

imagine 09
PROTOTYPING
efnMOBILE



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imagine 09 – PROTOTYPING efnMOBILE

Delft University of Technology, Faculty of Architecture,
Chair of Design of Construction

imagine 09

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FOREWORD

Strange as it may sound, building something is an experience that many architects and designers need to do. This is not just having a design realised, but actually using your hands, using tools, using skills to actually produce something yourself or better yet: with others. It is the act of making. There is nothing like the special joy of crafting something oneself.

This edition of Imagine is about a mobile workshop concept, which is and has been travelling across Europe. It links several universities that are members of the European Facade Network, which is developing a close-knit cadre of facade designers and specialists. What is interesting is to see how this workshop is fostering this network by serving as a platform to test concepts through the realisation of 1:1 mockups. Of course, none of the concepts are perfect or even properly functional, but it is the experience and the knowledge gained that are the real products – and once in a while good ideas do come out of it and voila: facade innovation is literally at hand!

The efnMobile platform has been made possible by the Alcoa Foundation, which sponsored the equipment and tour for three years – we are grateful for their support. The real lifeblood of the endeavour has been the enthusiasm of the docents who have travelled around Europe establishing links between technology, education and environmental impact. It has also been made possible through two professors, Uta Pottgiesser and Ulrich Knaack, who have consistently pushed the program's development. Enjoy this edition of Imagine – the ninth in the series and one chronicling the great story of thinking but also making the facades of the future!

Prof. Peter Russell
Dean of the Faculty of Architecture and the Built Environment, TU Delft



1. BACKGROUND AND CONTEXT

1.1. ABOUT EUROPEAN FACADE NETWORK (EFN)

Facade technology is the leading discipline within the building sector in terms of technological integration and technical complexity as well as in terms of its visibility. This leading role has its roots in the need for sustainability and energy-saving and in the design ambitions of architecture. Thus, the topic and the technology play a key role with regard to sustainable design.

At the same time, there is a lack of understanding of the technology, fabrication, design integration and “physical making of things” in the academic education of architects and engineers – with the consequence of misunderstanding and limited exploitation of the potentials for more sustainable results. Experience in research and education shows that this can be solved by “making of” experiences and 1:1 workshops – to inspire and educate young architects, engineers and designers.

Against this background, the European Facade Network (EFN) – a non-governmental association of the Universities of Bath (UK), Delft (Netherlands) Detmold (Germany), Lucerne (Switzerland) and San Sebastian (Spain) – is executing MSc programs in the field of facade design and construction and facade engineering. These educational programs are inter-linked to the research activities within the network and the participating universities, companies and industries.

EFN is supported by the Dutch Vereniging Metalen Ramen en Gevelbranche (VMRG) and the Swiss Centre for Windows and Facades

(Schweizerische Zentrale Fenster und Fassaden, SZFF), as well as by the Federation of the European Window and Curtain Wall Manufacturers' Association (FAECF). In addition, all members and students are invited to participate in the Society of Facade Engineering (SFE) and the digital platform of the European Facade Network (facades.ning.com).

There is also an international peer reviewed scientific journal, the *Journal of Facade Design and Engineering*. Supported by the Netherlands Organization for Scientific Research (NWO), it has had published five volumes so far.

To expand student networking and develop a professional network for the new generation of architects, designers and engineers the European Facade Network (EFN) established annual series of rotating international conferences in Delft/Bath (“The Future Envelope”: summer event) and Detmold/Lucerne (“facadeXX”: winter event). Around these conferences, educational workshops and courses are organized and embedded in the individual curricula of the Master programs.

Our task is to educate, build a network and boost future development by research in the field of the building envelope – to provide sustainable thinking, aesthetic potential and sustainable/innovative technology within and for the new generation. The focus lies on global activities to reduce carbon emissions and achieve green building standards, which – for the building envelope – translates

into energy efficiency in terms of performance energy and construction energy (embodied energy).

Also, the building envelope is seen as the interface to the interior and thus strongly affects the working and living space of people. The redesign and adaptation of existing interior environments is a key activity of the building sector in Europe. The physical interior environment directly contributes to well-being, health and productivity. Interventions should therefore be designed with regard to the needs of the users, combining aspects of layout, lighting and acoustics, ergonomics and materiality. The proposed activities and mock-ups are seen as a human-centered design approach, taking into account the perception and acceptance of the user. This approach is seen as a key factor in any improvement, which distinguishes these activities from primarily technology driven research.

According to its 2015 Memorandum of Understanding, the EFN seeks to advance and promote facade design and engineering at a European level and beyond. This is achieved through inclusive collaborative working between its members and alumni, resulting in skills and knowledge transfer/sharing in the following areas:

- **Conferences** and **workshops** rotated between EFN member institutions. The workshops are also intended for students.
 - **Publication** through the Journal of Facade Design and Engineering (JFDE) and related peer-reviewed international journals.
 - Industry driven experimental facade **testing**.
- Industry informed **research** on Masters, Doctoral and EU level.
 - Undergraduate and/or postgraduate facade design and engineering **education**.

1.2. ABOUT efnMOBILE

The European Facade Network seized the opportunity offered by the Alcoa Foundation to create a platform within the EFN for organized sustainable creative thinking.

efnMOBILE is a traveling platform to provide the network, its conferences and workshops as well as the facade industry and the architecture and engineering community with a regional platform for communication, exhibitions, innovative development and interaction. To support the interaction, efnMOBILE consists of a container unit, partially extended by a tent structure for workshop activities and exhibitions. efnMOBILE has been traveling along with the annual conferences of the European Facade Network and additional related events within Europe. Involving local Alcoa professionals, it acts as a European communication and technology exchange instrument. It provides a space to exhibit new technologies and research results as well as hands-on workshop events. efnMOBILE also has an “inter-Atlantic” component in presenting the results to the other participating educational institutions (and to the public) and discussing them. The program includes taking part in the requested knowledge-sharing and peer-to-peer learning events in partnership with the Alcoa Foundation.

During the initial phase, a container and foldable tent structure were assembled and exhibition equipment and some furniture were bought. Since then efnMOBILE has been traveling throughout Europe for a period of three years.

efnMOBILE has elaborated current facade topics at the annual EFN conferences: Detmold 2013, Bath 2014, Lucerne 2014, Detmold 2015, Delft 2015 and San Sebastian 2015.

In addition, efnMOBILE took part in two international trade shows for facades and glass: glasstec 2014 in Dusseldorf, Germany, and Gevel Totaal 2014 in Rotterdam, Netherlands.

There are plans to send efnMOBILE to selected cooperating universities in Barcelona, Copenhagen, Cambridge, Stuttgart, Munich, New York and Istanbul.

efnMOBILE follows an overall theme, focusing on new aesthetic, functional and technical potentials of the building envelope, namely to provide a human-centered function- and performance-based solution for facade technology: the “emerging envelope”.

This program concentrates on sustainable and integral solutions for the building envelope, focusing on materials as well as technologies in the spirit of placing the human being at the center of all considerations. The task is to inspire the upcoming generation of architects, designers and engineers to allow themselves to follow uncharted paths of development, to think outside the box, to build showcase examples, and to come up with ground-breaking solutions – for a better design in terms of climate, health and an overall building design approach. The concept is intended to foster the dialogue around sustainable design and development and to increase

awareness and actionable solutions for sustainable design.

Each event includes a one-week think-tank on location – to inspire and innovate – followed by a period dedicated to design development and engineering, concluding with a one-week workshop involving local Alcoa professionals and a final presentation with conference and exhibition. During each event, the participants build a 1:1 mock-up in different sizes of an emerging facade – expressing the design and innovative potentials. The final presentations at the trade fairs exhibit the results – for participants, interested designers and engineers as well as for society in general.

To reach this goal the project contributes with the following outcomes:

1. increased knowledge sharing between the various European research centers and between these centers and industry.
2. development of novel concepts and technologies and/or new combinations of existing technologies.
3. development of new knowledge such as effective evaluation tools/methods for adaptive facades.
4. start of new collaborations and research projects in the area of adaptive facade technologies.

1.3. efnMOBILE POWERED BY ALCOA FOUNDATION

KAWNEER – as part of the world's leading aluminum concern Alcoa – has always felt obliged to promote young people. Because they are the future of society and of our company! So it makes good sense to the Alcoa Foundation to support efnMOBILE with a six-digit figure and thus sponsor this activity, unparalleled in the building sector. In this case, this measure is not only owed to social engagement – like most of the foundation's projects – but rather to ensure the benefit of the European facade sector in several ways.

PROMOTION OF YOUNG PEOPLE

Firstly, young architects and engineers are drawn toward all facade related topics by the manifold opportunities that the local workshops at the different universities offer, and motivated to present their ideas and innovations in a practical manner in the form of a mock-up, built in a prefabricated frame and accompanied by descriptive posters.

THINK-TANK

Secondly, the studies and their makers who, within the scope of the workshop, are coached by experienced staff members of the university and KAWNEER, can be drawn upon to discuss the concepts, or even to elaborate them into the subject of a dual study/final exam or, ultimately, bring them to the market.

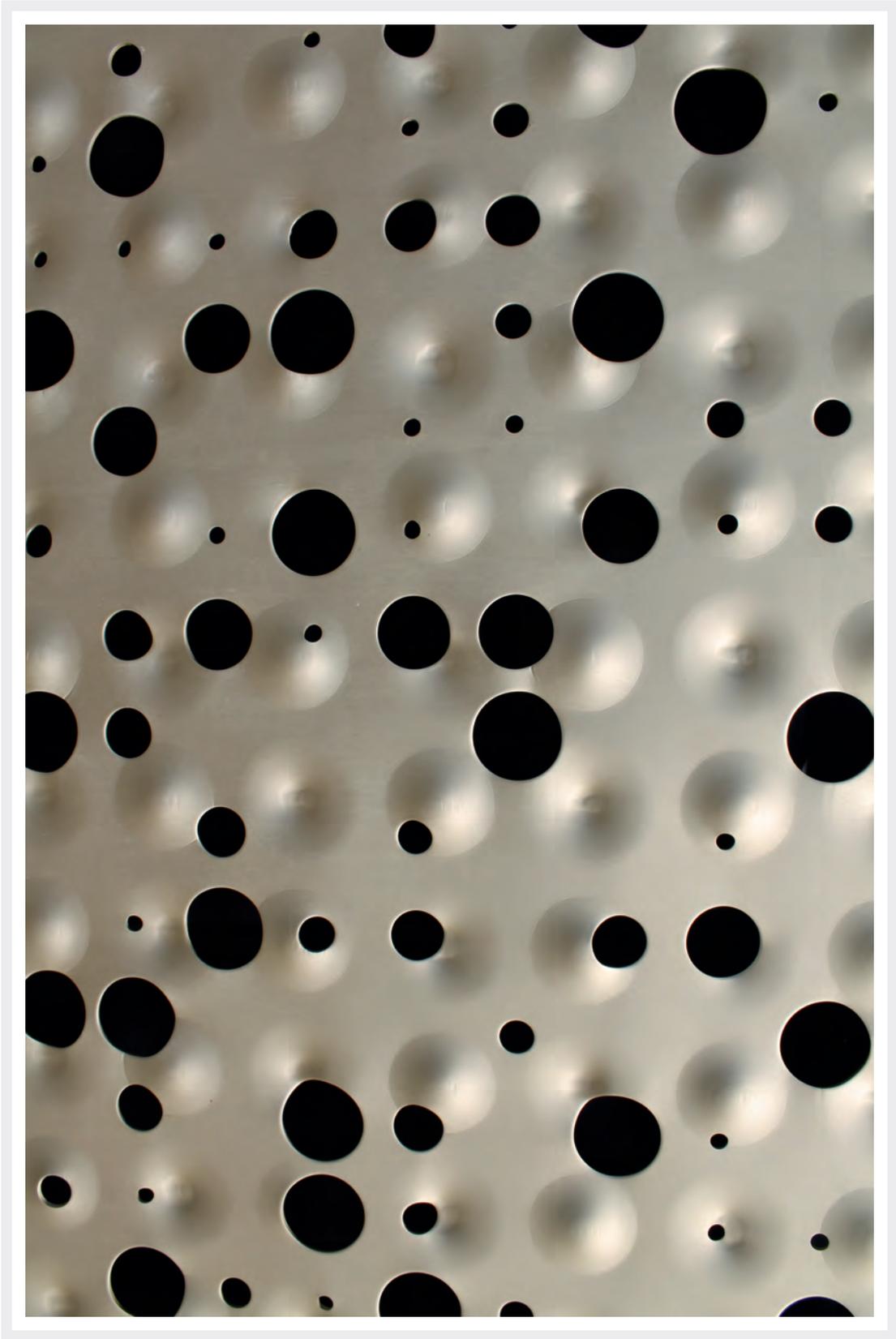
INTERNATIONAL FACADE MASTER

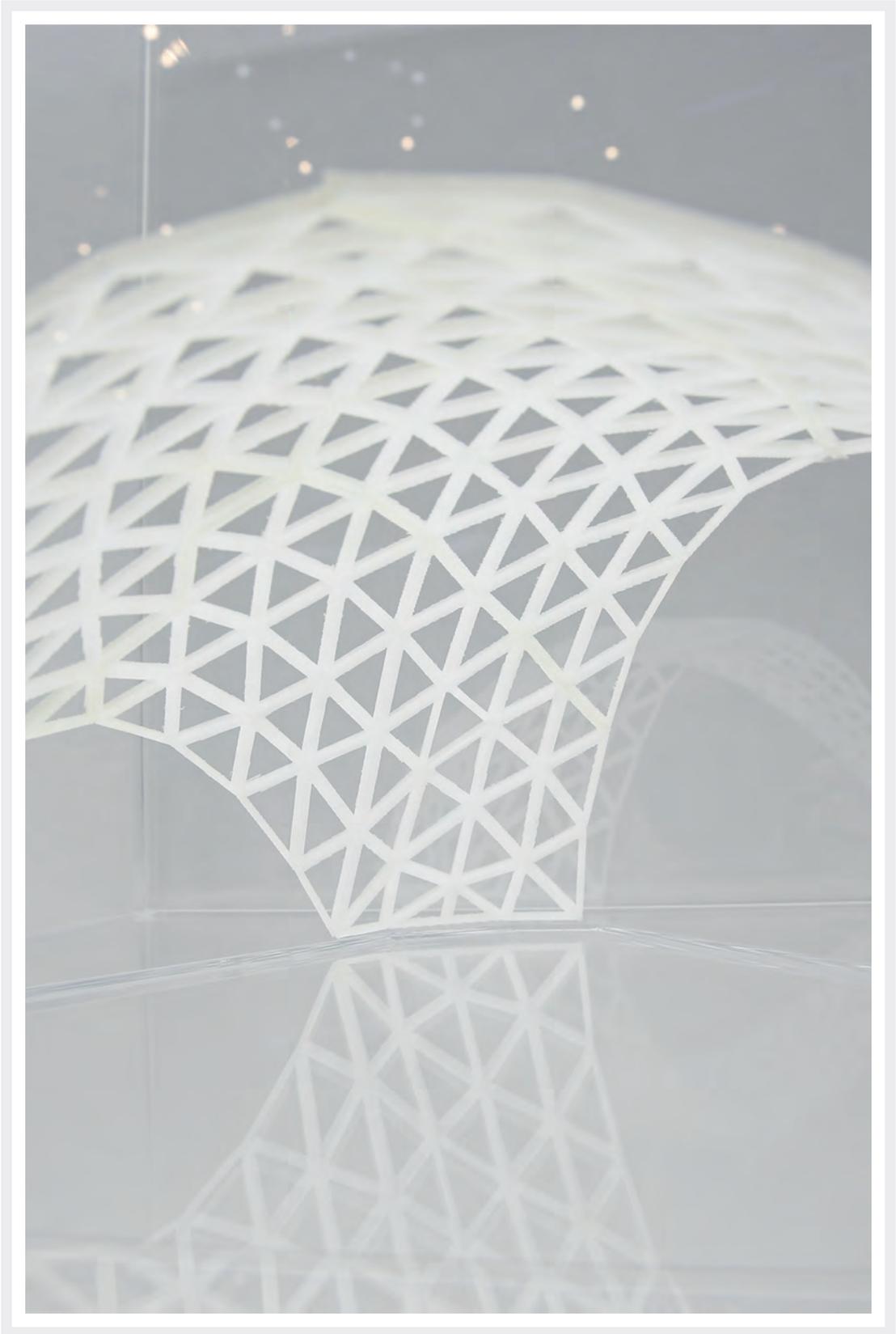
KAWNEER is an actively supporting member of the International Facade Master program at TU Delft, which is

part of the European Facade Master network. However, this project supported not only the Dutch Master program but also other participating universities – an aspect that fits well with the concept of networked collaboration – and not just by forming networks with companies or organizations for the benefit of harmonized European education, but also – and this is most important – by creating major networks amongst the students.

efnMOBILE

With its comprehensive technical equipment including an autarkic tent, the mobile workshop offers everything needed to carry out workshops at the participating universities as well as at market events such as trade fairs. Mock-ups can be built to test and evaluate new concepts on a 1:1 scale – with the aim of explaining the process as well as the results to students and to experienced designers and engineers from planning, manufacturing and industry.





2. ABOUT INNOVATION

ABOUT INNOVATION

*“CREATIVITY is thinking up new things.
INNOVATION is doing new things.”*

Theodore Levitt

McKeown (2008) defines innovation as “new stuff that is made useful” and differentiates between incremental, radical and revolutionary as well as between dependent and independent innovation. He also identifies the user as the one to define how useful an innovation is and sees adaptation as a key element. At the same time, the innovation activities of organizations are mainly influenced by rapid globalization, changing customer needs and shorter product life cycles. Taking this into consideration and to understand the different steps undertaken in the EFN workshops, it is important to take a closer look at the main types of innovation (fig. 1).

INCREMENTAL INNOVATION

Most approaches in product development are leading toward incremental innovation, which means that already existing solutions are improved within a given frame. We expect that the workshops will produce some of those improvements by mapping out existing and future technologies that can be deployed in future adaptive facades. This includes the development of experimental procedures and performance assessment metrics for measuring the dynamic performance of these new facades systems.

REVOLUTIONARY OR RADICAL INNOVATION

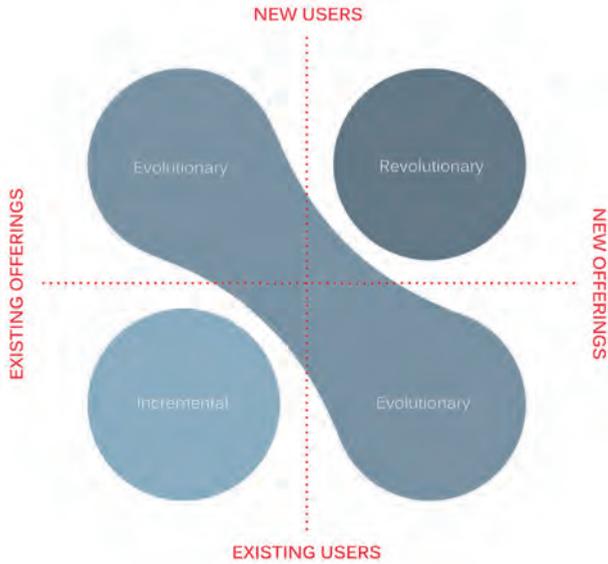
This innovation type is unexpected and often disruptive and new, and in general does not affect existing markets. To achieve such innovation, it is necessary that anyone responsible dealing with change within an organization must be inspired – and enabled to grow, deliver more and expand their horizons in tangible and sustainable ways. This means achieving a “change of frame” by modifying “the human-centered design process to require simultaneous development of multiple ideas and prototypes. By forcing the design team to simultaneously diverge into multiple directions ...” (Norman & Verganti 2014). We seek to deal with this potential in the context of the integration of components into the building envelope and related to the interaction of the user with the internal and external environment.

EVOLUTIONARY INNOVATION

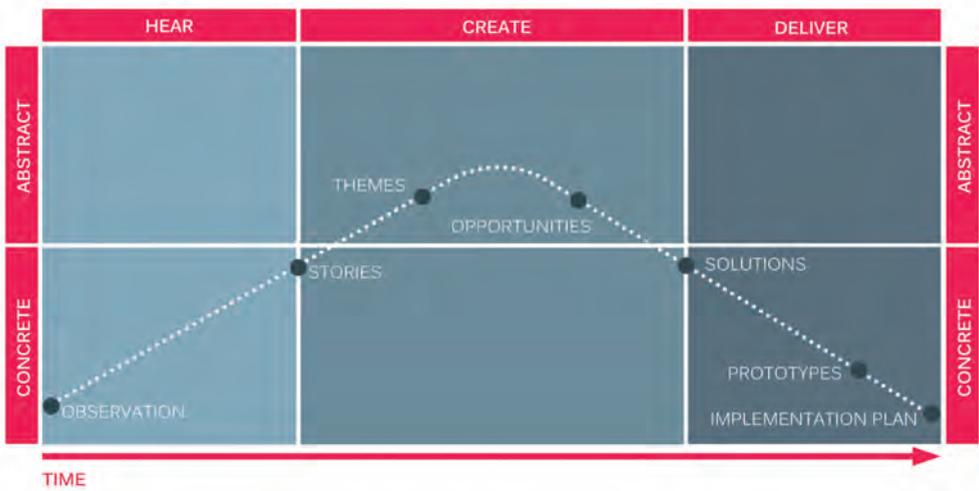
This expression was introduced by IDEO to interconnect the approaches of incremental and revolutionary innovation. Compared to those, evolutionary innovation means choosing to change only one of the configurations: existing users and new offerings, or new users and existing offerings.

