolition of these neighbourhoods may seem to solve the problem, but also raises many other as resources waste, social segregation and culture loss. Instead, there is great potential for achieving energy savings in the building sector, through the transformation of existing buildings. Energy efficiency-wise, transformations can save not only energy costs, but also embodied energy. There is a growing body of knowledge on energy efficiency in the built environment, though, primarily derived from samples, models, and/or buildings owned by housing associations. The private housing sector is largely understudied, as information remains either confidential, complex or costly. Consequently, there is still very little known on the energy efficiency of post-war neighbourhoods, and even less on the contribution of private efforts to raise energy savings through the transformation of their buildings. Yet, their transformation patterns can feed the debate and help determine the energy (in)efficiency of buildings and post-war neighbourhoods in particular. A framework for energy performance certification, as the Energy label, provides information on the energy efficiency of buildings, but also enables energy

savings to be determined and forecasted. It also systematically records information about the building stock and its transformation. There is great criticism on the reliability of the Energy label, particularly on the new process. Though, being an international framework, there is great potential to keep developing it into a reliable global monitoring tool, where buildings, neighbourhoods, cities and even countries could be compared on their energy efficiency, strategies to raise energy savings shared and the effectiveness globally validated.

This project targeted a duration of six months. There are seven main work packages, each offering relevant outcomes. We have created the online monitoring tool (<http://savingenergybattle.nl/>) to reach all building owners. Previous to the event, the website offered short courses, created to ease the submission process. Now, the website offers the outcomes of the SEB event. The sEB event was a great experience! Den Haag won first place (127), followed by Amsterdam (118) and Rotterdam (62)! The students are now doing the data analysis, but they already got invitations to present their results by RCE on 13 May. The results will be shared and disseminated in a publication prepared by both universities. We can't wait to show you all results. Stay tuned!

According to the International Energy Agency (IEA), the urban environment accounts for 40% of the total primary energy consumption and 20% of the total CO₂ emissions. Furthermore, in 2025 a minimum of 6% of the energy supply in the Netherlands has to be provided through solar energy. Solar energy can cover the demand of residential buildings with energy produced directly at the point of its end use. However, a limiting factor for traditional photovoltaic systems in the built environment is their orientation (preferably South) and inclination of the roof (location dependent). The structure of urban planning, especially the existing buildings, does not allow a fixed South orientation and a fixed roof inclination. Moreover, the appearance of traditional photovoltaics is far from looking natural. The result of a small survey, which has been part of some market research efforts, showed that 25% of new home buyers would prefer an aesthetic and sustainable solar collecting roof system, even at a higher cost.

Within a joint venture between the University of Twente and the Technical University of Eindhoven supported by the 3TU foundation the research team works on a new innovation that can overcome these disadvantages and can become the new trend in roof design of buildings. The invention is based on Luminescent Solar Concentrator technology, a device for capturing light from a large area and directing it to a relatively small PV (Photovoltaic) cell to produce electricity. In an LSC, sunlight penetrates the top surface of a lightguide made from plastic. The light is absorbed by luminescent materials, which are either embedded in the lightguide or applied in a separate layer on top and/or bottom of the lightguide. The luminescent materials can be organic fluorescent dyes, inorganic phosphors or quantum dots. The absorbed light is re-emitted at longer wavelengths; a fraction of the re-emitted light is trapped in the lightguide by total internal reflection. The emitted

light is guided to small PV cells attached to edges or the backside of the lightguide where it is converted into electricity.

Our product consists of colourful tiles that give a leaf shaped roof perception when integrated in the roof. Therefore, they do not only look natural, but also collect solar radiation and turn it into electrical energy. Because of its natural aesthetics, it is expected to be well received by residents, in contrast to conventional clay roof tiles or roofs covered by conventional PV panels. Its nano-scale technological features enable it to collect solar energy even in cloudy weather and therefore allow the system to be less dependent on orientation. Its shape and dimensions as well as the relatively small PV area boosts its performance. The solar efficiency is estimated to be 4-6%, but real scale tests are required to determine its performance and provide information about further product development. In this project, the final leaf shape and colour appearance will be studied, along with assembling and testing its durability.