The goals and systematics of innovation are widely discussed in the design community, which usually does not deal with the building sector but with traditional product and consumer industries (fig. 2). Kumar states that

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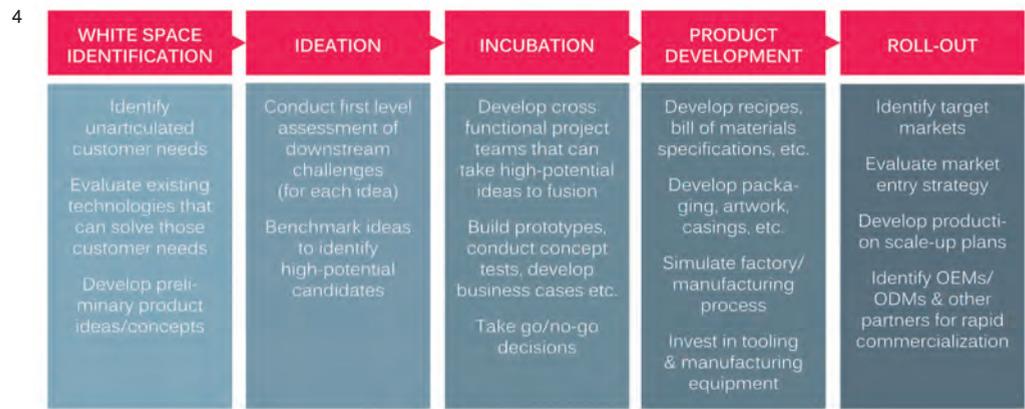


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1 Classification of incremental, evolutionary and revolutionary innovation according to the IDEO_ Toolkit for Human Centered Design

2 Innovation phases according to the IDEO_ Toolkit for Human Centered Design



3 Classification of the Ansoff Matrix (Product-Market-Matrix) to create and evaluate ideas in product development
 4 Key innovation phases according to Jain 2015

“innovation is a discipline, not a mystery” (Kumar 2012). Others argue that “the differences between incremental and radical innovation” are specified and it is considered that “human centered design methods are ... well suited for continuous incremental innovation but incapable of radical innovation” (Norman & Verganti 2014).

MARKET NEEDS

At the same time health and sustainability play an increasing role and represent a growing market within different societies, often referred to as LOHAS (Lifestyles of Health and Sustainability). The green building sector is supposed to be the second largest of those market segments. Nevertheless, the project orientated and iterative architectural design process still distinguishes the building sector from other industries and industrial product design processes. The growing global complexity of the markets and the increased importance of life cycle aspects will further foster a specific architectural product approach in industry and education (Klein 2013).

TECHNOLOGY AND USER

Next to aesthetic and functional aspects the further development of the construction technologies is a key aspect in the field of architecture (Knaack 2011). But technologies and systems must also be designed for end-user comfort and control in order to achieve long-term success in combination with a reduced environmental footprint in any project or product (Pottgiesser & Strauß 2013). This scope of different approaches is part of the educational and scientific activities and we identified the need to concentrate our activities towards the human being and global requirements. This means that next to technological-constructive aspects, meaning and function of the building envelope are the initial

aspects of all activity to improve the well-being of the user and society (Pottgiesser & Ashour 2013).

STRATEGIES

“Innovation is about people using new knowledge and understanding to experiment with new possibilities in order to implement new concepts that create new value.” Joyce Wycoff, Global Innovation Study Group

Innovation can be achieved by different strategies that discuss and result in the following questions and contents:

- how innovative does an organization want to be: type and grade of innovation;
- how does an organization distinguish itself from its competitors (quality or cost leadership);
- when does an organization want to start innovation: right time for R&D and market entry;
- to what extent does an organization use technology to realize innovation (technology leadership);
- to what extent does an organization use own and/or foreign resources for innovation activities. Innovation strategies are mostly divided into the following groups: market oriented, competition oriented, technology oriented, time oriented and cooperation oriented.

Market oriented strategies are generally divided into four alternatives that feature different levels of innovation. According to Ansoff (fig. 3) an organization can choose between market penetration, market development, product development and diversification. Market penetration and market development are aimed at skimming and extending markets where they are already represented. Product development and diversification also seek to extend the existing markets.

Competition oriented strategies define how an organization or parts of it want to compete with its competitors. In most cases it is about differentiation from the competitor or achieving relevant advantages over the relevant competitors by cost or quality leadership – often done by creating new or better products.

Technology oriented strategies deal with the technology position of an organization that it takes to the market. It also defines the technological fields in which it works and how much of its innovative activity is based on technology. In addition, the strategies decide which position an organization adopts compared to its competitors with regard to the applied technologies.

Time oriented strategies give an idea of all options an organization can choose when deciding the timing of research and development and also the timing of market entry. There is also the point in time by which R&D activities have to be finished or by which an innovation is launched on the market. A company can choose to act as a leader or as a follower in its research and development activities.

All strategic alternatives are very important for the success of innovations. They can also be combined. Further developments of these traditional innovation strategies are mass customization and open innovation processes such as crowdsourcing and also design thinking, business model innovation and collaborative innovation.

Cooperation oriented strategies focus on answering the question of whether innovation activities should be achieved alone or in cooperation with others (companies or institutions). Cooperation can have the advantage that

complementary competences and resources – which are necessary to start any innovation activity – can be obtained from other organizations and cooperation partners.

Jain (2015) and Hansen & Birkinshaw (2007) describe successful key processes in the innovation value chain (figs 4, 5). According to Kaplan (2012) many of these new strategies have been used by startups and then adopted by big companies to profit from new inputs such as:

- “Follow Customers Home” for finding and savoring customer surprises and unexpected insights;
- “Tap Outside Collaborators” is an option to invite “outsiders” to innovation sessions;
- “Stay Small” provides guidance to entrepreneurial teams;
- “Use The Best, Invent The Rest” to apply rapid experimentation by gathering “intrapreneurs” together from across the organization or by doing “expert acceleration sessions” of external experts with internal business teams.

Open source collaboration and innovation have been fostered in the new millennium by the power of the world wide web and digital communication and production technologies. “The networked medium of the internet lowers the technical barriers for distributed collaboration; however, there are many challenges for sustaining cooperative social enterprise towards product innovation across institutional boundaries,” according to Sawhney (2003) in his dissertation. This has been manifested in several writings, initiatives and networks such as “ThinkCycle”. This “MIT-wide initiative ... seeks to support Open Collaborative Design for sustainable solutions to challenges in the environment and underserved communities, with active

5

	IDEA GENERATION			CONVERSION		DIFFUSION
	IN-HOUSE	CROSS-POLLINATION	EXTERNAL	SELECTION	DEVELOPMENT	SPREAD
	Creation within a unit.	Collaboration across units.	Collaboration with parties outside the firm.	Screening and initial funding.	Movement from idea to first result.	Dissemination across the organization.
KEY QUESTIONS	Do people in our unit create good ideas on their own?	Do we create good ideas by working across the company?	Do we source enough good ideas from outside the firm?	Are we good at screening and funding new ideas?	Are we good at turning ideas into viable products, businesses, and best practices?	Are we good at diffusing developed ideas across the company?
KEY PERFORMANCE INDICATORS	Number of high-quality ideas generated within a unit.	Number of high-quality ideas generated across units.	Number of high-quality ideas generated from outside the firm.	Percentage of all ideas generated that end up being selected and funded.	Percentage of all ideas generated that end up being selected and funded.	Percentage of penetration in desired markets, channels, customer groups; number of months to full diffusion.

6



5 Key innovation phases according to Hansen and Birkinshaw 2007

6 Best practices cases for innovation initiatives according to Jain 2015

participation of universities and organizations worldwide.” In Open Source Architecture, Ratti (2015) sketches a new “networked, collaborative, inclusive model” for the architecture of tomorrow, describing a paradigm shift from the existing ego-centered authorship toward a “choral architect” who initiates and manages processes by orchestrating actions and interactions in the design network.

SUCCESS FACTORS

Cooper (1999) had already analyzed eight commonly-cited reasons for poor results in product innovation, related to the most relevant success factors that are noticeably absent from many typical new product development projects. He noticed that “teams and leaders seem to fall into the same traps that their predecessors did back in the 1970s” due to the fact that R&D productivity and success rates have not increased in the past. Govindarajan (2011) refers to nine critical success factors that need to be in good shape within an organization to innovate productively. And Jain (2015) identifies six best practices for organizations running innovation initiatives.

Cooper’s eight actionable critical success factors:

1. Solid up-front homework: to define the product and justify the project
2. Voice of the customer: a slave-like dedication to the market and customer inputs throughout the project
3. Product advantage: differentiated, unique benefits, superior value for the customer
4. Sharp, stable and early product definition: before development begins
5. A well-planned, adequately resourced and proficiently executed launch
6. Tough go/kill decision points or gates: funnels not tunnels

7. Accountable, dedicated, supported cross- functional teams with strong leaders
8. An international orientation – international teams, multi-country market research and global or “glocal” products.

Govindarajan’s nine critical success factors:

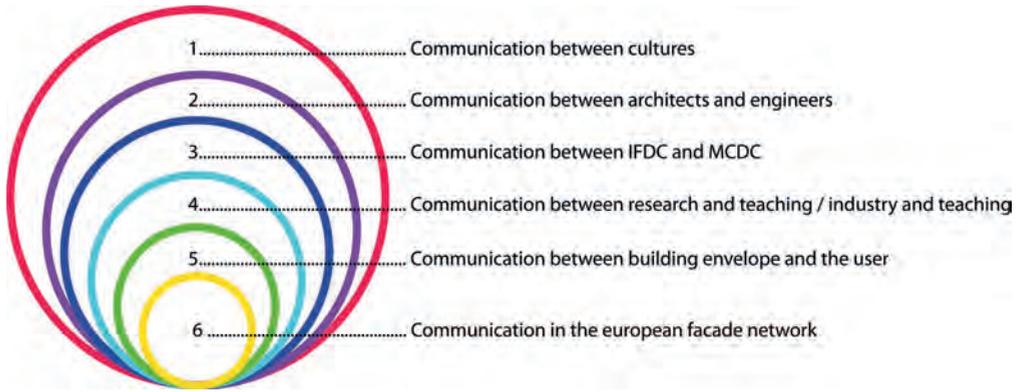
1. A compelling case for innovation
2. An inspiring, shared vision of the future
3. A fully aligned strategic innovation agenda
4. Visible senior management involvement
5. A decision-making model that fosters teamwork in support of passionate champions
6. A creatively resourced, multi-functional dedicated team
7. Open-minded exploration of the marketplace drivers of innovation
8. Willingness to take risk and see value in absurdity
9. A well-defined yet flexible execution process.

Jain’s six best practices for innovation initiatives (fig. 5):

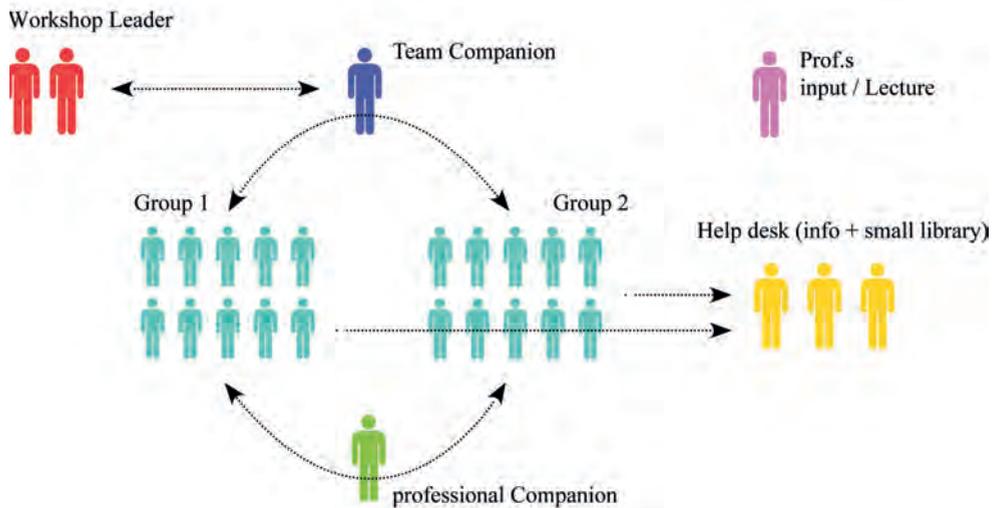
1. Setting up dedicated and cross-functional innovation teams
2. Creating innovation portals
3. Building innovation networks and global R&D presence
4. Digitizing the new product development (NPD) value chain
5. Assessment of effectiveness of innovation programs
6. Development of organizational culture to support innovation.

Consequently, to run successful innovation programs, the focus of companies should be threefold according to Kaplan (2015):

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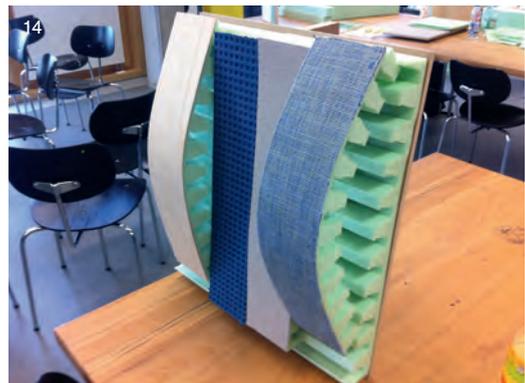


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7 Communication levels for innovation processes according to Ashour and Pottgiesser 2015

8 Pedagogical concept to foster communication in interdisciplinary teams (KOM, HS OWL)



- 9 Inside-Outside: workshop 2006 at HS OWL in Detmold
- 10 Grapevine: combining cut zip-shape form with other material
- 11 Hängmock: test cuts for optimizing the pattern geometry
- 12 Grapevine: detail of final zip-shaped wine shelves
- 13 Zipwall: increasing the size of the zip-shaped parts
- 14 Zipwall: prototype with different materials and surfaces

- Leverage innovation networks of internal and external partners to increase the influx of ideas and ready to use solutions to business problems
- Ensure visibility across the entire innovation value chain and set up processes to track the success of innovation initiatives so that innovation project managers can anticipate downstream challenges and make informed calls on go no-go decisions
- Understand that the reward systems for teams working on disruptive ideas are different from those that are followed by the rest of the company.

Organizations must work to create a collaborative startup-like environment so that innovation teams can collaborate across functions to drive new ideas to fruition. One reason why that innovation metric gap exists is that there is no set formula for what fuels innovation in the areas of leadership, employees and customers.

Based on these findings, the EFN workshops used elements and success factors from those new strategies to sensitize and instruct the students on the subject of collaborative and interdisciplinary design processes for future products. They also made us reform the educational process in facade design, development and engineering as well as foster cooperation with other related programs. The following six levels of communication (fig. 7) were implemented and vary from cultural and personal communication to professional and technical communication as mandatory elements in the curriculum of the master program and became crucial for the work program of the EFN workshops:

Communication

1. between cultures
2. between architects and engineers

3. between the master courses IFDC and M-CDC
4. between teaching, research and industry
5. between the user and the building
6. within the European Facade Network.

In order to guarantee that the students work in harmony and are productive during the tight time schedule of three- to five-day workshops, a pedagogical concept has been adapted in the last workshops to foster communication within the groups (fig. 8). Professionals in product design development and presentations by technical experts are usually invited to help the students to develop and communicate their ideas. The focus is on how to develop a conceptual idea for a product and what to present (and what not to present) to the audience. Besides this, presentation templates for posters, slides and physical models are provided to the students to support them in communicating their ideas and results.

WORKSHOP CONCEPTS

All workshops are based on the philosophy that interdisciplinary and intercultural collaboration will produce added value to idea generation and concept development due to the very different backgrounds of the participants: students, professionals and scholars. The first part of input and idea generation is often modified but linked to the same principle of open communication. Following this process and based on pre-defined criteria the ideas are evaluated, categorized and selected according to their market potential and technological aspects. Always important is the visualization and proof of concept by model-making and prototyping. This step puts the students as well as the professionals in the position to carry out a differentiated assessment.



3. BUILDING WITH STUDENTS

BUILDING WITH STUDENTS

Education in architecture and engineering should convey a relatively concrete understanding of building, of creating built projects – since this is what building is about: to create houses, infrastructure, components – and the materials from which they are created. Obviously, the education must include fundamental knowledge of the societal, historical and cultural contexts as well as experience in the field of design and organization of projects, functions and processes. It must convey a knowledge of mathematical, physical and technical mechanisms as well as of the resources, materials and energy sources available. And it requires an understanding of integrating the field of study into the societal context – and of the responsibility involved. But ultimately it is all about creating buildings – from concrete material and real technology – for a particular function and for people.

And this is exactly where the topic of this book, as well as earlier work on “building with students”, comes in: the objective of this key area of training is to provide future creators of buildings with the experience of HOW something is done. Not as a theoretical exercise but rather concrete, practice-oriented and focused on the skills involved. This hands-on approach must be understood as an educational concept that enables the student to translate theoretically developed knowledge and results into practical results. Our own experience shows that theoretically developed solutions – whether the design of a building or building part along technically

or functionally impossible lines or an engineering task transferred from one situation to another – that merely rely on known engineering methods can have disastrous results. Experience is needed to avoid this – i.e. practical experience. Sketching such a process highlights its value:

In the beginning, our students are usually inexperienced in handling traditional craftsmanly techniques and concrete technology – a circumstance that can be seen as an advantage since it offers the potential of addressing issues in an unbiased manner – but more about this later. This unbiased group of students is guided toward a task that defines the topic and the general orientation, to then be restricted by a stringent timeline and financial limitations. Such boundaries are useful since on the one hand they exclude excessively elaborate solutions and suchlike unattainable by the students themselves. On the other hand, such boundaries are helpful for the motivation of the students because it requires special effort and creativity to identify alternatives that make the impossible possible. The subsequent process of functional and technical development also depends on the dynamics within the group: usually, a leader personality as well as good team players establish themselves at a very early stage. Disruptive influences and sensitivities quickly become known as well. The advisor needs to intervene to prevent unrecognizable faults as well as to keep the group contextually active and not let it be encumbered by dynamic group processes.

This process of developing the object is followed by a concretization process – the preparation for building. Here, the focus lies on linking the invented function, the intended technologies and time and money, and preparing for the building process itself. Logically, this entails the first conflicts of objectives and frictions in the result. But it is these first experiences that form the most important teaching success for the group: things don't always go together, they fail to fit or are simply too expensive. Thus, intervention is needed, replacement, modification and adaptation. Beloved solutions become impossible and must be replaced; alternatives that first seemed unacceptable turn into good compromises. The advisor must help the group to help itself. Questions must be asked in such a way that the group identifies the true problem and its solutions – without it being obvious that the advisor already knows them or even directs the group toward them. The group must be directed in a way that it can always assume it makes the decisions itself. It is particularly important for the overall success of the project that a contextual and emotional bond is established with the project and the group during these early stages, important in order to be able to survive truly critical phases well and in unison. You must love your baby, even if you have to change its diapers.

A truly good advisor is one who can indoctrinate groups that drift aimlessly during this phase and present an opportunity for concrete results that

allows fragments to be translated into new ideas and then into realization. The trick is to have available a portfolio of possible but not yet expressed solutions as well as the capability to guide the group by means of questions and suggestions so that it arrives at one of the solutions itself. This can be an exciting process!

Subsequently, the project must be further developed so that materials can be procured and the building process becomes possible. For the latter it makes sense to think it through in detail – with the result that new topics can arise that might question what has been planned beforehand. For the procurement of materials, be it through purchasing or sponsoring models, it is necessary to guarantee timely delivery. Nothing is more frustrating for a group than to begin highly motivated, only to be slowed down later. Thus, logistics are an important aspect to address and possibly assign to individual students – a job that seems none too attractive at first but which is extremely important for the process and requires organizational talent, and thus relates to the core qualities of someone working in the building industry.

And now, building! High motivation at first, followed by the first problem issues. Direct solutions enable direct progress but usually bring the risk of making subsequent steps in the process or structural components more difficult. This requires the role of a problem-solver with foresightedness; a function typically taken



- 1 Exhibition pavilion of RTWH Aachen – student building project with a self-load-bearing glass structure
- 2 Library, Faculty of Architecture, RWTH Aachen: student building project with self-load-bearing glass facade
- 3 Students of the glass pavilion building project, RWTH Aachen

on by the advisor who – hopefully – has sufficient experience and foresight to predict the consequential process and tread alternative paths. Of course, certain qualities are eliminated in situations like these: perfection of detail is lost, touch-ups are required and many a design criterion must later be covered up with strips, foils or other means; however, these are necessary compromises that contribute to the teaching success of the project and represent the experiences to be had.

Bad advisors are those who are not present during this phase. This leads to frustration in the group, possibly resulting in unsolvable conflicts, and lack of experience can lead to decisions being taken that might later put the success of the overall project at risk. Projects are most likely to have good results if the advisor integrates him/herself, guides toward self-help – and takes responsibility in the event of problems.

Another significant aspect is the construction time: it should not be too long, must be logistically well prepared and include sufficient buffer to compensate setbacks. It is difficult to rekindle projects that are begun but then come to a standstill for a longer period – the group is scattered, motivation has gone to other topics and the project might already be outdated. Thus, the duration should be realistically estimated, with milestones built in to be able to evaluate the progress and to celebrate intermediate success – with the goal of keeping up motivation and the hope of a good finale. And during the last 15% of the project a good advisor is needed again, one who will take it upon him/herself to resolve unpleasant issues if things fail.

Finally: done! The last nail is in, the scaffolding dismantled and the first pictures are posted in social media. The entire group is proud, emotions are positive and people are congratulating each other. A good result. But now, during this last phase of the project, the completed object must not be lost from sight. Cleaning up, final modifications as well as removing traces of the building process are all unpleasant tasks, requiring a last mutual effort, but the work is worth it because the resulting images are those that will survive on hard drives or in digital media and will create the image of the final result.

To round things off, the results should be presented in the proper documentation: websites, booklets and papers are appropriate tools, since all participants enjoy presenting their work. This is the correct process, which must have been prepared during planning but is primarily done upon completion of the project. Experience shows that every single participant should be named, and that images are very important – not as many as possible but a few really good ones. As for textual documentation, the project should be described and explained briefly and to the point, avoiding too many details – the better this is done, the more broadly the results will be distributed.

An interesting addition might be to evaluate the development and building processes; this is rarely done, however. Logically, since the object is complete and everyone is feeling proud. But still, this step offers great potential for more in-depth teaching success. After the fact is the time to recognize less critical topics that influenced the project during the early stages. Questions raised during the building process will become part of the experience gained, and critical moments

in the project are valuable milestones will influence future projects, be they experimental or realistic. Reflecting on the experiences of the building group as well as of the interaction with external factors and players similarly expands the view of the whole.

It is interesting that the above-mentioned inexperience of the students paired with a skilled and motivated advisor offer potential for good projects – and even more interestingly, for true innovation. This is mainly due to the fact that students who don't know certain things don't consider them to be problems either, and can thus come up with solutions that someone with vast experience might view critically and therefore neglect – even if these might have great potential. “This is how we've always done it” and “there is no other way” are phrases that destroy any innovation. It is not without reason that large companies tend to install task forces with uninvolved participants to loosen up gridlocked processes. Student projects can work in the same manner: courage, audacity and a dose of ignorance in combination with technical competence for truly critical issues and sufficient motivation are criteria for creating the really new and surprising.

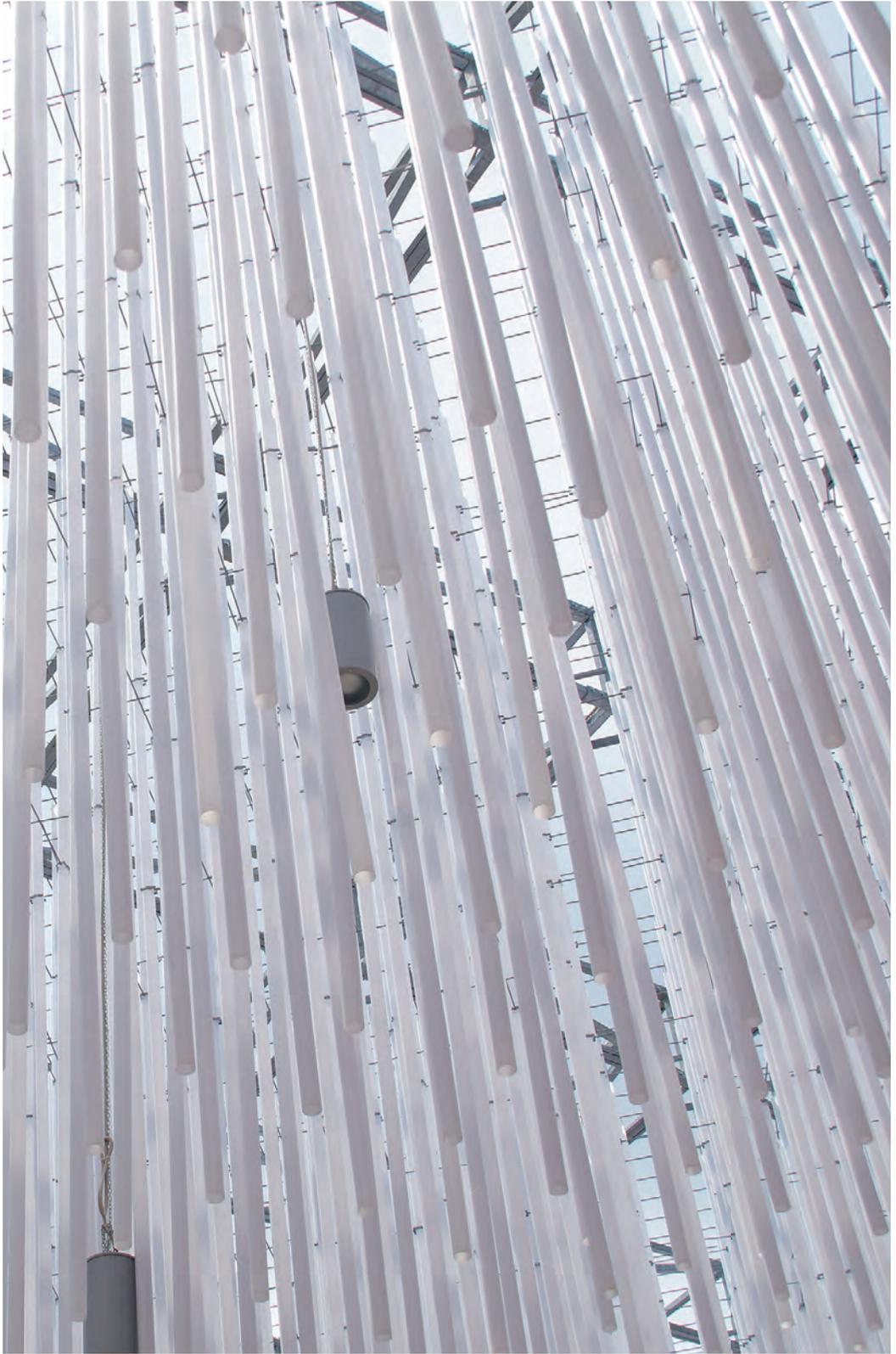
Against the background of the above-mentioned approach, the efnMOBILE project developed a mobile workshop that visits students at different locations to accompany them on various building projects and connect theoretical knowledge with practical realization. The technical facilities primarily consist of traditional craftsmanly tools for DIY projects as well as transportation logistics and a sufficiently large tent to be able to build at any location in any weather. One of the goals of the program was to facilitate the interaction between students

at different locations, to develop an international network in facade technology as a field of study – since personal relationships following a collaborative building project are closer than after visiting a seminar together. In order to promote this even further, one of the prerequisites of the workshops was that students from different locations intermingle in the mobile seminars, thus growing into international and sometimes interdisciplinary groups – the result being a wide-ranging social network.

The individual projects are undoubtedly carried by the students. However, the entire program is only possible with an enthusiastic and involved advisor. Without advisors who get intensively involved in the preparation, logistics and organization, who personally contribute to the building process, who solve problems and conflicts, and who don't hesitate to grab a broom and clean up themselves, projects such as the efnMOBILE or similar could never be realized. So a special thanks to these people!



- 4 Jackbox, at HS OWL in Detmold – student project made of thermally activated composite concrete panels, realized as an exhibition pavilion
- 5 Concretable project at HS OWL linked to a student seminar around the topic of experimental concrete constructions
- 6 Bridge construction at TU Delft with the aim of researching vacuum-supported building parts and their potentials and risks
- 7 Stylos pavilion – student seminar and exhibition building with green facade
- 8 Bucky Lab at TU Delft, prototype of the mobile building laboratory for student seminars – project for a beach pavilion, Terschelling



4. DRIVERS

DRIVERS

What drives us to advance developments?
What are the topics that give impulses,
why do we choose certain directions?

When discussing drivers for development, various topic areas make an appearance. On one hand, we develop from our own personal knowledge and environmental context. On the other, we are rooted in general trends and lean on known technologies. If we want to break open this process, we need an orientation with regard to the direction in which a development should be aimed. And it is this aspect that this chapter addresses: What are the topics that inspired us in the development of the efnMOBILE program – what are the future challenges that we want (or rather need) to fulfill?

The workshops of this program are contextually oriented to topics that are relevant today in societal and technological terms and issues in the building sector. In other words, they lean on research work in the field of building envelopes, whose topics allow us to address current issues. Innovative approaches to solutions are to be developed within the scope of the workshops, based on these questions. Thus, formulating the topics can be understood as the driver for the workshops.

Three topic areas were identified for the program:

Adaptation – the possibility of maximum adaptation to a maximally changeable environment. This is a particularly exciting approach when seen against the

background of the topics Smart Data and Big Data, since the energy and media flow in the building envelope can be utilized to optimize performance by means of networking, information retrieval and information exchange – which in turn can result in great potential without further constructive measures.

Considering technological development as well as the performance of energy systems and energy gains, it is sensible to discuss material-bound energy – the so-called embedded energy – in a next step.

The third topic, actually an introduction to the other two since it precedes them in the workshops as well as in the overall context, deals with the performance of the building envelope. Besides common issues such as structural safety (load-bearing capacity, load-bearing system, fire protection) and serviceability (waterproofing, insulation properties, etc.) we deal here with complementary parameters such as changeability in the sense of, for example, light and air permeability or optical properties related to controlling visual relationships. And issues such as energetic activation, for example collecting and disposing of solar energy or cold, can also be considered part of this field. Yet another point of consideration could be the potential of decentralized storage systems in the building envelope, firstly to avoid transportation and secondly to enable faster response times – and therewith creating a synergy between energy gain, storage and distribution.

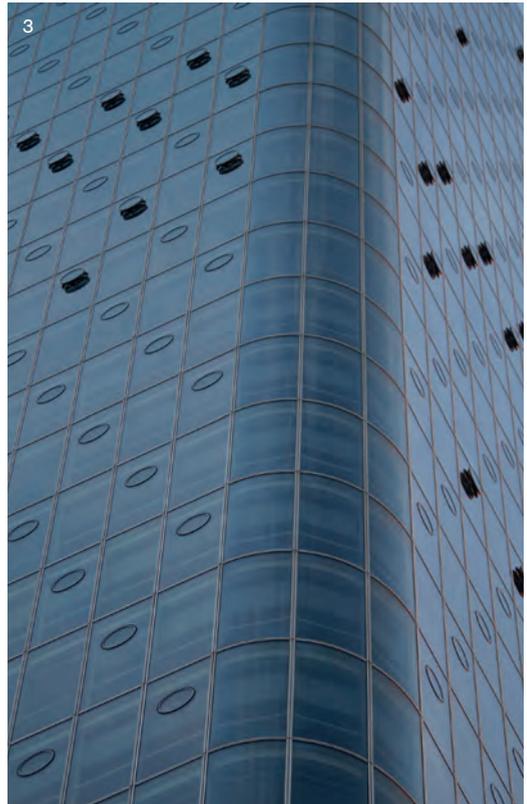
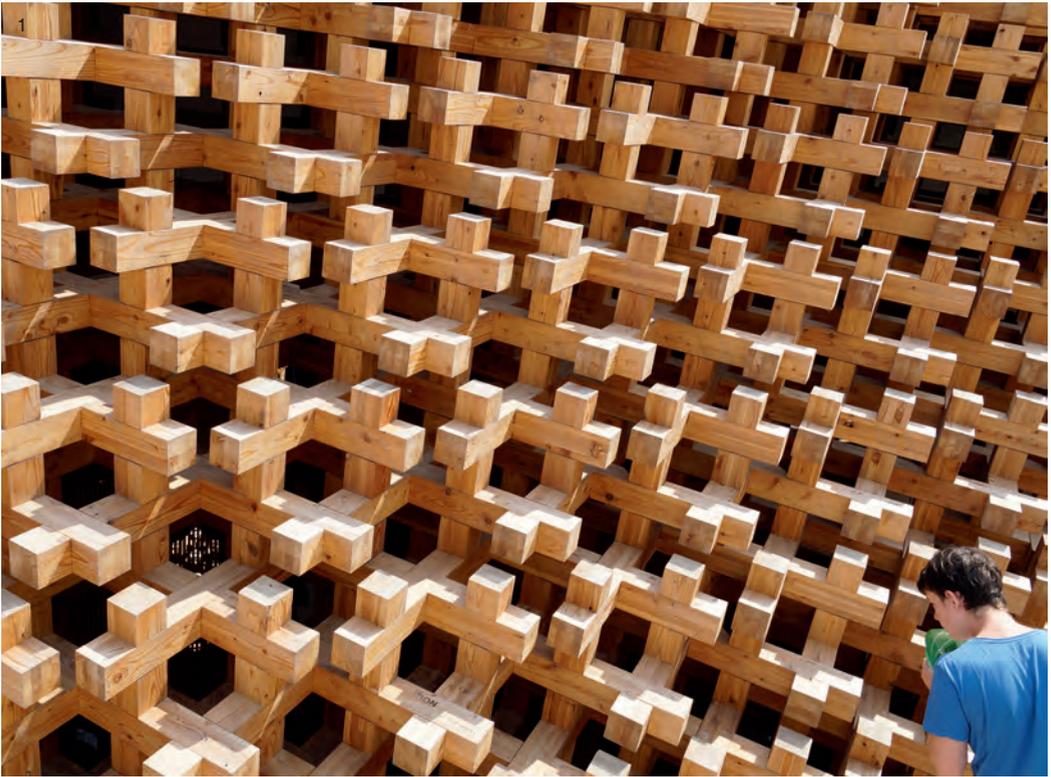
Back to the topic of adaptation, a term we mostly know from biology. It means the capability of a living being to adapt to changing living conditions and circumstances. In nature, this capability is essential for survival. Today, we assume that adaptability as a strategy can be transferred to facade construction, and can contribute to powerful solutions.

The building envelope mediates between the interior and exterior space of the building. In this role, it is confronted with the environmental influences of the surroundings as well as with various requirements of the use of the interior space. It also has to fulfill far-reaching building functions, from defining the outer appearance and aesthetics to structural integrity and building physics to usage aspects such as enabling various degrees of opening and visual relationships. Today, the facade also takes on ever more comprehensive building service tasks. Its impact in terms of energy consumption and interior comfort is accordingly high. We currently subject these aspects to severe and ever more stringent requirements.

The environment that a building is subjected to very dynamically changes. These additionally take place in different time increments, for example, short-term changes such as between different weather conditions or between day and night. But there are also long-term changes such those as caused by the different influences in the transitions from season to season or in the course

of climatic change. And the needs in the interior space can change during the operating time of a building, for example due to a change in the type of use. Thus, while fulfilling its tasks, the building envelope is faced with constantly changing requirements. During planning, the actual conditions that a building is subjected to over the course of its use are very difficult to anticipate. So the building envelope itself must efficiently balance such changes to guarantee an unvaryingly high level of comfort in the interior. The better it fulfills this task, the more energy can be saved in the area of building services, for example for heating or cooling the building.

In this respect, adaptability has great potential for facade constructions. For a long time, the building envelope was understood as a sort of barrier with which to protect the interior space from exterior influences. The concept of adaptive facades opposes this attitude: armed with changeable construction properties, the facade should take on a mediating role by no longer sealing off the interior but rather exploiting exterior conditions as much as possible for interior comfort. Its adaptability will increase the performance of the building envelope in terms of ensuring high indoor comfort levels with the lowest possible energy consumption. Dynamic adjustment of the facade construction to the prevailing environmental conditions and requirements can be seen as optimizing the building in its operating phase.



- 1 Wood – sustainable construction material
- 2 Green facades – nature in urban environments
- 3 Performance – Integrated facade

Facade construction is not necessarily bound to certain structural types; partially or entirely movable transformation into a kinetic construction is indeed possible. Responses by the building can be transformed through the mechanical movability of the construction. Currently, the topic of the “adaptive building envelope” is discussed in particular against the background of the possible automation of such responses. Over the past decades, computer technology has developed at lightning speed. It allows for self-regulating adaptation of the facade based on digitally managed information. In this context, automation comprises three essential aspects. One is collecting relevant data with sensors. Next there is digital control to process this information. And lastly, there is the output, an impulse generator through which the responses of the building envelope are triggered.

Exciting technical components are already available, for example, in the field of sensor technology: many of the climatic outdoor influences can be recorded as data. It is only due to sensor technology that automation is possible at all, since it records the current state of the environment in the form of an input value. Due to the vast number of different influences, the bandwidth of available sensors is very broad. For example, there are sensors to measure light intensity, temperature, humidity, CO₂ content and acoustic levels. These are complemented by a wide spectrum of actuators, technical components that use motors or impulses to trigger the transformation of adaptation responses. Between the collection of information by sensors and the corresponding output with actuators there is a digital control, with which we can monitor the behavior of adaptation. In this context information technology plays such an important role, not least due to the fact

that it enables the internetworking of different responses and their digital processing, in addition to mere control. In current building projects, individual functions of the building envelope are often solved with automated adaptive building parts. Against the background of possible internetworking, the collective responses of the facade as a balanced overall system are particularly promising for future constructions.

Currently, many new technologies are being researched that will expand the spectrum of possibilities in the field of adaptive building envelopes in the future. Armed with the slogan “the internet of things”, the digital interconnectedness of our environment is driven forward. Parallel to this, the machines of a production line are attuned to one another in “Industry 4.0”. The developments and strategies can gradually be applied to the building sector as well, for example to regulate adaptive facades. In the field of building materials, the current hot topic is “Smart Materials”. These can automatically react to changes using predefined material properties. “Biomimicry” means the transfer of strategies from nature to man-made products and constructions. This is another field of research that produces exciting new technologies that can be applied to adaptive building envelopes.

An increase in future adaptive facade constructions can be derived from the need for high-performance solutions, based in automation technology available today. In the current developments, the facade increasingly steps out of its former passive role into that of actively balancing the indoor and outdoor conditions of a building. When planning building envelopes, however, this also presents us with new challenges. We need new specialized knowledge in various areas

that none of the traditional disciplines cover. Knowledge in the fields of information technology, electrical engineering and mechatronics is gaining in importance. In addition to planning moveable parts, the conception of adaptive building envelopes must also consider behavior and response. Automation itself primarily affects the usage phase of a building. This results in new responsibilities for architects and specialized planners, who until now see themselves responsible for their spectrum of services which end when the building is handed over to the client. Increasing automation with regard to adaptive building envelopes is creating new tasks in conceptualization and maintenance of the behavior during the operating phase of a building.

One of the driving topics of the efnMOBILE program, a topic particularly bound up with the above-mentioned challenges, is “adaptability”. During the workshop series the students in their role as future specialized planners are to be sensitized to this topic and given an understanding of the processes of automation. The program is also to elaborate innovative concepts for the sensible and effective use of automation technology in building envelopes. It is concepts like these that the efnMOBILE workshops on “adaptive building envelopes” seek to develop.

We began by asking the question of what drives us. So, what does drive people? What do they aim for? And for what purpose?

One answer to these questions could be that people want to be healthier, more comfortable and richer; in short, they strive for an allegedly better life. Unfortunately, it's in the nature of things

that these goals don't come true by themselves. Quite the reverse: we battle bodily decay with fitness, creams and surgery, as more and more technology allows for a comfortable life, all requiring expensive devices and elaborate constructions. Societal prestige is reflected in status symbols; our position in society must be maintained or elevated, even though we are facing permanent decline in monetary value, namely inflation. But... people can do anything! With much effort and large measure of energy, resources and inventiveness (genius) we think we can attain a ‘better life’.

Let us now transfer this thought from the philosophical to a concrete level. In thermodynamics disorder is described as a continuous entropy; we can also call this disorder disintegration. Entropy leads to the fact that all things are permanently allocated to a ranking of lower order. Only the use of energy, resources or genius enables us to keep these things on the same level of order, or to even elevate them to a higher order. Our topic, the facade, is a good example: upon completion, fully assembled, it is of its highest quality, it is therefore in a state of the highest possible order. Usage, contamination and wear transfer the facade to a lower order over time. Only explicit effort – the use of energy, resources and genius, for example to clean, maintain or repair the facade – can keep it at its original level of order.

A “better life” can therefore be equated with the ranking of higher order. A higher order or the “better life” is made possible over time because continuous innovation allows for ever higher ranks of order: more comfort, a longer life, more money, or a more innovative facade. As mentioned before, energy, resources and creativity are

needed to reach a higher order or merely to counteract entropy.

Human beings, all of us, have developed a powerful drive for a higher order over the past 200 years. And we have used a lot of resources and energy to do this. Now, some of the natural occurrences of our most important resources are almost depleted. These were refined with much energy, modified according to our use and thus transferred to a higher order.

The fact is, these materials of a higher order are still available – even if, following long entropy or other influences such as end of use, they can no longer be used. Shouldn't the consequence of the amount of effort put into these materials be to maintain the materials in the same ranking of order, to reuse or continue to use them, ideally with minimal additional energy and resource effort?

The two workshops, “The Emerging Envelope” in Bath and “High Architecture – Low Carbon” in San Sebastian, were dedicated to this topic.

They dealt with questions about the energetic effort and use of resources for facades, and the possibility of maintaining these energetically valuable materials. To this end, ideas were developed about handling high-energy building materials and their alternatives. In this respect it is decisive to search for local materials with little transportation requirements for the future facade, as well as handling the existing facade in a resource-friendly manner as well as developing an awareness of high-energy processes and materials.

So, on the one hand it is about using valuable building materials in facades intelligently and on the other it is an important task for the future to recover

and reuse them. This means applying new constructions, wall compositions and joining techniques. We should strive for the unmixed disassembly of facades, as well as for system structures that either allow further use of building parts one-to-one or feed them back quickly and sensibly into a cycle without them leaving the ranking of higher order.

Now, please combine the concept of alternative and sustainable materials such as clay, wood, aluminum and straw with the concept of unmixed demountable joining techniques such as hinging, clamping, knotting and screwing. Well, what does your sustainable facade of the future look like?

Our two workshops therefore began life under the slogan “Waste is a lack of fantasy”!



5. WORKSHOPS

INTRODUCTION

Mobile workshops form the core of efnMOBILE. Traditionally, workshops are bound to an infrastructure that needs to be present at a particular location. This means workshop facilities with the appropriate equipment and allotted time frames and staff thoroughly skilled in working with the machines and in guiding students. All well and good – but too inflexible for ad-hoc activities. And not available in many locations where efnMOBILE would like to be active.

Therefore, we have developed a mobile workshop based on Bucky Lab, the mobile workshop led by Marcel Bilow at TU Delft and named after Buckminster Fuller. It can be packed into a trailer and a bus to travel to various places in Europe for temporary use.

Its equipment is designed to include the necessary technical facilities for prototype building for groups of up to 40 students. Included are common tools for woodworking and some for metalworking, as well as mobile tables, a compressed-air system and two tents of 50 m² each with a height of 4 m. This allows for a virtually autarkic workshop that merely requires firm floor space as well as suitable electrical connections.

In order to be able to transport and exhibit the workshop projects as well as create comparability, a frame system was developed beforehand, which was then adapted to the particular programs and prefabricated for project use. The documentation for the workshops was organized in the same manner: the design and building result data was fed into in a digital template to be exhibited alongside the built mock-up.

In accordance with the program, a workshop was held in 2013 in Detmold (Germany). It was followed by workshops in 2014 in Bath (UK), Delft (NL) and Lucerne (Switzerland). For 2015 workshops were planned in San Sebastian (Spain), Delft and again Detmold. To prepare for the particular project, the advisors traveled to the hosting university to launch a seminar/design project with a local partner. After a development and design phase, the mobile workshop was brought to the hosting university and set up. Typically, the workshops lasted for one to two weeks and ended with an exhibition of the results during a conference organized by the European Facade Network.

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- 1 Map of efnMOBILE workshops
- 2 efnMOBILE on its way from Spain to the Netherlands – 2015
- 3 Bath team – 2014
- 4 San Sebastian team – 2015
- 5 efnMOBILE tent in Bath, UK

5.1. PERFORMANCE

WORKSHOP "PERFORMANCE", DETMOLD

The theme of the first efnMOBILE workshop was "Performance". It was divided into four areas that exhibit great potential for the development of facades and are most relevant to solving today's problems. International and interdisciplinary teams elaborated the topics of noise reduction, light quality in the interior, energy generation and "green" and transferred them to the facade.

Facades as building parts enclosing interior spaces have to fulfill numerous tasks and requirements. For example, sealing (protecting from climatic conditions), insulating and load-bearing are very important and long-known tasks. But others, such as ventilating the interior spaces, optimizing the view and solar protection, require further development and improvement.

But how can we add even more performance to today's high-tech facades? Which are the requirements for future facades? And how can we realize the expansion of performance?

In this context, the first efnMOBILE workshop was held in November 2013, shortly before the facade conference "Design vs. Development", led by Prof. Uta Pottgiesser and Anan Ashour in Detmold, Germany. Students from Facade Technology and Computational Design and Construction

(MCDC) as well as from almost all partner universities teamed up in groups. First, the students approached their individual topics with a scientific study, which included critically examining existing ideas and suggestions for solutions. In this way the groups narrowed down their area of investigation and identified the problems they needed to solve.