Our tiles can simply be connected to a roof using a click-connection system; overlapping of the tiles will waterproof the roof. The technology allows each tile to collect solar radiation and transport it to its centre or edge, where a small solar collector is located. A relatively large collecting area serves a much smaller PV area. The colours of the tiles can be varied to create different appearances.

The outcome of this project will be a prototype of the leaf roof system that could be installed on roofs. It is expected that a successful completion of this project will lead to a continuation of the collaborative research in this field with the project partners, which have multi-disciplinary knowledge. The team consists of scientific and entrepreneurial experts. The long term goal is to increase the Technology Readiness Level of the leaf roof tile systematically from TRL 2 (technology concept formulated) to TRL 7 (System prototype demonstration in operational environment).

Conventional solar energy collection technologies have a lot of limitations with respect to their applicability in the urban environment. The PV cells of the buildings need to be oriented towards the South at a specific angle causing restrictions on urban planning. Moreover, the aesthetics of PV cells are not well suited for building design, creating a generally dull and industrial look in urban environment. The 3TU Lighthouse Leafroof project focuses on creating a roof design, inspired by the natural shape of leaves. By incorporating the Luminescent Solar Concentrator (LSC) technology the system can collect and "trap" solar irradiation and concentrate it to a much smaller area of PV cells located at the centre or the edge of the leaf tiles. This approach allows more freedom of building orientation and roof inclination compared to the conventional PV system. Subsequently, it enhances freedom in urban planning. The goal of this project is to create a "leaf roof" prototype and form a feasible solar energy collection technology that is competitive to conventional systems.

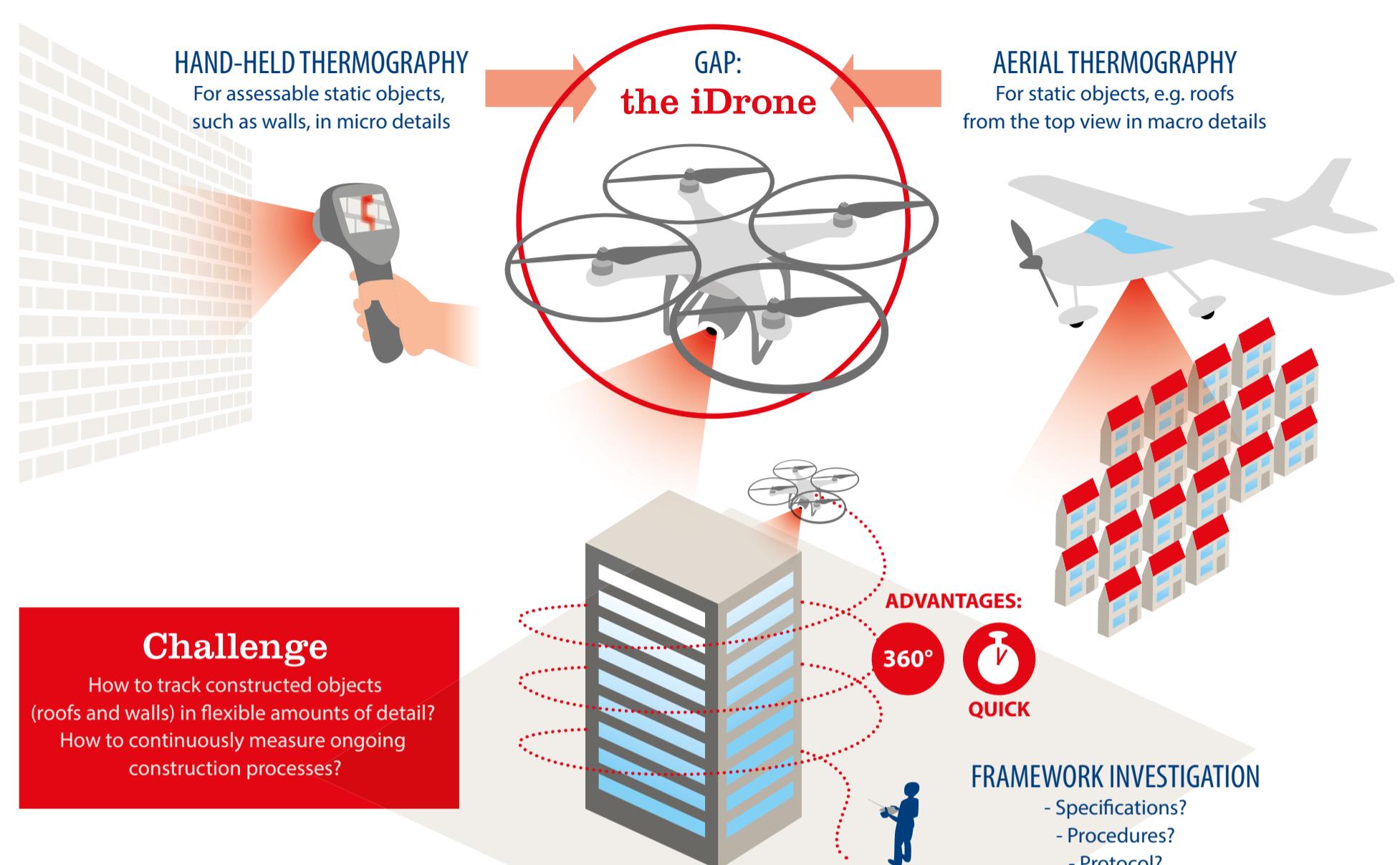
Solar energy can cover the demand of residential buildings with energy produced directly at the point of its end use.

Eindhoven University of Technology
prof. Dr.-Ing. Alexander Rosemann,
ir. ing. Guillaume Doudart de la Grée,
ir. Argyrios Papadopoulos, dr. Michael Debije, ir. Mark Cox

University of Twente
prof. dr. Angèle Reinders

Gemeente Laarbeek
Frans van Zeeland

THROW IN THE I-DRONE



Although many consider drones to be toys, multiple industries, such as the agriculture and mining industry, already know what advantages professional Unmanned Aerial Vehicles (UAVs) can offer. However, many companies in the construction industry do not seem to be familiar yet with the possible advantages of UAVs for their projects. In our 3TU Lighthouse project "Throw in the i-drone" we, the University of Twente, Delft University of Technology, and BeemFlights, would like to make the construction industry aware of the possibilities UAVs have by demonstrating possible usages, by providing a protocol on how to use them and by simplifying the interpretation of data collected.

We target to provide the missing link for the micro to macro temperature mapping continuum.

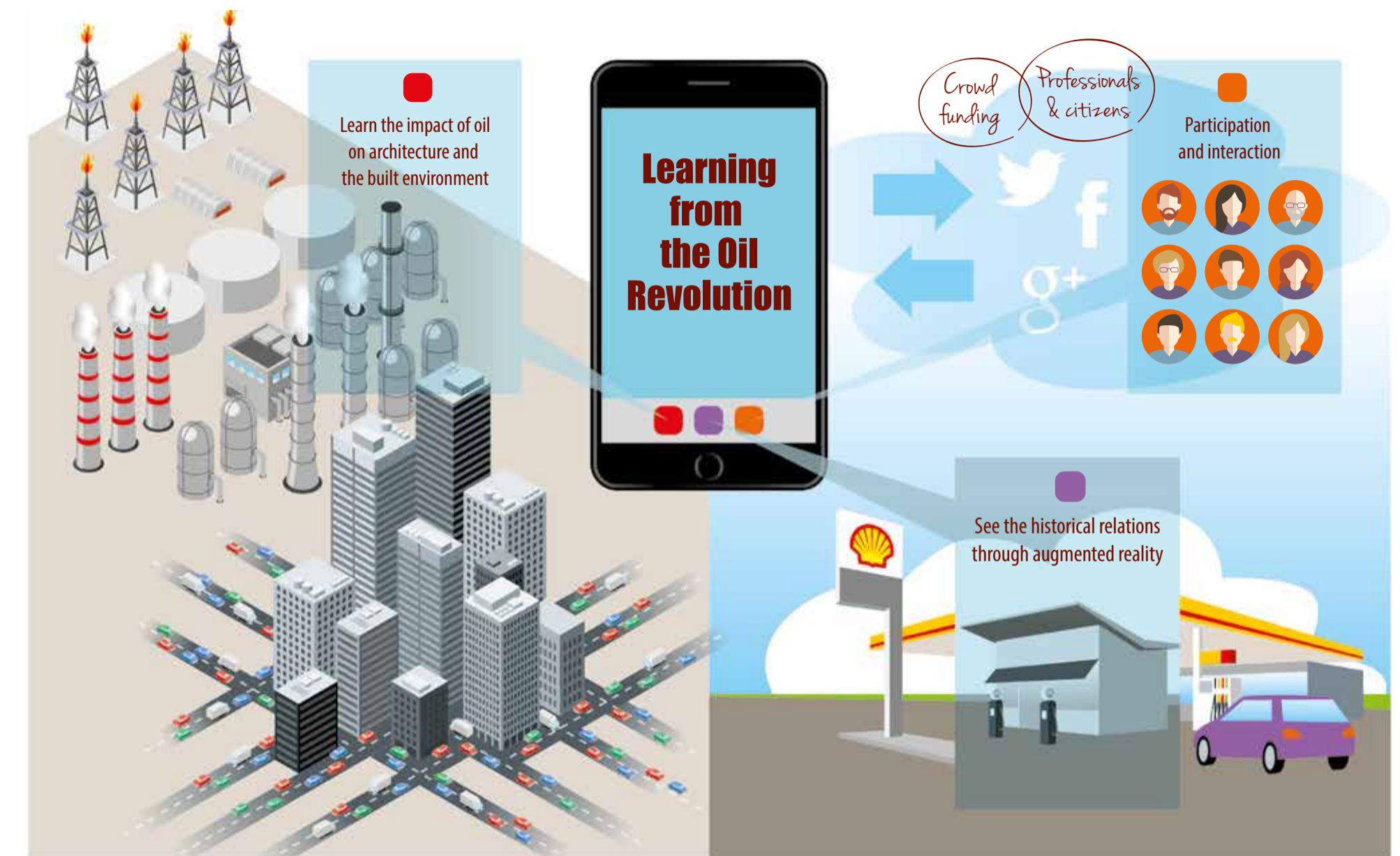
University of Twente
dr. ir. Bram Entrop, MSc. Alexandr Vasenev

Delft University of Technology
dr. Regina Bokel, ir. Eric van den Ham

BeemFlights
Sander Mutsaards

LHP2015

LHP2015



Thermography enables us to distinguish surfaces with different temperatures. Temperature data from infrared cameras can, for instance, pinpoint flaws in the thermal shell of buildings or electric problems in the meter cup board. The application of thermography on buildings is already a well-known practice. Unfortunately, this process is tedious and time consuming. On the other hand, large-scale airborne temperature mapping is both applicable and useful to document temperature signatures on the scale of whole suburbs at once. Still, that method is expensive and less controllable. As a result, these micro- and macro-scale of temperature mapping solutions help specific niches, while the intermediate meso-scale stays underexplored.

The University of Twente, Delft University of Technology, and BeemFlights want to collaboratively challenge the current rules of temperature mapping by exploring this meso-scale. We target to provide the missing link for the micro to macro temperature mapping continuum. Specifically, we aim to leverage current advances in IR-technologies and remote control UAVs to fill this gap by utilizing an "i-drone". The versatility of a UAV combined with enhanced IR vision enables new innovative type of temperature mapping, not available on micro and macro level.