Thus, the group whose topic was "noise reduction" concluded that additional facade performance could predominantly solve problems related to sound emission from outside to inside and noise reduction in the outside space itself. The students tackled the problem of street noise in intercity areas. The objective was to neither use hard-walled reflection of the emission back to the outside space because this would exponentiate the noise there, nor let the sound penetrate the interior in spite of several other, contradicting requirements such as transparency and ventilation.

Human beings experience daylight as extremely comfortable; because of it, they achieve the highest productivity and a higher motivation. Daylight is important for the body's melatonin production and thus the inner clock. The second workshop team dealt with the question of lighting quality in the interior space. They deemed it especially important to

generate high daylight quality deep inside interior spaces as well as in the vicinity of the facade.

In the context of the energy revolution and the rethinking on producing renewable energy, the rising question is how and where to generate more energy in the future. The students of the “energy generation” group soon realized that the transportation of energy is as important as its production. So they developed the requirement that the facade should generate as well as use energy in a decentralized manner. Another problem to solve was the continuity of energy production, since the dependence on climatic conditions can have a negative effect on the production.

Everyone is talking about “greenwashing” and “sustainability”. Therefore, the fourth workshop team dealt with the topic “green”. What are truly sustainable materials? Can they be applied to facades in spite of their high requirements? The “green team” formulated two theses: 1) future facades must consist of recycled building materials or “waste” materials and 2) they may only consist of materials with a low amount of bound energy. Thus, upon completion of the research, four new performance requirements were formulated:

1. Absorbing noise emission from the outside
2. Directing daylight deep into the interior space
3. Generating decentralized and permanent energy
4. Building with sustainable materials.

After the research phase, pairs of groups were joined into one planning team so that two mock-ups could be developed, each with two new requirements. In all cases, the design of the facade was foremost.

Two further teams, “light quality & noise reduction” and “generating energy & green”, designed different concepts to merge the selected requirements with as many standard requirements as possible. This was to bring about an interdisciplinary exchange between soon-to-be software experts and facade planners. Besides, the concepts could then be discussed from two perspectives.

A distinctive feature of these designs is “thinking of the facade as a product”. Industrial designer Joanna Funck, head of Product Design at GENERATIONDESIGN, instructed the teams to think of the facade not, as is common, as an individual object in a prototypical sense but rather as a product, even an entire product system. In order to generate one tangible concept from the many, the team was supported by various experts from the fields of acoustics (Christoph Kirch), materials (Christian Grabitz) and building and realization (Sascha Hickert and Max Ernst).

During the following building week, the two designs were developed to execution planning using 3D modeling. Once materials and dimensions, functions and their realization were determined, the students began building the mock-ups; a steel frame with the dimensions of 2.38 x 1.16 x 0.4 m was made available to each group for this purpose.

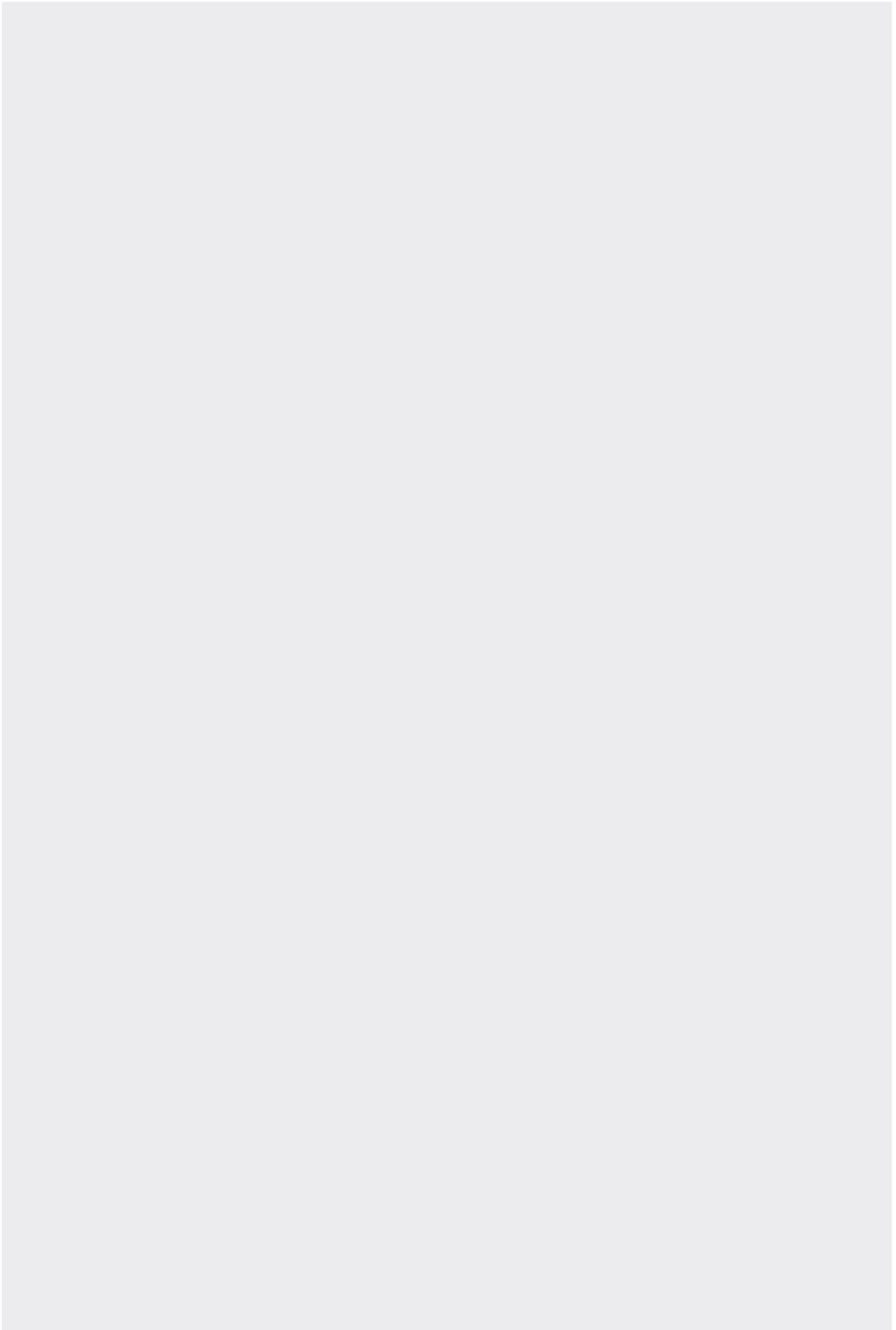
The students were able to experience and learn the entire process of research, conceptualization, design and execution planning all the way to physically constructing a facade mock-up in interdisciplinary teams. While building the mock-ups the students learned about and applied various traditional and mechanical techniques including basic metalworking, joining by welding and screwing, using an angular grinder and steel drills. And woodworking, of course: the participants worked with wood and plastics with the help of carpenters from the Detmold School for Architecture and Interior **Architecture**. And the selected projects enabled the teams to get to know electronics. Diodes were coupled to piezo motors and light conductors were used. All in all, it was a very exciting and comprehensive building task.

The Detmold workshop was supported by Industrieverband Gitteroste (Industrial Association for Gratings) with material and technical data. The result was successful synergies and innovation exchange between the industry and education. Thank you very much for that!

At the subsequent conference, "Design vs. Development", the functioning mock-ups were presented to a broad expert audience that showed great interest and encouraged the students to elaborate this performance further and also participated in critical discussions. However, we are all aware that facades can integrate even more performance and will become integral building parts to be developed in this same way by similar teams.



1-2 Interdisciplinary student group work in Detmold



WORKSHOP “PERFORMANCE”, DETMOLD**“NOISE AND LIGHT”**

WHEN 25/11/2013 – 29/11/2013

IMAGINED BY Ethan Kerber, Elisavet Tsakiri, Endrias Tedla Sime, Phuong Pham, Juan Sebastián Sepúlveda, Maan Balela, Sarawut Gumngen, Sai Naveen Yarabarla

SUPPORTED BY Uta Pottgiesser, Christoph Kirch and Anan Ashour

Large cities are subject to constant growth. This means that the infrastructure, public transportation and traffic all increase. But land use also increases, and buildings must be based on a corresponding economic concept. This situation forces architects to sometimes make unpopular decisions, which lead to negative consequences for users and others.

Two examples of such situations are increased noise, particularly in street canyons, and less daylight in work spaces that are located deeper inside the building or in secondary rooms such as corridors that receive no daylight at all.

To counteract these two issues in inner-city areas, the “noise and light” group of the Detmold workshop developed interesting solutions.

CONCEPT

In inner-city, highly frequented areas the facades of buildings of different use will absorb daylight like a collector, and direct it into the depth of the building, while at the same time protecting the building from street noise by absorbing it.

TECHNOLOGY

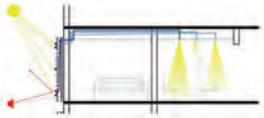
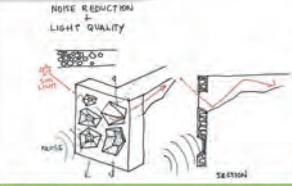
Three different strategies are applied to achieve more effective noise reduction in the street space. They are reflected in the three different layers of the facade: the first, exterior layer is a perforated facade cladding with apertures of different sizes so that sound of different wavelengths can be absorbed. The size of the apertures can be predefined according to the wavelengths of the noise present at the location. The second facade layer is a soft insulation layer, which, on one hand, naturally takes on thermal insulation of the facade, but on the other hand, also serves as a diffuse sound absorber for penetrating sound waves. Mass is one of the most important criteria for sound absorption. Thus, the third facade layer is a reinforced concrete wall that provides acoustic insulation between the interior and the exterior space. Of course, this wall can serve load-bearing purposes as well. In order to direct daylight deep into the interior of the building, the facade comprises solar collectors, some of which are located behind the apertures in the sound absorption. These collectors consist of mirrors that are arranged in a funnel shape. At the end of each funnel there is one glass fiber cable. Bundled together, these light-conducting cables are fed through the ceiling to the desired position inside the building, where they end in a glass lens that distributes the daylight into the room.

DESIGN vs. DEVELOPMENT

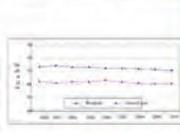
facade 2013

NOISE REDUCTION & LIGHT QUALITY

1 CONCEPT



2 LOCATION



The Hospital located at a corner of a very busy main street, surrounded by skytrain route and many shopping malls, stadiums, and entertainment places.

Noise Level in Bangkok

BANGKOK - THAILAND

3 TECHNOLOGY & MATERIALS



Fiber optic



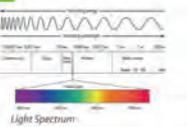
Human Biological Clock



Release of Cortisol and Melatonin in a Day Cycle



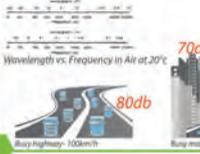
Interaction of the Sun with a Building



Light Spectrum



Resonance



Wavelength vs. Frequency in Air at 20°C

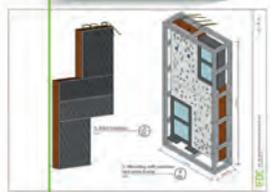


80db Busy highway: 100km/h
70db Busy main road: 50km/h
60db Residential road



Noise reflection

4 DETAILING



5 BUILDING THE MOCKUP



DESIGN

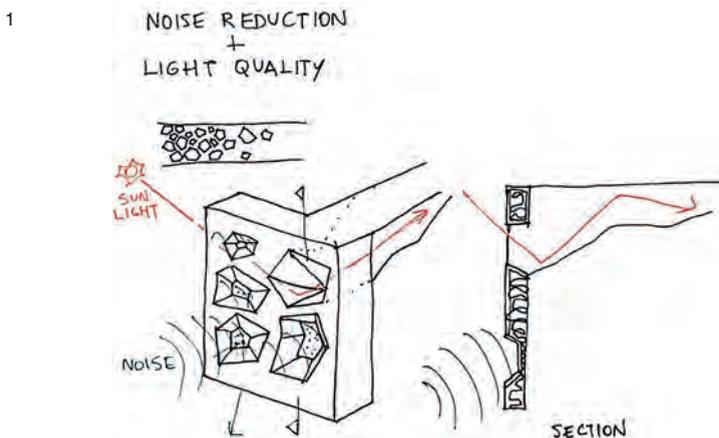
Within the scope of product systematic, the “noise and light” facade offers the opportunity to position the individual facade element with additional elements such that it allows for different window sizes. Thus, the window of each element can stand alone, but it can also be combined into a window twice or four times as big. The perforation of the facade cladding offers the opportunity of a free, homogeneous distribution of the apertures in the facade, as well as cloud forming and a visual dissolution at the edges, for example. Also conceivable are entire images, logos etc. in the facade cladding made with the perforation pattern.

MATERIAL

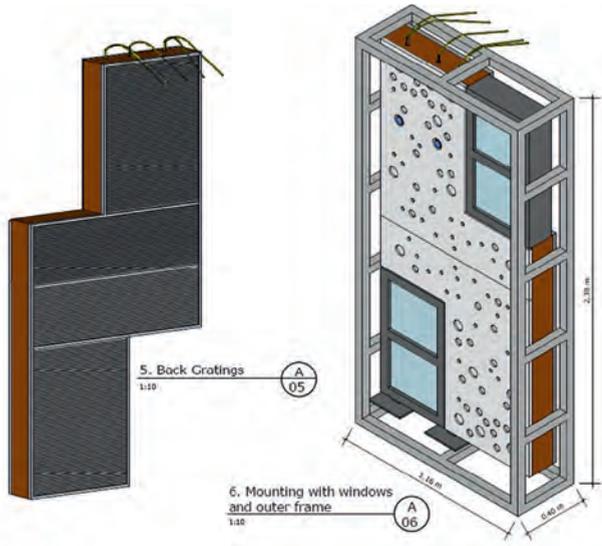
The external layer of the facade consists of a weather-proof skin, for example, made of sheet metal; plywood was only used for the mock-up due to its simpler processing. Behind the external layer there is a soft insulation layer, consisting of mineral wool, for example. In order to achieve even more effective sound absorption and in climatically suitable regions, an acoustic panel can be applied as well. Behind this layer there is a massive wall, in this case made of concrete. The cross-section of the light conducting cables must be as large as possible in order to capture a sufficient amount of daylight, while the cable should on the other hand remain flexible enough so that it can be laid in cavities and around corners.

REALIZATION

First, a robust frame was made of construction wood, onto which all layers and other parts can be mounted. On the rear side it was filled with concrete, and then clad with insulation on the outer side. On the side facing the interior space, a cladding made of wooden slats was installed. For the mock-up, the facade cladding consisted of plywood. This was perforated with a laser cutter to achieve the desired facade pattern. Then, prefabricated mirror funnels were glued behind some of the apertures, at the end of which a thin light conductor was mounted. In a bundle these light conductors function like a lamp fed with daylight.



2



3



4



- 1 Concept sketch for noise reduction and light quality
- 2 Isometric view of a 3D model and the design of a product systematic
- 3-4 Mounting of wooden frame and steel frame

WORKSHOP “PERFORMANCE”, DETMOLD

“GREEN AND ENERGY”

WHEN 25/11/2013 – 29/11/2013

IMAGINED BY Alamir Mohsen Soliman, Madeleine Zimmer, Chen Anthony, Wael Ajam, Aoun Amanda, Arezou Fathi, Darryl Lennart Menezes

SUPPORTED BY Uta Pottgiesser, Christoph Kirch and Anan Ashour

It is mandatory to handle energy carefully; in fact, to save energy wherever possible. However, currently the worldwide demand is increasing continuously. This means that we need to produce in a resource-friendly manner; for example, by means of renewable energy sources. In the building/construction sector, energy is not only used to operate a building (usage energy) but also to produce the buildings and related materials themselves. Furthermore, many resources are mined, refined and used for this purpose. (See Imagine 05 – Energy, Rotterdam 2011)

The “green and energy” team deals with exactly these two topics: the energy needed to operate buildings as well as the resource mining and energy consumption to build them. In the Detmold efnMOBILE workshop the interdisciplinary team addressed the requirements of producing energy in the facade (decentralized and continuously) as well as the use of sustainable materials.

CONCEPT

Just imagine you could produce electric power on virtually every facade.

Similar to the photovoltaic systems installed on many rooftops, this cladding facade would generate electricity from a natural and renewable source.

The “green and energy” module is a clad facade system that moves in the wind like a leaf on a tree, and thereby produces energy. It is particularly suited for regions with strong and continuous wind such as the coastal regions in the north-eastern US and Canada, the Atlantic coast in Europe or Korea, Japan and eastern Russia.

TECHNOLOGY

Electrical current is produced by means of piezo generators that are triggered by parts moved by the wind. Two different types of piezo are used: in one, so-called leaves are freely suspended from piezo generators that react to jack-knifing, and in the other, pressure-responding generators are mounted on a frame that rotates around an axis.

DESIGN

The appearance of the cladding facade should also create a direct relation to the element wind. Thus, the design includes many small surfaces that move with the wind, to resemble the leaves of a tree. A module-sized, moveable frame increases the effect of movement on the facade. Not only the small leaves but also wind catchers are mounted in both vertical and horizontal directions in this frame.

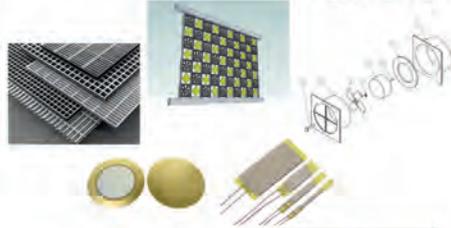
DESIGN vs. DEVELOPMENT

facade 2013

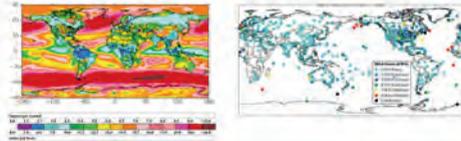
GENERATING ENERGY & GREEN

Since environmental welfare has become one of the humanity main concerns, thus generating energy and sustainable architecture are important topics that we need to dig deep down in.

01 CONCEPT



02 LOCATION



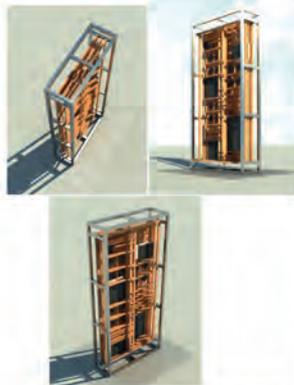
Location classification according to the wind speed maps:
A, Northeast America, East coast of Canada, Northwest coast of Europe, Korea, Japan and East coast of Russia.
B, South America, South Africa and Australia could be also good locations, especially coastlines.
C, Middle Europe and most of Mediterranean countries.

TECHNOLOGY

The new product is a cladding panel that can cover a part of a facade or may be expanded to cover the whole facade. This cladding has several functions: shading, decorating, and generating energy.



04 DETAILING & MATERIALS



The main structure could be the building limit of slab or steel frames fixed on front of the main structure.
The grating frames presented as inner frame connected to a rotating axis in its middle is linked from both sides.
The grating filling considered of squares are filled with materials complying with the green architecture principles and the others filled with small acrylic sheets moving with the wind.
Due to the wind pressure applied to the panels, the inner frame will rotate and the small sheets will oscillate, this mechanical energy will be transformed into electric energy and stored using the piezoelectric effect.

BUILDING THE MOCKUP



MATERIAL

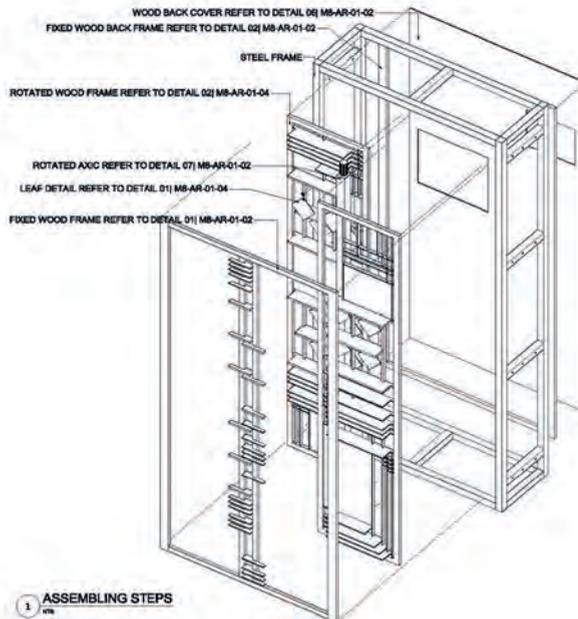
Due to the material's high degree of sustainability, the small and large frames are made of wood. The leaves and wind catchers are made of hard-wearing plastic to resist the constant quick movements that they are exposed to. The type of plastic should preferably be bioplastic or at least thermoplastic to meet the sustainability objective. The axis around which the frame rotates is made of steel, as are the ball bearings mounted on the axis to resist the loads.

REALIZATION

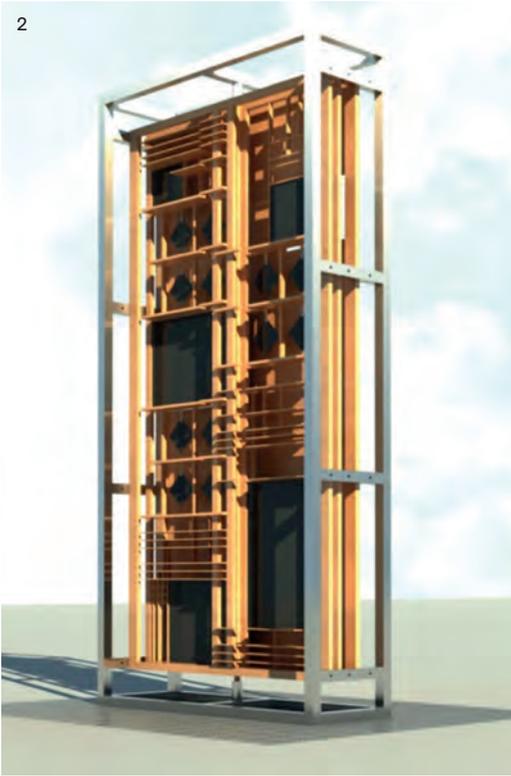
The larger outer frames were made with traditional craftsman techniques in the carpentry shop. The fillings, especially the wind catchers, were made with small pieces of wood that slot into each other to create a self-bracing system. The small and individually shaped wind catchers were produced with a laser cutter. The prefabricated plastic sheets were mounted with small metric screws. Then, the filled-in frame was inserted in the steel frame, and a ball bearing was mounted at the top and the bottom of the center axis. Now the piezo generators had to be glued to the moveable frame as well as the steel frame, and a striker pin at the exact opposite position to trigger the piezo. Hereby we noted that the moveable frame had to be repeatedly pushed back into its original position with springs. These springs need a rather soft pre-tension since they have to be compressed by the wind.

In order to visually reflect the effect of electricity production, all piezo generators are connected with copper leads to diodes in a display case. It works: If the frame and the leaves move the diodes flicker visibly.

1



2



3



4



1-2 3D-model of the Mock-up

3 The large wooden frame rotates around the axis on ball bearings

4 Alamir Mohsen mounted the wind catchers

5.2. EMBODIED ENERGY

WORKSHOP “LOW COST – LOW ENERGY CLIMATE RESPONSIVE FACADE”, BATH

The second workshop of the efnMOBILE workshop titled “Emerging Envelope” took place from 2 – 6 June 2014 in Bath, England. All participants of the “International Facade Design and Construction Masters” (IFDC) at Detmold School of Architecture and Interior Architecture and all students of “Sustainable Environmental Engineering” at the University of Bath were invited.

After the first “Emerging Envelope” workshop in Detmold had raised questions about the expanded performance of the facade, the focus of this second workshop lay on the sustainability of facades and their embedded energy. And the students addressed the topic of affordable building and building with local materials. The requirements were linked to different climate zones, for example to those of North Africa, China and other warm, tropical climates.

The research background for this topic lies on the main focus on requirements such as “environmentally friendly building, affordable building, low-energy and climate-neutral building”, while considering building with local materials, waste and constructively simple technologies. This in stark contrast to many other research projects and designs that rely on complicated building physical theories, adaptive and kinetic application or new materials.

Probably, only a good combination of these two aspects will result in good and new facade systems at roughly the same price with local materials and of higher quality. Following an opening event by Prof. Dr. Linda Hildebrand with the entire group and subsequent conversations, the students of both universities had to carry out background research to develop their ideas and concepts for the workshop week. During this time the students were supervised by Dr. Stephen Lo and Sukumar Natarajan in Bath, and by Linda Hildebrand in Detmold.

Shortly before the intensive workshop week during which the teams were meant to build their mock-ups, they were faced with the following question:

“How to design energy efficient facades for different climates at half the price of local traditional systems?”

The students found very different answers to this question. They imposed different functions and requirements on their facades, and dared to broach a broad field of possibilities. Thus, there were concepts for a simple solar chimney, for solar protection, or, for example, for ventilation coupled with anticyclical dehumidification. The workshop in Bath was led by Prof. Dr. Linda Hildebrand, assisted by Dennis Dück. After the two had shipped 4.8 tons of building material, tools and tents to



1 Students from Bath and Detmold use sustainable material from a nearby construction site
2 Warm-up workshop in the tent
3 Students from Detmold traveling with Prof. Dr. Uta Pottgiesser and Prof. Dr. Ing. Ulrich Knaack

England, the first team-forming activity was undertaken – the tent had to be set up and the workshop furnished. The next great challenge was the fact that none of the participants had ever used any kind of tool or machine to build mock-ups. Thus, they had to learn to handle the equipment necessary for the task. After a short introduction into the functionality of the various machines and the handling thereof, the process slowly got underway. After four intensive workshop days the students had managed to create five mock-ups.

Particularly the work with local materials was an unusual experience for the students, and challenged their sense of creativity. They had to mentally put themselves into the conditions of their planning region, and filter the location specific climatic particularities. At the same time, they had to work with the building materials from England, and thus had to improvise. The results were wonderful, yet so very self-evident ways to translate an idea into a mock-up. For a mock-up requiring thermal mass, for example, students just got some earth from a nearby construction site.

Another team discovered bamboo canes as an affordable, quickly re-growing and thus sustainable building material for their particular climate zone. And yet another group searched for affordable mass and waste products from production processes and discovered a children's toy. All of these common materials are very simple to apply to building facades, yet they are very innovative. And this was exactly what the workshop was

about: to develop facade ideas with simple means and easy yet intelligent constructions that allow for environmentally friendly, affordable, low-energy and climate-friendly building.

The five completed mock-ups cover the following topics: ventilation, sun protection, climate design and multi-adaptive.

The final mock-ups were exhibited and intensively discussed at the conference "The Future Envelope 8". About 80 representatives from research, development and the industry were at the international facade symposium on 6 June 2014 in Bath, England, titled "Mind the Gap". Lectures about practices and theory sketched the current outline of high-end facade technology being investigated and built. Challenges like shape, climate, client, costs and construction technology lie at the center – but in the end it is about convincing each other that something is possible and then to build it!

The international representatives from research, development and industry had occasion to see and discuss the students' concepts. This discussion is one of the key economic and technological issues that many European companies and consultants face.

“LOW COST – LOW ENERGY CLIMATE RESPONSIVE FACADE”, BATH BAMBOO FACADE

WHEN 02/06/2014 – 06/06/2014

IMAGINED BY Wael Salman and Necdet Bahadir Buluk, Xiaohong Lin, Zhongxin Lin, Kaixuan Wu

SUPPORTED BY Linda Hildebrand and Dennis Dück

Bamboo is a fast growing and widespread plant, making it an ideal sustainable building material. In addition, bamboo is very hard-wearing and has a homogeneous structure. The bamboo facade utilizes these advantages to serve as a variable sun protection system. A system consisting of frame, gearing and rotating elements can be mounted immediately in front of a window and can be individually controlled by the user. When adjusted accordingly, the bamboo facade can also serve as a wind catcher, and thus improve the natural ventilation of the interior space. This makes it particularly suited as an add-on in warm and humid climate zones. The connection of the bamboo canes demands particular attention because, in this mock-up, canes that rotate in different directions need connecting to each other. This aspect is solved with metal connectors that allow for axial rotation.





PROGRESSIVE FACADE INSTITUTE

LOW COST LOW ENERGY CLIMATE RESPONSIVE FACADE

BAMBOO FACADE

CONCEPT

The concept targets hot humid climate. It proposes using low-cost bamboo made of bamboo cane as well as guiding the wind into the building by the opening of cross-ventilation.




LOCATION

The concept is based on using bamboo as an available local material to provide functional facade elements. The local cane for sun-shading is to be used as well as a wind catcher that allows to transfer the building in order to reduce discomfort caused by high humidity.



TECHNICAL CHARACTERISTICS

The bamboo shows a considerable structural quality thanks to its tubular form. It is used for frame and the supporting structure. Moreover, it is characterized for being rot-resistant.

The bamboo is a natural plant and comes in different sizes. The challenge is how to create connections and openings in such variations. Different types of connectors are used for both the supporting structure and the bamboo frame.



CONSTRUCTING THE FACADE



CONCLUSIONS

After constructing the mock-up, it was possible to approach some problems. In the three images (left), three components were produced concerning the rotation mechanism and enhancing the connections (also to rain and air to help).



by Wael Salman & Necdet Bahadir Buluk

“LOW COST – LOW ENERGY CLIMATE RESPONSIVE FACADE”, BATH MODERN MASHRABIYA SHADING SYSTEM

WHEN 02/06/2014 – 06/06/2014

IMAGINED BY Sai Naveen Yarabarla, Juan Sebastián Sepúlveda, Siwar AlKalha, Dunya Al-Ani, Gargi Singh

SUPPORTED BY Linda Hildebrand and Dennis Dück

Waste products from industrial processes, cheap mass goods and recycling products from waste are great sustainable building materials. It is even better if they consist of organic or regrowable sources. This is where the concept of the sun-shading system for Mashrabiya comes in. Taking their cue from the local historic ornaments in Jordan, the sun-shading system consists of narrow painted recycled pieces of wood. The individual colored wood elements are threaded on rotating axes twisted toward each other. During rotation they interdigitate in such a way that the greatest possible area of shading is created. Hereby, the patterns in the facade change constantly, making it appear like a moving ornament. The rotating axes are mechanically connected and balanced out to guarantee smooth opening and closing of the sun-shading. Like other common sun-shading devices, the system can be controlled by the user from the interior. The rotation mechanics itself offers another possibility to use recycled materials, since disused gears and cassettes as well as bicycle chains could be used.



MODERN MASHRABIYA SHADING SYSTEM

CONCEPT
To develop an adjustable solar shading system which is controlled by rotation. The design was developed using Massarabiya, traditional sun-shading elements used in Arabic countries as an inspiration.

LOCATION
Amman Jordan
Longitude: 35.93° E
Latitude: 31.95° N

TECHNOLOGY
It is a sun shade system that can be rotated. A system of four gears that will rotate half a turn when triggered by a button. The button is connected to a motor. The gears will be rotated by a gear train. The use of recycled materials is possible. The use of recycled materials is possible.

DETAILS
Dimension of single shading element: 100mm x 100mm x 100mm.
Spacing between each element: 10mm.
The shading elements are connected to a bracket rail, which is rotated using the gears which are connected with a belt. The system is connected to a motor which is located inside the building.

BUILDING PROJECT
The mock up was built at University of Bath by students of Highgrade CIVIL and University of Bath in the efn mobile workshop.

Logos: efn, ISO 9001, FOC

“LOW COST – LOW ENERGY CLIMATE RESPONSIVE FACADE”, BATH MULTI-PURPOSE FACADE

WHEN 02/06/2014 – 06/06/2014

IMAGINED BY Darryl Lennart Menezes, Elisavet Tsakiri, Wengang Yin, Cheng Lu
SUPPORTED BY Linda Hildebrand and Dennis Dück

The idea behind the Multi-purpose Facade is to add a multitude of additional functions to an existing facade with only one additional layer. A system structure made of the sustainable material wood is suspended in front of the existing facade. It can be combined from different modules. Due to its orientation and dimensioning the structure itself offers a sun-shading function. The sun-shading is designed to absorb very little of the low-angle sun during winter and thus warm up the existing wall, or to let daylight penetrate through the window openings, but to absorb the light when the sun is at a higher angle at other times of the year. Additional modules can be inserted into the structure, such as acoustic absorbers for the exterior space. In this case, profiled absorbing foam is inserted into some of the openings so that sound waves hitting the facade are absorbed. Another option is to use a module with a titanium oxide (TiO₂) alloy, which in combination with sunlight functions as a catalyst for the air to clean it. A third option for a module for the structure of the Multi-purpose Facade concerns elements to vegetate the facade. Small planting pots can be mounted from which climbing plants can grow across the facade.



Multi-purpose Façade

LOW-COST LOW-ENERGY CLIMATE RESPONSIVE FACADE

CONCEPT

- Modular System
- Self-Shading
- Acoustic Absorption
- Titanium Dioxide (TiO₂) Technology
- Green Facade

No need of any kind of control. Can adapt to the surrounding environment, absorb energy and provide shading, absorb noise and improve air quality.

TECHNOLOGY

- Integration ability
- Flexibility
- Sustainable material
- Polystyrene acoustic
- Titanium Dioxide (TiO₂) Technology
- TiO₂ coating
- Photocatalytic action
- Removal of air-borne fungi, viruses and bacteria spores

LOCATION

Düsseldorf

Latitude: +51.50 (51°31'00" N)

Longitude: +10.50 (10°30'00" E)

Time zone: UTC+1 Hours

Climate: Continental

Source: www.weather.com

Climate data for Düsseldorf, Germany

Month: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Temp (°C)

10 10 12 14 17 20 23 25 24 20 15 10

Precip. (mm)

55 45 35 30 25 20 18 20 25 40 55 65

DETAILING

BUILDING THE FACADE

“LOW COST – LOW ENERGY CLIMATE RESPONSIVE FACADE”, BATH CUSTOMIZABLE VENTILATION FACADE

WHEN 02/06/2014 – 06/06/2014

IMAGINED BY Amanda Aoun, Sarawut Gumngen, Jeongyeon Lee,
Sihao Chen, Yang Li

SUPPORTED BY Linda Hildebrand and Dennis Dück

The Customizable Ventilation Facade is particularly suited to difficult climatic conditions such as tropical and subtropical climates. This is because it combines three essential functions that can influence the climate of the interior space. The facade can ventilate individually as well as regulate humidity and increase through-ventilation. Inside the facade a turbine-like four-layer funnel is mounted that, due to its shape, channels the air inside the interior space. The exterior layer consists of slats that protect the facade aperture from rain. Behind this is a coconut fiber mat that conditions the incoming air in terms of humidity and collects water droplets from the air. The third layer is a perforated panel with various degrees of perforation. The panel is quartered and comprises sections of 0, 25, 50 and 100% degrees of penetration. Then follows another panel with a quarter that is 100% open; the rest of the panel is closed. This inner panel can be individually controlled by the user, who can adjust the degree of ventilation with the differently perforated panel. The concept resembles a salt shaker. The entire facade consists of wood and coconut fiber. Both are affordable, regrowing natural building materials.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

In May 2015, the international workshop in San Sebastian took place. Under the slogan “High Architecture – Low Carbon”, 45 students from 12 countries met at the University of the Basque Country in Donostia/San Sebastian. Linda Hildebrand and Max Ernst from RWTH Aachen and the Detmold School of Architecture and Interior Architecture led the corporation workshop with Bachelor students from the University of the Basque Country and students of RWTH Aachen. Inigo de Viar and Josemi Rico supported the workshop onsite.

“High Architecture – Low Carbon” is the art of creating architecture and facades of high quality with a minimal ecological footprint. The intention here (in addition to good design, of course) is to use sustainable materials. And the constructive possibility of simple and mono-material disassembly is an absolutely relevant criterion of the “low carbon” idea. The objective was to create recycle-friendly facade mock-ups that can be fully fed back into a recycling cycle in their entirety.

In order to approach the topic of “deconstruction”, the participants were given the task to analyze facades three months before the actual workshop. The focus here lay on the joining technologies used. Then, the teams discussed the potential for disassembly and sketched possible solutions for potential problems.

Based on this experience, the teams developed concepts for new and cycle-friendly facade types during three meetings onsite, under the guidance of Linda Hildebrand. Then the students were asked to generate a design from their ideas, which had to fulfill three functions. One basic requirement for all facades was thermal insulation, a second was that they had to be recycle-friendly (i.e. easy to disassemble) and the third was left to the choice of the teams, encouraging them to identify an extra function that suited their particular concept.

After all preparations for the workshop week were done, it finally began on May 21. On that day, Sascha Hickert and Max Ernst made the 24-hour trip to San Sebastian, the efnMOBILE trailer in tow, filled with building material, tools and machines and the tent. As mentioned before, the first day began with the team-building measure of setting up the tent. The concepts and execution plans of the mock-ups were fine-tuned and missing building material was purchased.

The students thoroughly enjoyed getting to know the tools of the trade. Very few had ever worked with a cordless drill or a circular handsaw before, let alone a router. Many were astonished about what can be created with the proper tools and one’s own hands.



1-3 Workshop San Sebastian group pictures

The following four workshop days were spent learning the basics of woodworking, plastics processing and metalworking. The students discovered many points of connection, copied tricks from one another and transferred them into their models.

The result was nine mock-ups, all of which exhibit an interesting concept worth further elaboration. Two teams worked on easy ways to exchange modules for facade vegetation. Two other teams developed individual concepts for disassembly in only five minutes, with one solution based on timber-framing and the other on steel-framing. And the idea of a facade that is recyclable in its entirety was translated into a mock-up. Other facade concepts are based on sustainable wood as the only building material used. They have additional functions, such as opening and closing of entire facades, furnishings for the exterior space, or again vegetation of the facade. Wood was also the focus of choice of the eighth group: the team deemed it important to guarantee wood preservation that is fully recyclable and does not consist of chemical or inorganic substances. For this they developed a slot connection system and treated the surfaces with fire. The ninth mock-up was based on a modular system with many additional functions for passers-by that building owners can incrementally mount on the facade for insulation purposes.

On the last day of the workshop week, all participants were invited to attend the "International Conference of Architectural Envelopes" in the wonderful congress center

designed by architect Rafael Moneo in San Sebastian. Here, the students were able to exhibit their mock-ups and present them individually to the interested expert audience. Some of the facades were fervently discussed, showing the high potential and a readiness to realize such ideas. Others earned approving smiles.

A spontaneous tour led by the organizers of the entire congress center, which was awarded the European Union Prize for Contemporary Architecture in 2001, was a wonderful closure to the workshop week. It was followed only by the now well-practiced packing of tools and tent into the trailer and shipping the new facade mock-ups back to Germany.

WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

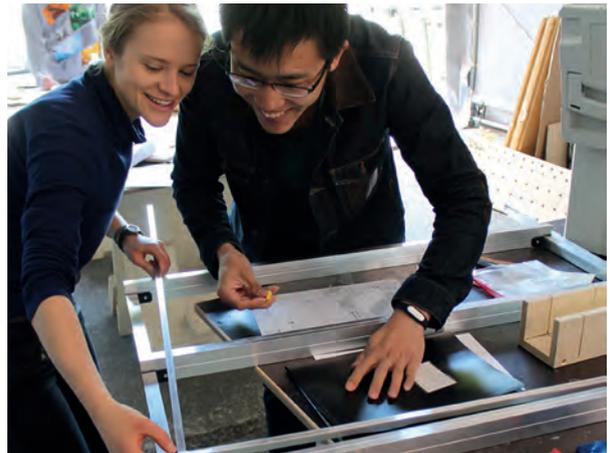
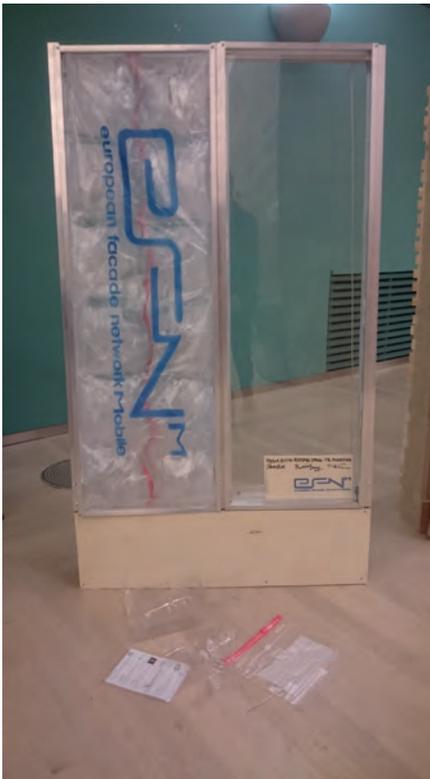
5-MINUTE STEEL-FRAMING

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Metals are a valuable and highly refined building material. Most metals can be recycled without loss, and exhibit a well-functioning cycle in themselves. 5-Minute Steel-Framing by the team of RWTH Aachen allows for fast assembly and mono material disassembly of the entire facade into all material groups. The steel profiles of the frame are mounted with special plug-in connectors made of plastic. The filling of the frame can be easily exchanged by means of hook-and-loop fasteners, offering many possibilities. The example shown with this mock-up uses a glass panel and another frame as insulation element. The insulation is itself a recycled material, consisting of old torn and crumpled-up plastic bags, and can be fed back into its cycle.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

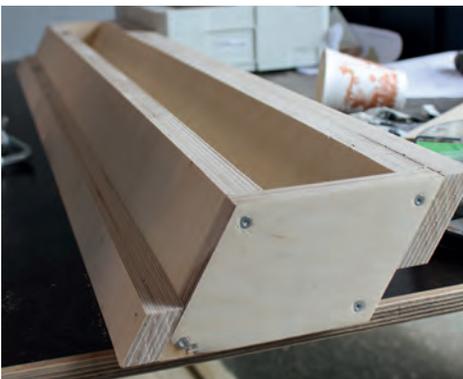
ROTATED VENTILATION FACADE

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

The concept of the Rotated Ventilation Facade is to create a facade consisting solely of wood, possibly the most sustainable building material there is. In this mock-up, building parts exposed to structural stress were made of solid construction timber, the frames of laminated wood, the thermal insulation of wood fiberboard, one axis of a wooden slat and the facade cladding of thin wood panels. Thus, the entire facade can be looped back into an end-of-life process. The Rotated Ventilation Facade of the international group of the workshop offers additional functions such as opening the entire facade for ventilation. To achieve this, the individual modules are able to rotate on their axis. They have a trapezoid cross-section with a tongue and groove system for sealing. The modules can accommodate different functions, e.g. a window, thermal insulation, or fold-out parts to be used as a table or as display cases.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

MODULAR INSULATION FACADE

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Nowadays, insulation to be added to existing buildings is often glued directly to the exterior wall. Such a joint between insulation and massive wall is hard to separate later, often resulting in contamination of the individual materials during disassembly. The Modular Insulation Facade, by contrast, is a separate wall in front of the existing wall. It can be assembled step-by-step by a single person, without a firm connection to the existing wall. This is achieved with a system of wooden cubes equipped on the rear side with protected insulation and interconnected by means of a simple rail system. On the outside, these cubes offer a variety of possibilities to enhance the exterior. They can, for example, accommodate a bicycle rack, an info box, or a table and chair. A planter can also be installed at the front of balconies on the top side with the help of the rail system. The idea behind this facade is to make it possible to add sustainable insulation to existing walls at any given time and in accordance with current (financial) means.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

5-MINUTE WOOD FRAME

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Wooden constructions are well known, for example in post-and-beam facades. However, disassembling such facades with just four hand movements is new. The 5-Minute Wood Frame facade consists of a timber frame construction as the load-bearing element. The corners of this timber frame are warp resistant connected with a special mortise and splint joint method, yet the frame can be quickly disassembled into its parts by simply pulling out the splints. The filling consists of wood fiberboard, protected by an individual and exchangeable facade cladding (loop-and-pile fastener).