This challenge has not widely been picked up by the construction industry, due to the risk of failing to repay the costs of the equipment. We expect it to open new horizons and enrich a number of practices. Among other tasks, the UAV will be very useful in monitoring building processes, studying the thermal losses of roof-systems, malfunctioning photovoltaic panels and for the inspection regarding building regulation. We will test the combination of UAV and IR cameras for constructions in use, e.g. dwellings, industrial buildings, and/or office buildings. In April, this already resulted in great footage to support our

research and external communication. With the help of an UAV with a conventional camera a small movie, a so called teaser, was made to show the possibilities of drones with an infrared camera in the construction industry.

In this project, we will plan to assess the potential impact of utilizing drones in the construction industry by conducting interviews or taking questionnaires among construction companies, facility managers and building advisors. Furthermore, we will study how to integrate the data obtained by the UAV and the output of data analysis into standard automated assessment procedures, reducing the amount of time normally needed to select, prepare and analyze the data. We plan to test the i-drone and the new temperature mapping method for a building in use by the end of the year.

The project will develop an open-access digital environment, a technology enabling a variety of users, collectively interested in promoting a more sustainable future, to interact in different ways with information about oil as a global commodity. It draws on geo-information systems and augmented reality that others have used in architectural history guides and crowd-augmented repositories such as MIMOA. Our project will expand these tools by establishing links between related pieces of information: that is, by depicting networks and flows as well as buildings.

Users of this digital environment will track oil through usually hidden networks of pipelines, ships, rail, and roads; of petrochemical production, resale and consumption; and of urban formation and growth. They will be able to visualize the multiple ways (including philanthropy) in which oil products and interests have shaped urban form, architecture, and art. The tool is geared to both the professional community and the general public and will be open access. It may also attract interest from diverse energy companies, including established oil companies engaged in documenting their history and new energy companies seeking to trace their growing presence. As an open, informative platform, it will give producers of green energy, architects, urban planners, policy makers, and citizens additional arguments for establishing a comprehensive approach to a sustainable energy world and for pooling the resources of the general public. Social media and augmented reality companies can use this new tool to visualize content and ways to promote it. The project will be a stepping-stone to documenting other networks in the built environment.

Our project is innovative in four ways: 1. Using information about the oil industry to analyze the built environment, its physical form, and cultural construction, as part of tangible and intangible flows and networks of oil. 2. Translating this novel approach into easily readable digital map overlays and into augmented reality to give visual and spatial expression to historical relations. 3. Making this technology available to a broad group of people on computers or cell-phone apps; using social media for the dissemination and crowd-sourcing of information. 4. Providing a new foundation for a collective construction of a more sustainable environment.

Flows of oil span the globe and intersect with local and national processes in multiple ways. As a case study for understanding how oil builds cities both physically and mentally, we have chosen

UNDERSTANDING THE PAST

This project visualizes the history and current presence of oil in our everyday surroundings in order to facilitate long-term urban sustainability and energy innovation. Designers and citizens around the world want buildings and cities to be more sustainable and ecological. While their initiatives to reduce energy use are relevant, they often concentrate on individual structures rather than larger global flows, and on technological approaches disconnected from history, society, and culture. They fail to build a new ecological mind-set, a widespread popular culture of sustainability. An older culture already characterizes our cities: petroleum has shaped our modern world. To make a new world, we must first understand the pervasiveness of petroleum; how its production, consumption, and physical and financial flows have shaped cities and rural landscapes such as the Rotterdam/Antwerp area; and how oil companies, governments, and citizens co-constructed an oil-based modern culture over the last 150 years. This project allows practitioners of the built environment and the general public to map how the petroleum revolution has driven architectural and urban design and how it has shaped both our behavior in and our perception of our cities. We seek to increase popular awareness as a foundation to develop new sustainable solutions.

It will give producers of green energy, architects, urban planners, policy makers, and citizens additional arguments for establishing a comprehensive approach to a sustainable energy world and for pooling the resources of the general public.

Delft University of Technology
prof. dr. ing. Carola Hein, dr.ir. Alexander Koutaminis

Eindhoven University of Technology
prof. dr. Bernard Colenbrander