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

CHANGE AND GREEN

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

The Change and Green facade offers facade vegetation, whereby the planters can be replaced, complete with plants and everything. The planters hang in frames with cross rails and can be exchanged according to season. In addition to creating a green facade, they also protect the insulation behind them. The “French group” of the workshop developed an individual facade image from which the plants can grow. The wooden modules protect them from weathering from the inside with Geo Fleece; on the outside the plants will grow to form a dense weather barrier over time.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

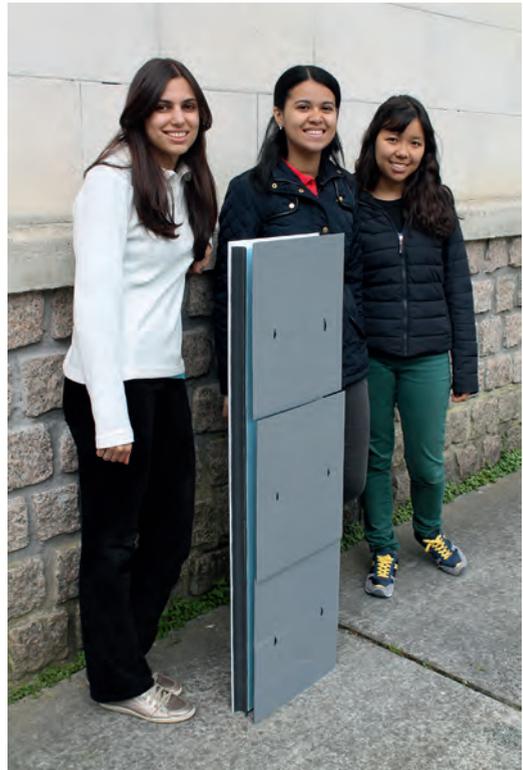
FULL PLASTIC FACADE

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Plastics do not necessarily have to be ecologically bad materials. Thermoplastics can be re-melted and processed into new plastic products. It is this idea that lies at the basis of the Full Plastic Facade. It consists of one type of plastic used for different building parts. The facade cladding is made of plastic panels of various colors and sizes. Behind it are plastic pipes used as distance pieces that are fixed to the foam-filled plastic insulation with cable ties. Thus, the Full Plastic Facade can be applied as a retrofit facade insulation system, and it can be fed back entirely into a recycling loop at the end of its life.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

ROTATED BALCONY

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Planting, ventilation and sun protection in one element. That is the idea behind the “rotated balcony” facade. The functions are fulfilled with extremely lightweight facade elements that rotate about one axis, are equipped with a planter and are covered with a translucent textile material.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

FIRE AND WATER

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

Protecting wood from weather influences without the use of chemicals and other coatings poses a great challenge. In this mock-up, the wood is protected by charring its surface. In addition, individual gutters built from these charred pieces of wood are at a distance from the closed facade, so that although the outer cladding of the wood pieces is exposed to the weather they are permanently ventilated at the same time. The advantage of this type of wood protection is that, when disassembling the facade, the wood can immediately and without difficulty be transferred to thermal processing. Another idea of this concept is to use the wooden gutters to catch rainwater, which can be collected in the center via pipes. As soon as rain falls, the gutters fill up and impose different weights on the facade. This causes the threaded wood pieces to move, creating an interesting play in the facade.



WORKSHOP “HIGH ARCHITECTURE – LOW CARBON”, SAN SEBASTIAN

KANGAROO FACADE

WHEN 21/05/2015 – 27/05/2015

IMAGINED BY workshop “High Architecture – Low Carbon”,
University of the Basque Country

SUPPORTED BY Linda Hildebrand and Max Ernst

The idea behind the Kangaroo Facade is to combine changeable facade planting and weather protection into one. Sustainable jute bags are suspended from hooks on the facade, filled with substrate and plants. Immediately behind the jute bags is a wood fiberboard, which, even though protected by the bags, can dry through rear ventilation in case it gets wet. On the inside of the facade the insulation is covered with a very beautiful mesh of thin wood strips. Thus, the Kangaroo Facade is built solely from sustainable materials.



5.3. ADAPTATION

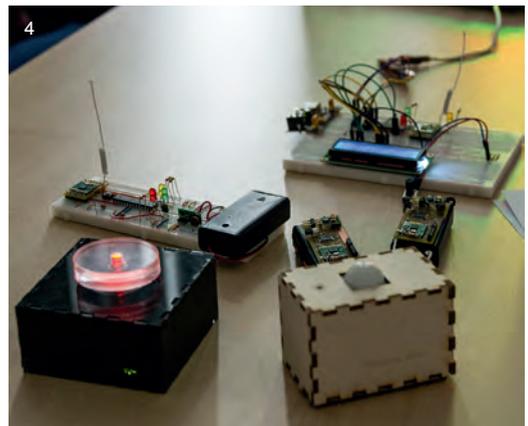
WORKSHOP "THINKINGSKINS", AACHEN

The first workshop of the efnMOBILE program around the topic of adaptation took place at RWTH Aachen. It was carried out in interdisciplinary collaboration between the disciplines of Architecture, Information Technology and Product Design, and it was part of the semester program for the summer of 2014. Students of the different disciplines formed interdisciplinary teams which were supervised by representatives of those fields of study: Peter Russell, Thomas Stachelhaus and Christian Möllering for Architecture, as well as by René Bohne, Jan Borchers and Dominik Schlütter. Ulrich Knaack, Sascha Hickert and Jens Böke accompanied the program as representatives of TU Delft, Ostwestfalen-Lippe University of Applied Sciences (HS OWL) and the efnMOBILE workshop series.

The workshop was planned based on the Solar Decathlon 2014. In this context, the topic of multi-functional and intelligent adaptive building envelopes was particularly interesting in terms of both energy-saving and increasing the functional scope of automated facades. A facade consists of an interior and an exterior side, both of which need to fulfill a number of functions. The functions can work individually or attuned to each other. The interior as well as the exterior side can be equipped with sensors, which allows them to collect information about temperature, air

quality, sound level, light, solar radiation, approximation and other aspects. Based on this information, changes to the facade, for example the degree of openness or its shape, can be controlled. In the workshop, digitally controlled automation was to be used to expand the performance spectrum of the building envelope with regard to the interplay of various functions. It was expected that the interdependencies between the different tasks of the building envelope would create potential for intelligent control systems. Thus the task was to develop innovative concepts for the building envelope of the future by combining two facade functions. Considering existing technical possibilities, the students were to develop new approaches to solutions that reconsider existing conventions. The task was to create a concept with an appropriate facade panel on a 1:1 scale. The results of the individual groups had to function independently of each other. However, preconceiving certain interaction between the results was desirable.

The initial task was to come up with creative ideas in a moderated kick-off event. After the participants of the workshop got to know each other, they collected and recorded terms relating to the possible functions of the building envelope. Puzzling with these terms resulted in initial ideas for combinations. During this first event these ideas were



- 1 Ideation session – students presenting their very first ideas
- 2 Post-its as an ideation tool
- 3 Final configuration of the “Smart Mesh”
- 4 Result of the project: Smart RFDuino

already sketched as possible concepts, and thus needed to be presented to the large group in a sales-oriented manner. The end of the event already saw first visions of adaptive facades that shall be able to perform better than constructions known today with the help of intelligent control.

The initial ideas were quickly developed into comprehensive concepts, oriented to concrete scenarios, and not only considering the requirement of use but also the possibilities of technical components. The development was done in work teams of three to four students. The collaboration was carried out in individual group meetings and in seminars during which the groups received feedback on their projects.

The core aspect of the workshop was creating 1:1 prototypes. "How can we realize our ideas?" was thus the next significant question. Building material was available in sufficient quantities and combinable frames were built to accommodate the different prototypes. Building prototypes and models is a core part of our work in developing new solutions. Digital fabrication was used to create the building parts. The necessary data was generated by the student teams with various 3D planning and construction programs. A university-owned FabLab equipped with assorted machinery was put at the students' disposal. This included a CNC controlled 3-axis mill, a 3D printer and a much used laser cutter. A specialty of this project was that the models had to be functional. Thus, the conceptualized automation of the functions

had also to be demonstrated. This task in particular confirmed the idea of the interdisciplinary team set-up. Know-how from the areas of design, product design, information technology as well as electrical engineering and digital fabrication had to be combined in the development work.

Automation was realized based on the Arduino platform. At the core of this platform are small, affordable microcontrollers that offer relatively easy access for non-commercial users. Each team had a starter kit with different components at its disposal, such as a R3 Uno board, a breadboard, resistors, a set of sensors, as well as several actuators. Special project-related components had to be purchased. Today, so-called physical computing offers manifold new opportunities to realize automation on a small scale. Sensors, resistors and actuators, such as a servo motor, can be connected with each other and controlled by programming.

Programming the functionality of the individual prototypes was part of the workshop task as well. Contrary to the expectations of many, this includes not only the factual programming but also conceptualization of a certain behavior. Which information must be linked to which response? Which measure is triggered based on different collected data, and with which interval and at which speed will repetitive adjustment steps be carried out? The conceptualization of adaptation generates new questions that go beyond existing knowledge in the conception of static construction solutions.

THE PROJECTS

A total of seven individual projects were carried out. The development work of the individual groups was documented online with "instructables", which recorded every important step of the prototype building process with text and images. The posters and prototypes of the project results will be presented at the exhibition "Glasstec Messe 2016" in Dusseldorf, Germany.

Photo credits:

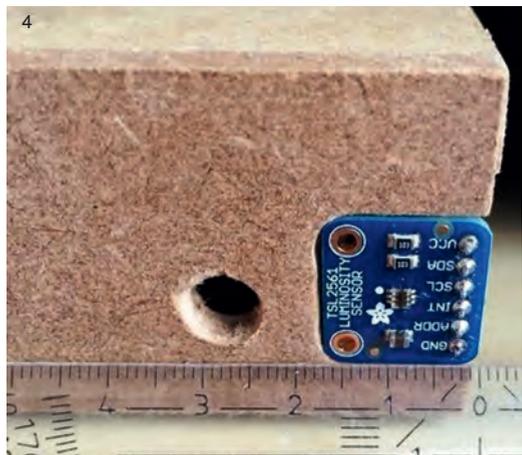
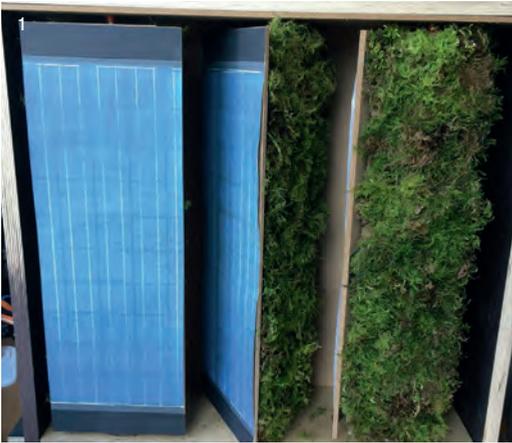
Thomas Stachelhaus, Chair of CAAD, Faculty of Architecture, RWTH Aachen

Dominik Schlütter, Chair of CAAD, Faculty of Architecture, RWTH Aachen

WORKSHOP “THINKINGSKINS”, AACHEN**TEAM 1 – MOSS SOLAR FACADE**

IMAGINED BY students of the workshop ThinkingSkins in Aachen
SUPPORTED BY Professors of the RWTH

The concept of the Moss Solar facade combines two functions of the building envelope in one intelligent building part. The scenario for this design is an urban context with particulate matter load: the facade is able to generate energy as well as clean the environment from particulate matter. Photovoltaic elements generate the electric energy from solar radiation and thus contribute to sustainable supply of the building. The cleansing of the surrounding air is achieved with the filtering effect of moss growth. Both functions are subject to the influence of the sun: while the PV modules only work efficiently with sufficient solar radiation, the moss must be protected from direct sunlight since it would otherwise dry out. The two functions are mounted facing each other on a rotating element. Sensor technology analyzes the prevailing environmental conditions and leads to appropriate exposure of the particular function surface.



- 1 Transition between the two sides
- 2 Mounting bearing for the rotating elements
- 3 Integration of the sensors
- 4 Integration of the electronics

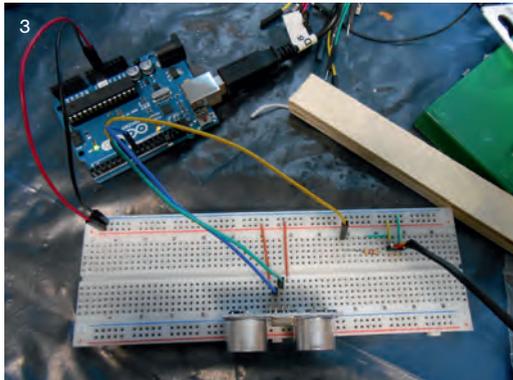
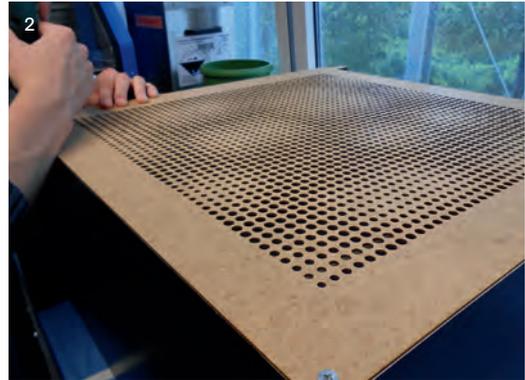
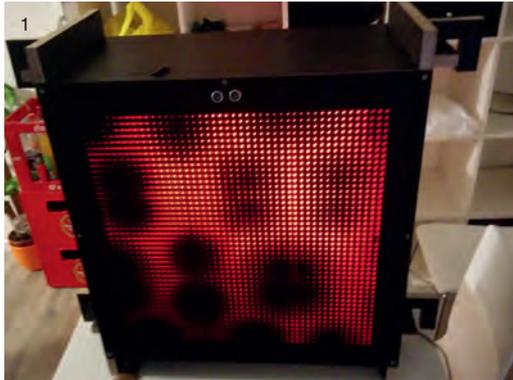
WORKSHOP “THINKINGSKINS”, AACHEN

TEAM 2 – ACOUSTIC WALL MODULE: SONICMOIRÉ

IMAGINED BY students of the workshop ThinkingSkins in Aachen

SUPPORTED BY Professors of the RWTH

SonicMoiré is the concept for facade integrated, acoustic insulation. The goal is controlled filtering of certain sound frequencies to minimize the noise level in the interior. The system can also help to reduce the noise penetrating from the interior to the exterior. A module consists of two perforated plates that can be shifted individually. In the presented prototype, the information of the soundscape was recorded with a microphone. When the noise level changes, a servo motor introduces a shift in the plates. The different settings are controlled by an Arduino Uno Board, for which an independent program was developed within the scope of the project. The different settings of the mutually overlying aperture patterns are to filter certain disturbing frequencies from the overall spectrum of the soundscape. The result is a Moiré effect, hence the project's name. The idea is based on the so-called Helmholtz absorber. SonicMoiré combines the purely functional aspects of selective noise reduction with a visual communication of its working method. This was further enhanced by integrating rear lighting.



- 1 SonicMoiré module
- 2 Fixing the first layer
- 3 Preparation of the sensors

WORKSHOP “THINKINGSKINS”, AACHEN

TEAM 3 – ISOLOCKER

IMAGINED BY students of the workshop ThinkingSkins in Aachen
SUPPORTED BY Professors of the RWTH

The building envelope's scope of functionality can be enhanced to fulfill daily household tasks. Today, the building envelope is a mediator between the inside and the outside space. Traditionally, it regulates the air exchange, solar incidence and the temperature balance. The project IsoLocker deals with the exchange of wares, of food in particular. Hereby, the constructive setup of a building envelope is seen as an ideal storage space. A new interface between delivery and receipt of goods is to be created by integrating a thermally insulated cavity. The IsoLocker is linked to a web-based platform and comprises two accesses: one on the inside and one on the outside. The aspect of automation in this project relates to the control of access rights. Suppliers use their access data to deposit the goods in the IsoLocker from the outside, which can then be removed from the inside, with secured access codes if needed. Considering the current development of rising market share of online warehouses, this enhancement can contribute to a time independence in daily life, since the customer need not to be personally present to accept goods.



- 1 Insulation of the interior
- 2 Assembly of the apertures
- 3 Interior volume of the IsoLocker

WORKSHOP “THINKINGSKINS”, AACHEN**TEAM 4 – SMART MESH**

IMAGINED BY students of the workshop ThinkingSkins in Aachen

SUPPORTED BY Professors of the RWTH

The objective of the Smart Mesh is to increase the thermal comfort of the interior space of buildings. The module consists of a grid of pneumatic components that allow gradual opening or closing of the building envelope. The system responds to inside and outside conditions, information about which is collected with light and temperature sensors. Changes in the weather trigger an adaptation of the construction. To realize the prototype presented here, the team used conventional balloons. An Arduino controller triggers the activation of a compressor system based on the sensor data, causing inflation or deflation of the balloons. The long-term vision of this idea assumes realization in the form of a network of many pneumatic parts distributed across the building envelope.



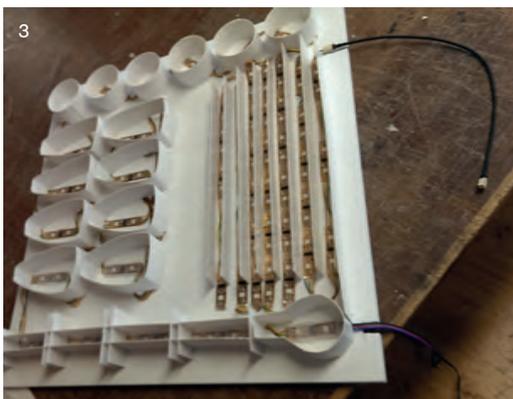
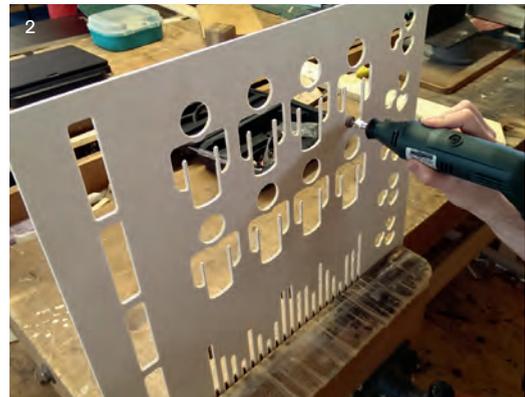
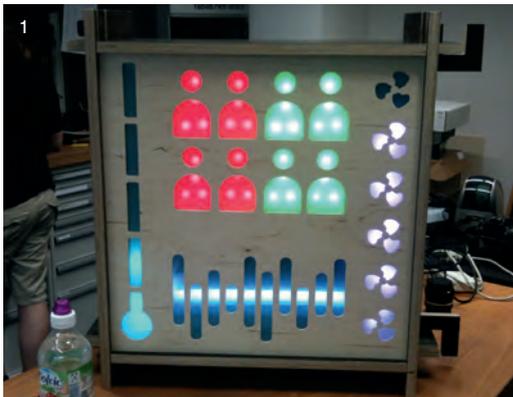
- 1 Prototype of Smart Mesh
- 2 Integration of micro-compressors
- 3 Function test of the compressors
- 4 Smart Mesh in closed state

WORKSHOP “THINKINGSKINS”, AACHEN**TEAM 5 – MONITOR**

IMAGINED BY students of the workshop ThinkingSkins in Aachen

SUPPORTED BY Professors of the RWTH

The idea behind the project “Monitor” is the visualization of relevant data concerning the indoor comfort of a multi-purpose classroom. Many schools and universities offer various rooms to be used for studying outside class hours. The conditions inside such rooms are important for successful studying: occupancy, noise level, temperature or oxygen level can strongly influence concentration. Relevant sensors can capture various indoor conditions. The data is analyzed and visualized in a simplified manner on a monitor. The presented information can help identify suitable rooms with good conditions, as well as introduce measures to improve certain conditions. In a long-term vision, the Monitor project is understood as a network of sensors that collects information throughout the entire building, and feeds it to one central area.



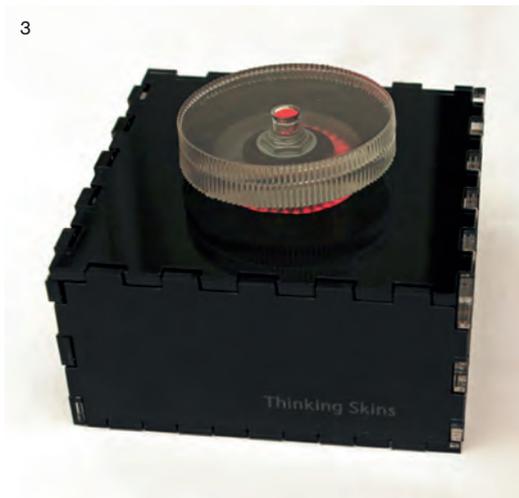
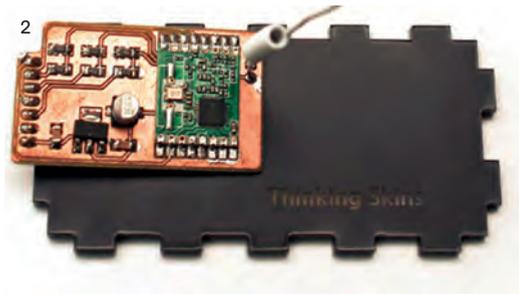
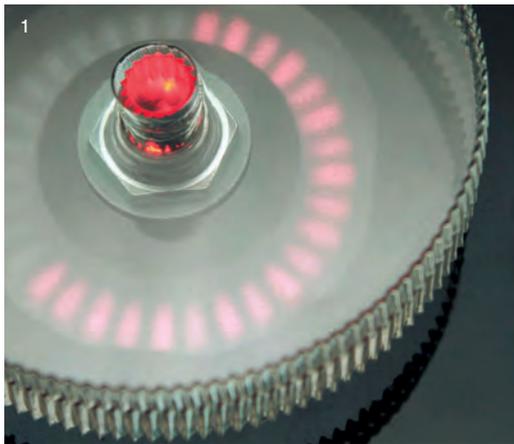
- 1 Monitor result 1
- 2 Post-processing of the front panels
- 3 Final rear side
- 4 Hardware of the wireless sensor

WORKSHOP “THINKINGSKINS”, AACHEN**TEAM 6 – SMART RFDUINO**

IMAGINED BY students of the workshop ThinkingSkins in Aachen

SUPPORTED BY Professors of the RWTH

In the project m3RFM, the building envelope is not exclusively understood as a physical barrier or a tangible construction. It deals with the virtual translation of a building envelope into an invisible network that covers the building. On one hand, this network comprises a multitude of sensors that collect indoor data throughout a building. Each sensor is equipped with a radio sensor with which the information is sent to a controller wirelessly. There also is a wireless network of actuators that can make adaptations to the interior according to the evaluated sensor data. The vision behind the idea is digital networking and the control of physical building parts. With this, the idea tries to transfer the concept of the “internet of things” to buildings, and to equip buildings with a virtual nervous system. In this project, prototypes with radio sensors were used as well as a platform for their communication. Instead of a facade panel the result was a concept of information and connectivity between the other prototypes of the workshop.



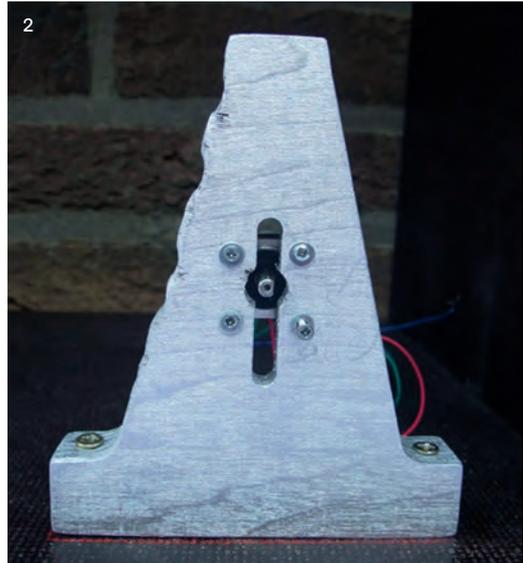
- 1 Rotary Encoder 1
- 2 RFM69 Breakout Board (BOB)
- 3 Rotary Encoder 2

WORKSHOP “THINKINGSKINS”, AACHEN**TEAM 7 – POLARIZING WINDOW**

IMAGINED BY students of the workshop ThinkingSkins in Aachen

SUPPORTED BY Professors of the RWTH

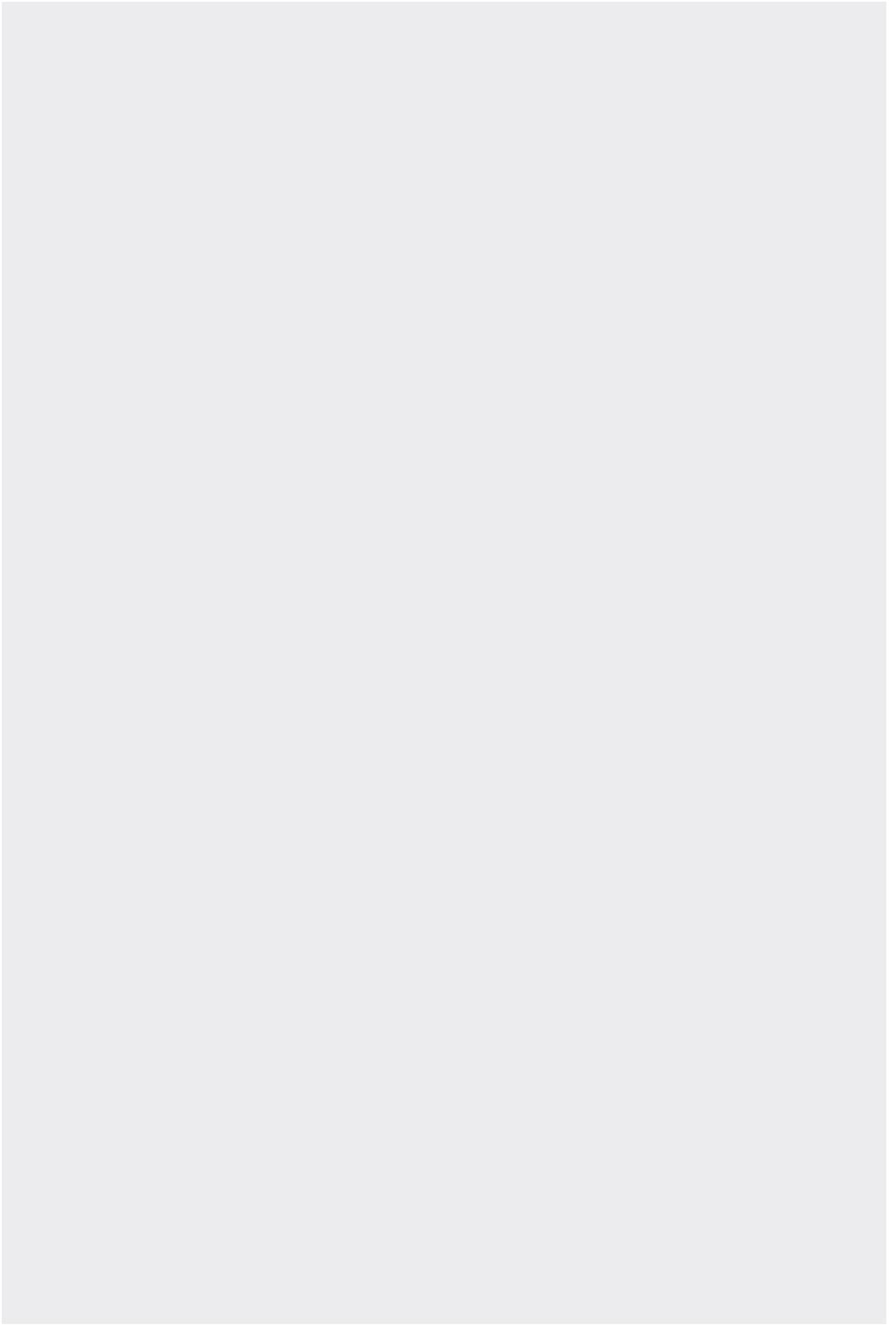
The goal of the Polarizing Window is automated shading of the indoor space with electrochromic glass or polarized foils. The design focuses on learning environments and is intended to provide very comfortable natural lighting. Direct and glaring light was to be avoided. The system was to be autarkic by evaluating current daylight conditions with sensors and thus generating dynamic shading. Electrochromic glass is very expensive; therefore, the team decided to realize their prototype with polarized foil. Hereby, two foils laid one above the other are rotated against each other. When the structure of the two foils runs parallel, the plane is transparent; when they are at a ninety-degree angle, the breaking of the light waves creates shading. When in operation the prototype uses the data of a light sensor for the automated realization of the function.



1 Polarizing Window – without cover

2 Mounting with integrated motor

3 Integration of the sensors



LUCERNE 2014: INTERACTION DESIGN

The main topic of the workshop in Lucerne was the human-computer communication or interaction, which is also known as interaction design, often abbreviated as IxD; it is about shaping and designing digital things, tools, products, environments and services for user needs. Interaction design has some interest in form and appearance but the main focus is on behavior. Students should imagine how their new designs and products are going to create new environments and experiences for the user. It is closely connected to software engineering and programming languages, and its main goal is to create a new experience for the users and satisfy their needs and desires.

The approach in the workshop was focused on solving individual problems and needs of the users by creating emotional responses in those users. During the semester – and before the workshop – the students of IFDC and MCDC worked on developing ideas and learning technologies to build new concepts and mock-ups. They were offered a short intensive course in Firefly (plug-in for Grasshopper). It is an open source software that allows students and users to start experiencing programming language functions and working with microcontrollers to control motors without the need to learn programming languages. It took the students only a few weeks to start playing with Arduino (a single-board microcontroller) and be able to give some orders to the computer controlling motors connected to the mock-ups. These ideas and mock-ups were the starting point for the three workshop days in Lucerne where around 30 students from three different

universities (HS OWL, Lucerne and TU Delft) and 17 nationalities met to challenge and further develop the ideas created at HS OWL.

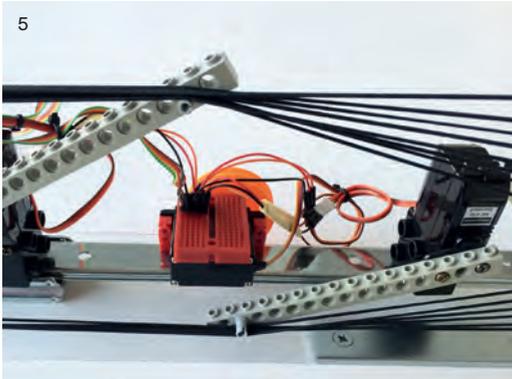
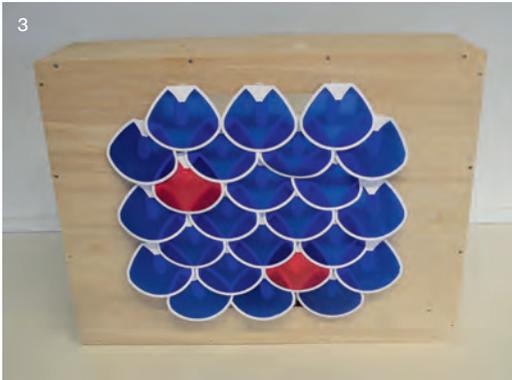
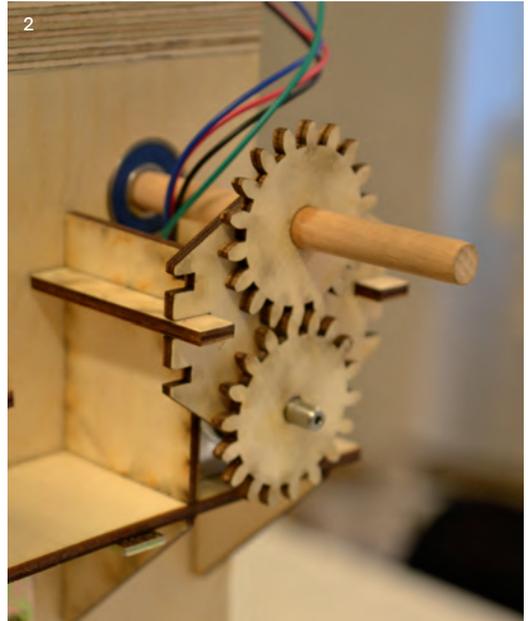
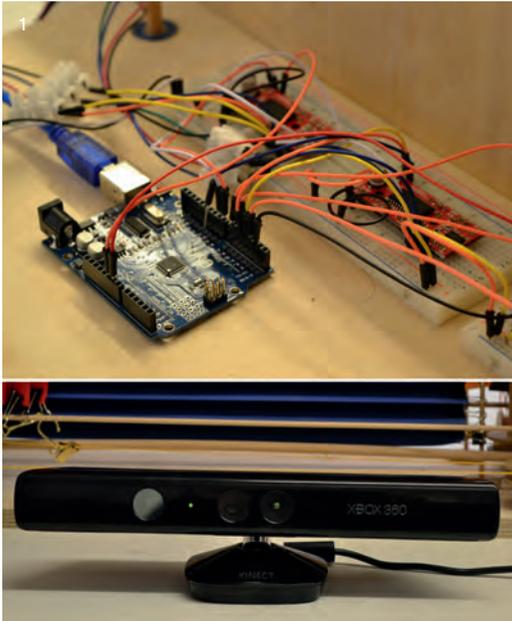
MOVABLE WINDOW

The “Movable Window” translates the human body movement into physical movement of facade elements. This will be especially useful for people with poor mobility who want to control the amount of light in the room, privacy and view (functional aspects and communication) just with the movement of their hands. Each user can create an individual gesture to control the window and adapt the position and size of the window according to their needs (individuality and communication). Controlling the movement of a heavy element from a long distance by mere movement of the hands is no longer an exclusive ability of superheroes in terms of emotional and fun aspects and communication.

Body movement is read by a Kinect Camera, an Xbox video game tool (technology from another industry), and is translated into the digital model. The Grasshopper Firefly definition connected to an Arduino UNO board converts the physical movement of the hands into the physical movement of the window elements using a specific formula. In a brief interdisciplinary workshop, the students built a very interesting physical prototype.

INFLATABLE FACADE

Indoor air quality affects comfort and productivity of the users. High CO₂ concentration causes headaches and lethargy especially in multi-user areas such as



1-2 Movable window
3 Inflatable facade
4-6 The nervous facade
5 The walking entrance mock-up

classrooms, conference rooms and offices. Users do not always notice that the CO₂ concentration is high and open windows. But opening windows may not be a solution when it is windy and cold. The system proposed in this concept detects the amount of CO₂ and adjusts the lamellas of a facade to enable the required fresh air to enter the room.

Inspired by Mimosa movement, the adaptive facade closes when air is released from the system and vice versa. The shape is inspired by the scales of fish; the panels overlap, which serves drainage functions as well.

The mock-up was realized by using Arduino (a microcontroller board), sensor or smart phone application, Grasshopper software and motors. Arduino takes the data and transmits it to Grasshopper which analyses the input and generates the corresponding movement of the Rhino 3D model. Arduino transmits the movement to the motors as well. The communication between Grasshopper and Arduino is established via Firefly (Grasshopper plug-in).

A step motor making a 180-degree rotation movement was used to control the movement of the lamellas. This movement is converted to a linear movement by a Scotch-Yoke mechanism enabling pistons of the syringes to make their way back and forth. The syringes are part of an air circuit composed of pipes, connectors and latex balloons. Each balloon is connected to a panel. When the syringe sucks the air from the system, the balloon is deflated and the panel drops. When the syringe blows air into the system, the balloons are inflated and move the panels up.

NERVOUS FACADE

The goal of this project was to design a cladding system that is not only visually attractive, but also warns about oncoming rain and provides shelter. The goal is to create an

emotional connection between people walking in the street and the envelope itself, and to draw them closer to the building. The cladding system is supposed to shiver and change the shivering frequency on the basis of online information (weather forecasts), for example to highlight the chance of rain showers – information obtained from meteorological centers by a program connected to the Grasshopper definition. The cladding system is also supposed to open and provide rain shelter for people once it starts raining. It is connected to the water sensor using Firefly and input for the Arduino.

The mock-up was realized with Grasshopper software (Firefly plug-in), an Arduino board, a gear motor and a servo motor. There were two different definitions made by Grasshopper that controlled the mock-up, the first with regard to the shivering movement to warn people about expected rain and the second with regard to the lifting mechanism that raises a number of cladding panels to protect people from rain.

The Arduino was programmed using the Grasshopper plug-in called Firefly in such a way that when the chance of rain is great the gear motor begins to rotate, causing the panels to shiver; the greater the chance of rain, the faster the panels will shiver. On the other hand, when there is water present on the rain sensor, the servo motor rotates the panels 90° to provide a rain shelter, and when the sensor is dry, the motor pushes the panels back to their original position.

Basically, Arduino converts digital input obtained from Firefly/Grasshopper to mechanical output for the motors. The mechanisms are achieved by using circular discs mounted on an 8mm diameter rod. There are 3mm diameter sticks mounted on the discs at various angles for the shivering mechanism and longer 3mm diameter sticks for the lifting mechanism.

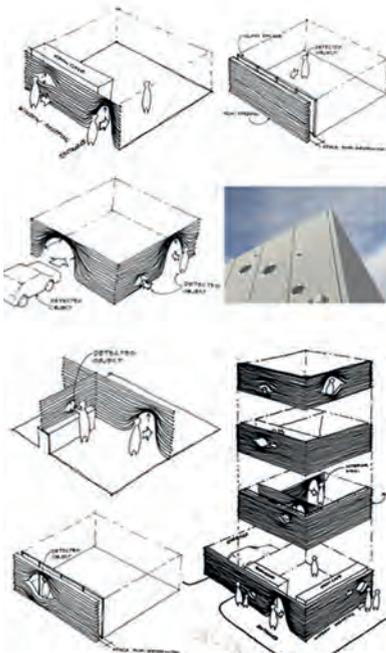
WALKING ENTRANCE

Where is the entrance? This is a typical question when people approach a building, especially if it is a big building. This small challenge to find the entrance was the core idea for this mock-up. The solution for this challenge was quite simple; instead of the people moving around trying to find the entrance, why not have the entrance start moving around to find the people, and let them get inside the building whatever the angle at which they approach it.

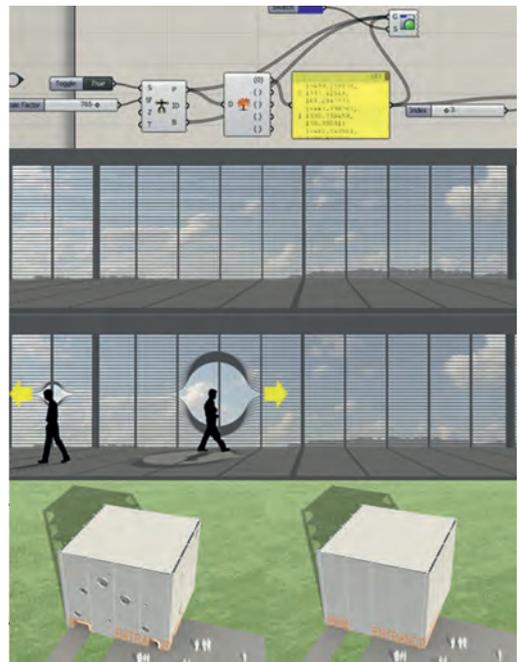
The mock-up was realized by using Kinect (an Xbox video game tool), one stepper motor and two servo motors, rubber strings, Lego parts and a track.

The envelope of the building was represented with rubber strings mounted horizontally along

the mock-up. Kinect was used to detect the skeleton and the movement of the person approaching the building. Kinect transfers the human skeleton and its movement to points with coordinates on the computer using Grasshopper software (Firefly plug-in). These coordinates are transferred to control the motors using an Arduino board. The movable door was called "Roby": it has two horizontal arms which rotate in different directions to create the opening in the envelope for the person using two servo motors. These arms also define the size of the "door" opening in relation to the distance between the person and the building: the closer the person gets to the building, the bigger the opening by Roby will be. Roby also moves on a track, using a stepper motor, in order to follow the person approaching the building.



The walking entrance concept



WORKSHOP "THINKINGSKINS", DELFT

IMAGINED BY students of the Technical University Delft,
Lund University and Ostwestfalen – Lippe University of Applied Sciences
SUPPORTED BY Jens Böke and Jens Renneke

The workshop took place in June 2015 at Delft University of Technology. As part of the facade week it was connected to the conference "The Future Envelope 2015". The workshop was led by Jens Böke, oriented toward his doctoral thesis with the same topic: ThinkingSkins – intelligent control of adaptive facade functions. A total of nine students from the disciplines of architecture and facade planning from various locations such as TU Delft, Lund University in Sweden and Ostwestfalen-Lippe University of Applied Sciences in Germany participated in the event. The contact person on site was Arie Bergsma, who organized the link to the running educational program as well as the availability of rooms and machines. In terms of technical issues, the workshop was accompanied by Jens Renneke who supported the students in building the prototypes with his craftsmanship experience. The workshop was conventionalized, based on the conviction that such intensive collaboration poses great potential for developing new ideas. Firstly, the workshop took place in a predefined time-span. It is

particularly such a time-limited collaboration that forces participants to work in an intensive and result-oriented manner. The description of the task, the first ideas, their realization and subsequent presentation covered a mere three days. Due to the short timeframe, the organization of the materials, locations, machines and external input was focused and thus very efficient. In contrast to other workshops of this series, no groups were formed. Each participant developed an individual project. However, communication within the workshop was particularly intensive. Hereby the debates about ideas and questions between the participants were as important as the dialogue with the supervisors.

The workshop was preceded by various preparation tasks that were predominantly carried out at the University of Applied Sciences in Detmold. One objective was a comparable format of the results. This was to be ensured by prefabricating frame constructions, into which the students were to integrate their prototypes. The properties



of the frames were subject to various requirements: they had to be combinable so that several results could be merged into one prototype in efnMOBILE format. In addition, transportability and affordable production were important prerequisites. Therefore, MDF boxes (dimensions: height 30cm, width 74cm, depth 38cm) were built at the University of Applied Sciences Detmold as templates.

Templates were also created for the poster-based graphic elaboration of the concepts. This was to ensure the completeness of all project content and their comparability. According to this template, each project comprises three posters: firstly, a template for the analysis of the facade function and its requirements related to possible automation;

secondly, a template to present the concept; and thirdly, a template to document the development process of the prototype. Materials for the creative process of generating ideas as well as building materials for the production of the prototypes were acquired. All aforementioned preparations ensured the desired project quality and the possibility to focus exclusively on the content of the task during the intensive work days of the workshop. The mobile format of the workshop event required additional logistical preparations. Transportation of the prefabricated frames and gathering existing tools and devices had to be organized between Detmold and Delft. And other organizational issues had to be coordinated from remote.



4



5



- 1 Empty MDF frame as realized for the workshop
- 2 Loading for the transportation of tools and MDF boxes to Delft
- 3 EFNm Toolbox
- 4 Digital model of single template frame
- 5 Digital model of combined template frames

WORKSHOP DAY 1

The workshop itself began with an introduction by Susanne Gosztanyi, from Sweden's Lund University, who conveyed important background knowledge about adaptive building envelopes. What is an adaptive facade? Why is this topic interesting with regard to building envelopes? What are the characteristics and functionalities of adaptive building envelopes and which mechanisms are necessary to realize adaptation? The lecture offered the participants a basic understanding of the topic, and was thus decisive in providing all participants, with their various knowledge bases, with a contextual reference to the driving topic. Jens Böke's lecture was based on the background information given by Susanne Gosztanyi, and concentrated on the concrete topic of the "ThinkingSkins" workshop. When researching ThinkingSkins, the main aspects are intelligent control and possible inter-networking of automated, adaptive facade functions. The research is in its infancy and it is not yet clear which facade functions, beyond those of ventilating, heating, cooling, lighting or shading, have the potential to be automated. Traditionally, the building envelope's tasks are fulfilled with static constructions. But which of these can be automated in which way? And what is the concrete added value, the performance gain, of an adaptive version? The relevance of possible automation has hitherto only been proven for a few, mostly obvious parts of the building envelope. A classic example is sun protection; a comparatively simple adaptation of a shading system based on the solar angle can achieve good optimization.

It is also interesting to examine the requirements various functions make of possible automation if a basic potential has been identified. An understanding of the classic construction principles of individual facade functions is mandatory for such a discussion of the topic, as well as an examination of the influences and factors of the functions relevant to automation. The workshop topic was precisely this discussion about the individual facade functions and their transfer potential into automated adaptive realization. Besides a presentation of the topic, the lecture also described the tasks and process of the workshop.





The concrete workshop task was to examine the transferability of individual facade functions into adaptive realizations, and to develop appropriate concepts of construction. The starting-point for the development of ideas was individual functions of the facade. By drawing lots, each student was given a facade function, which formed the topic of the particular project.

In a first step, important information about the particular facade function needed to be determined for the concept development. Each function is subject to specific influences and dependencies that need to be understood when trying to develop new solutions. Furthermore, there are different requirements for the feasibility of automation; for example, whether information about relevant influences can indeed be collected. Or whether reactions make sense in particular scenarios. In addition, it is crucial to know whether conceivable measures can be realized with technical means, for example with a motor. The results of this analysis of the facade functions were recorded in poster 1; they serve as the basis for further developing innovative proposals.

Based on the analyses, initial ideas for possible function automation were generated. Scenarios were developed for which automation seemed to make sense. This step enables a clear formulation of the changing influences on and requirements of the adaptation to be conceptualized. Each participant sketched a total of three project ideas on posters: here each idea was to be described using a title, a short description and simple graphic illustrations. It was important to convey the core idea of the adaptation. At the end of the first day the ideas were presented to and discussed by the entire group. The goal was to choose the option that offered the greatest potential for further elaborating the topic from the three options presented by each participant. Often, the decision for a particular idea was not easy, since many ideas involved interesting aspects.

- 1 Kickoff lecture by Susanne Gosztanyi
- 2 Ideation 1
- 3 Discussion of concepts
- 4 Presentation and discussion of first ideas 1

WORKSHOP DAY 2

On the second day of the workshop Wijnand Manen, representing the Alcoa company, gave an impromptu lecture. Under the motto “Enabling Technologies” he offered an industry-oriented insight into current new developments. Amongst others, additive manufacturing was presented as a technology available for facade construction. Additionally, he presented several prototypes of 3D printed facade nodes that offered a tangible understanding of the topic. Part of the presentation was an illustration of the so-called Next Facade, which also deals with intelligent automation of the building envelope.

Another work phase followed the lecture during which selected ideas were to be transferred into realizable concepts. These quickly became concrete: passive ventilation based on the chimney effect, controlled by opening and closing a nozzle; acoustic insulation that lets pleasant sounds penetrate, and filters acoustic disturbances in accordance with the particular soundscape; or a Mashrabiya that allows for different degrees of openness of the facade by means of pattern layers that can be shifted individually. The elaboration of the concepts was carried out based on the second poster template. Besides the revised illustration of the work principle of the automated function, the realization of the concept in the form of a functional prototype now stood at the forefront. It was important to understand the prototype as a sort of visualization of the automation. Thus, the development of the prototype was not the primary goal of the workshop but rather a tool to illustrate and examine the particular concept of automation. How can the work principle of the automated function be translated into a prototype?

The prefabricated MDF frames were the starting points for building the prototypes. They were given to the participants at the beginning of the workshop together with a digital model. The students were free to use both for their task. While some participants only used the 3D model to verify dimensions and to visualize the concept, others used it for digital planning. This was because many of the developed prototypes included mechanical parts for which the requirements and assembly depended on precisely executed digital preplanning. Digital tools were





always used in those cases where complex geometries had to be generated, or the prototype comprised large numbers of individual building parts or involved precise mechanics.

Consequently, the availability of machines for digital fabrication was vital: during the workshop a 3-axis mill was used with which several complex and larger building parts were processed. There was also a 3D printer (Stratasys – plastic for robust results/resilient mechanical building parts), which was used for several smaller building parts that exhibited a degree of complexity due to their use at mechanical key positions. However, the most often used fabrication tool was the laser cutter, which allowed the students to produce a large number of two-dimensional parts made of wood, cardboard and acrylic in a relatively cheap manner. In addition to the digital fabrication, various smaller tools from the efnMOBILE inventory were used; a table saw, clamps and pliers, glues and cutters were essential tools for the successful realization of the models.

Depending on the concept, materials choices had to be made; some were available but many had to be purchased. Besides the requirement to use the prefabricated frame there were no requirements or restrictions concerning the choice of material. But the expressiveness of the design, the processability with the available machines and tools as well as the financial expenditure for the materials were criteria for the selection. In some cases, parts for the prototype were made from cheap consumables or products such as moving boxes, lamp shades, freezer bags or paperclips. The focus lay on the expressiveness and the proper functioning of the result. The development process of the prototypes was documented on the third poster template, and was thus part of the graphic documentation of the projects.

- 1 Workshop atmosphere 1
- 2 Working on the prototypes
- 3 Elaborating concepts in 3D
- 4 Mounting the adaptive shading device

WORKSHOP DAY 3

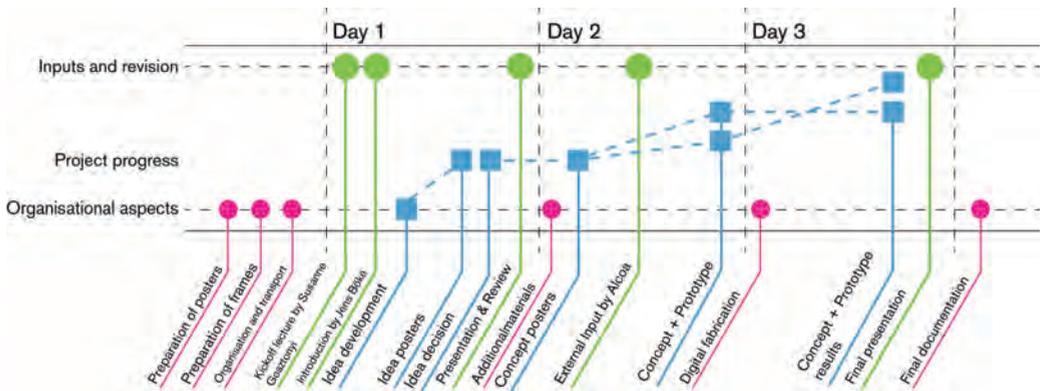
Day 3 was the day of presenting the results and was accordingly intensive. Firstly, the prototypes were completed. The digitally fabricated individual parts necessary for almost all projects had been produced overnight. The morning of the third day was all about the final assembly of these components. Depending on the design, the efforts to produce it varied greatly and the workshop participants helped each other to meet the deadline. The actual building of the prototypes sometimes resulted in new insights and subsequent adaptation of the design concept. Such changes were recorded on the presentation posters during the last layout phase. The building phase also resulted in a lot of imagery to be added to the presentations. The three posters of each project had to go to the printer at the same time. With the technical support of Jens Renneke all results were realized in time and then exhibited. The presentation took place as an agenda item of Facade Week 2015 in Delft, before the committee of the European Facade Network (EFN) in Delft. The event was rounded off with a barbecue at the Faculty of Architecture at TU Delft.



- 1 Group image of the workshop participants
- 2 Laser-cut plywood elements
- 3 Detail of assembled result
- 4 Final presentation of posters and prototypes

RESULT

The result was a total of eight individual projects, consisting of concept posters with the related prototype. Part of the workshop was to examine those functions of the building envelope for which automation does not immediately seem obvious. Surprisingly, in many cases automation of the examined facade functions was indeed promising, and very different scenarios arose in which automation was conceivable in different ways. The project results were exhibited and presented at the conference “The Future Envelope 2015” in Delft.



COMBIP

Combi-panel daylight level

COMBIP is a modular facade system designed to optimize daylight levels in office spaces. It consists of a grid of panels that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

COMBIP - DAYLIGHT LEVEL

COMBIP is designed to provide a high level of daylight in office spaces. It is a modular facade system that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

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Flexi-Fabric Facade

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The Flexi-Fabric Facade is a revolutionary building facade system that combines the benefits of glass and fabric. It is designed to be flexible and adaptable to different building types and climates. The facade is made of a series of interconnected panels that can be adjusted to control the amount of light entering the building.

EXTERIORS

The Flexi-Fabric Facade is designed to provide a high level of daylight in office spaces. It is a modular facade system that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

No sunlight with sunlight

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CONTROL AIR-CHANGE / „Fan-ry“

Why CO2 demand control?

CO2 demand control is a system that allows for the adjustment of air change rates based on the current CO2 levels in a space. This helps to optimize energy usage and improve indoor air quality.

Problem: Usually shade conditions will no need for adjusting air change rates across the facade.

Solution: The fan-ry control system allows for the adjustment of air change rates based on the current CO2 levels in a space. This helps to optimize energy usage and improve indoor air quality.

CONTROL AIR-CHANGE / „Fan-ry“

The fan-ry control system is a revolutionary building facade system that allows for the adjustment of air change rates based on the current CO2 levels in a space. This helps to optimize energy usage and improve indoor air quality.

CONTROL AIR-CHANGE / „Fan-ry“

The fan-ry control system is designed to provide a high level of daylight in office spaces. It is a modular facade system that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

MONITOR FACADE PERFORMANCE / „Control Panel“

MONITOR - No basis of the Control

The monitor facade performance system is a revolutionary building facade system that allows for the monitoring of facade performance in real-time. This helps to optimize energy usage and improve indoor air quality.

MONITOR - No basis of the Control

The monitor facade performance system is designed to provide a high level of daylight in office spaces. It is a modular facade system that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

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Electrostatic Transparency - Preventing unwanted energy loss

ELECTROSTATIC TRANSPARENCY

Electrostatic transparency is a revolutionary building facade system that allows for the prevention of unwanted energy loss. This helps to optimize energy usage and improve indoor air quality.

ELECTROSTATIC TRANSPARENCY

Electrostatic transparency is designed to provide a high level of daylight in office spaces. It is a modular facade system that can be adjusted to control the amount of light entering the building. The system is designed to be flexible and adaptable to different building types and climates.

Electrostatic Transparency - Preventing unwanted energy loss

Electrostatic Transparency is a technology that allows light to pass through while blocking heat. It is used in windows to reduce energy loss.

Whoever is careless with the truth in small matters cannot be trusted with important matters. Albert Einstein

Solar Fly Collector Facade

Thermal energy collecting facade

The facade is designed to collect solar energy and convert it into electricity. It is made of a material that is transparent to light but opaque to heat.

Solar Fly Collector Facade

The facade is made of a material that is transparent to light but opaque to heat. It is designed to collect solar energy and convert it into electricity.

Protect against falling out of the window-net Facade

The net facade is designed to prevent people from falling out of the window. It is made of a material that is transparent to light but opaque to heat.

Whoever is careless with the truth in small matters cannot be trusted with important matters. Albert Einstein

Protect against falling down out of the window-net Facade

The net facade is designed to prevent people from falling out of the window. It is made of a material that is transparent to light but opaque to heat.

VETB

Research in Laboratory, Experimentation

VETB is a research project that focuses on the development of a new type of facade. It is designed to be transparent to light but opaque to heat.

VETB

Water EVAPORATIVE COOLING works

The water evaporative cooling system is designed to cool the air by evaporation. It is made of a material that is transparent to light but opaque to heat.

Allow Visual Contact

Visual Contact

The visual contact system is designed to allow people to see each other through the facade. It is made of a material that is transparent to light but opaque to heat.

Allow Visual Contact

The visual contact system is designed to allow people to see each other through the facade. It is made of a material that is transparent to light but opaque to heat.

SAMPLE PROJECT

ACOUSTIC INSULATION

IMAGINED BY Alexander Fillies

SUPPORTED BY Jens Böke and Jens Renneke

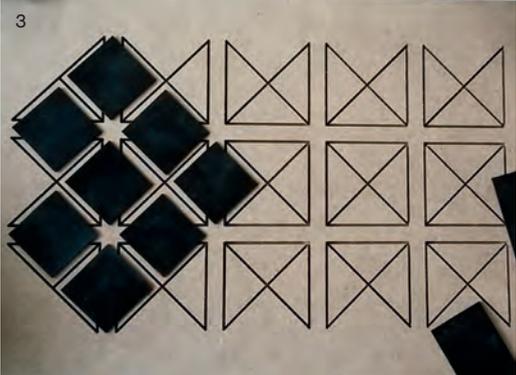
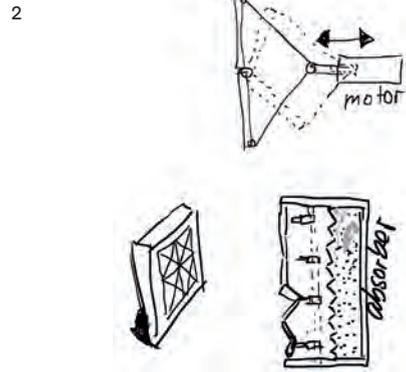
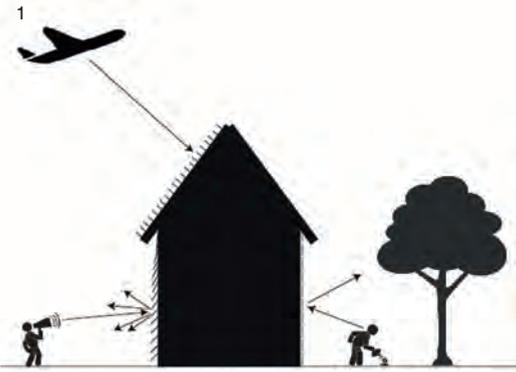
This example is the project of student Alexander Fillies, dealing with the facade function of “providing acoustic insulation”. His concept mainly focused on protecting the indoor space from disturbing sounds from outside.

In the beginning, different sound sources were examined. Sound spreads via waves and is differentiated by volume, frequency and duration. Depending on the type and source, it is sensed positively or negatively. A concrete scenario was developed for this design, with a building being exposed to different acoustic influences. Pleasant sounds, such as sounds from nature, were to be allowed to enter the interior whereas disturbing sounds such as airplane or construction noise was to be filtered.

Initially, it was necessary to collect differentiated information about the acoustic influences. Multi-faceted and affordable acoustic sensor technology is readily available. Simple microphones can collect information about the intensity and quality of acoustic signals and can make them usable for computer-controlled responses. In Alexander Fillies' design, a network of such microphones was to be distributed across the entire surface of the building envelope, integrated in the construction. The result is a 360° sensation of the acoustic environment that can also detect the direction of the sound source by means of measured volumes. The measured values are analyzed in real time via digital control, and are then transferred to a corresponding response by the building envelope.

There are three possible types of response: reflection, absorption and diffusion. With reflection, smooth and hard surfaces allow the soundwaves to be reflected in the opposite direction. With diffusion, the soundwaves are broken up and blurred by structured material surfaces, while soft and porous materials absorb the sound. The adaptive construction by Alexander Fillies can react dynamically by opening and closing a sound absorbing layer in the facade. Depending on the measured acoustic environment, the sound is absorbed in the event of noise overload. This example proposes a network of independently working opening mechanisms that responds locally to volumes measured in certain areas of the building envelope.

In addition to the poster based concept visualization, this project also included a prototype, mostly realized with digital fabrication. The prototype comprises a system of openable flaps, driven by servo motors, to illustrate the opening and closing of the absorbing layer. Several microphones were installed to collect surrounding acoustic data. The responses were controlled with an Arduino micro-controller programmed accordingly.



- 1 Concept image 1
- 2 Concept image 2
- 3 Assembly of the opening mechanisms
- 4 Final assembly of the front panel
- 5 3D printed gears are connected to a servo motor to automate the prototype
- 6 Final pattern of openings

WORKSHOP

"FACADETRONICS", DETMOLD

IMAGINED BY students of the Lucerne University of Applied Sciences and Arts and Ostwestfalen-Lippe University of Applied Sciences in Detmold
SUPPORTED BY Jens Böke and Jan Christoph Kahre Heidemann

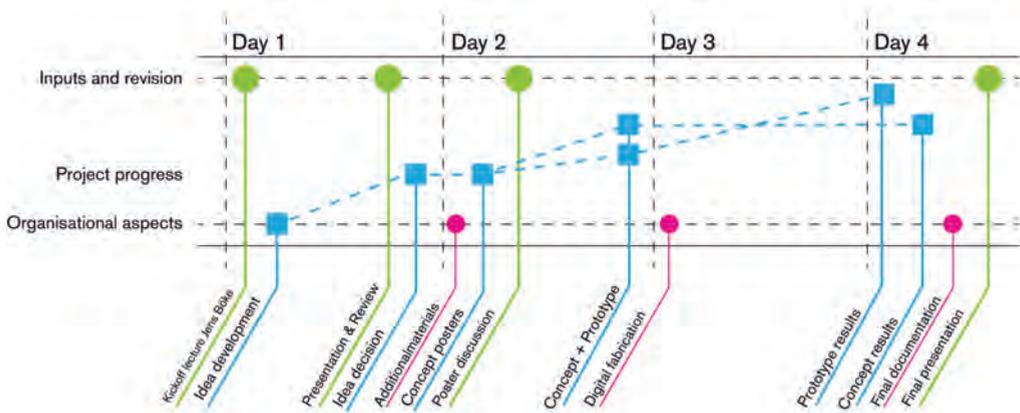
The workshop is the fourth in the series with the driver topic "Adaptation". It took place from 23/11 to 26/11/2015 as an international event at Ostwestfalen-Lippe University of Applied Sciences in Detmold, Germany. Participants were students of the facade Master program in Detmold and Lucerne, as well as students of the parallel Master program Computational Design and Construction in Detmold. Jens Böke was responsible for the content of the workshop. Jan C. Kahre Heidemann provided technical support to the participants for the realization of their prototypes. Titled "Facadetrronics", the workshop served to develop innovative automation concepts for future "adaptive" facade systems. The topic can be understood as an elaboration of the workshop in Delft. The projects of this workshop were developed based on the same format and model templates as those in the Delft workshop.

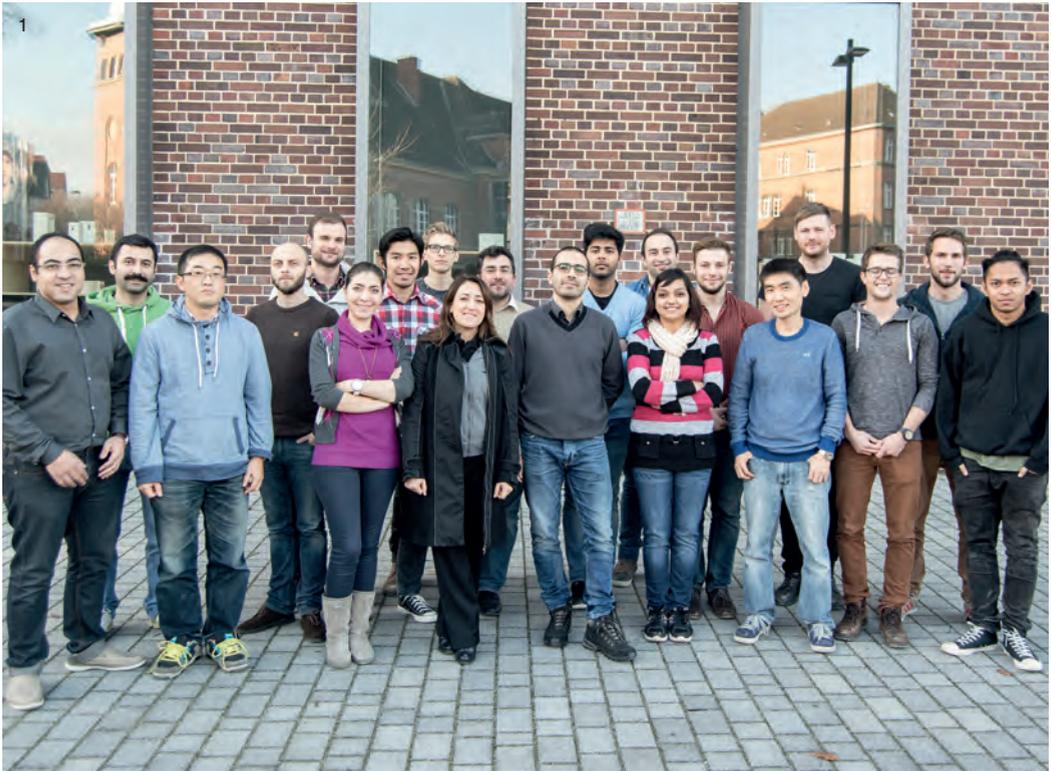
The workshop was closely linked to the conference "facade2015 – COMPUTATIONAL OPTIMISATION" held on 27/11/2015. At the conference, the influence of computer technology on design and production processes and their results in facade development was discussed.

The event was divided into three parts: session 1 - design phase, session 2 - production, and session 3 - operational phase of buildings.

In the context of adaptive building envelopes, computer-based digital control of automated facade functions during the usage phase of building is gaining importance.

The "Facadetrronics" workshop should be seen against this background. Again, the starting point was the functions of the facade.





Contrary to the preceding workshop in Delft, however, the functions were limited to those that are influenced by the factor "sun". The participants in the workshop formed teams of two to examine functions such as "control daylight radiation", "provide a comfortable daylight level" or "redirect daylight" as to their potential for automation. Another focus of this event lay on the development of kinetic building parts for facades, particularly based on the conception of digitally controlled behavior. Therefore, the prototypes were to include integration and control of electro-technical parts.

A total of eight new projects were generated during the four days of the program, each documented with a poster and a prototype. All projects were developed based on a digital design process. The designs stepped off from 3D models constructed in different programs depending on the field of study of the students. In many cases, Rhinoceros3D in

combination with Grasshopper3D was used. Similar to the other workshops, digital fabrication was extensively used to build the prototypes in addition to the tools of the efnMOBILE program. The laser cutter proved to be a significant fabrication tool, used in every single project.

1 Group image of the workshop participants in Detmold

WORKSHOP DAY 1

On the morning of 23/11/2015, the workshop started in the atelier for three-dimensional design at the chair of Architecture in Detmold with an introduction by Jens Böke. The introductory presentation included the contextual background of the topic, the concrete workshop task as well as organizational aspects such as availability of tools or the intended progress of the workshop. Mutual introduction of the students, team setup and task assignment were also part of the introduction.

Each team then developed three automation ideas for its respective assigned task. The students only had one hour before they had to present these ideas to the rest of the group. Following a round table discussion, the most promising of the three ideas was selected. Thus, each team had a concrete idea to work on in the afternoon of the first workshop day. It had to be elaborated with additional knowledge and summarized on a poster before the following morning.



- 1 Concept development
- 2-3 Team based discussions
- 4 Feedback and support

WORKSHOP DAY 2

On the morning of the second day there was another presentation of the concept posters completed up to that time. During a feedback session the concepts were critically questioned, and adapted or added to if necessary. Possible realization of the prototypes was discussed as well. How can the concept be visualized true to functionality? It was necessary to quickly decide on a particular method of realization in order to acquire necessary materials in time. The student teams received the frame construction templates during the following work session. The frame templates were also provided as digital 3D models to offer the students quick access.

In the afternoon, Jens Böke gave the teams contextual input in individual conversations, and Jan C. Kahre Heidemann offered technical consultancy on the realization of the prototypes. At the end of the day all teams had a concrete idea of how they wanted to create their prototype. A shopping list was drawn up of all missing items and materials, to be purchased the next morning.



WORKSHOP DAY 3

Wednesday was used purely as a working day. The teams received final, individual advice for the realization of their projects, and otherwise worked on their concept posters or prototypes. The 3D models of the concepts were completed during the afternoon, tested in smaller work models and then output as production data. The laser cutter was used to produce the parts. Poplar wood, MDF or cardboard was used, depending on the concept. The laser cut parts were integrated and mounted into the prefabricated frames. Most projects included moveable and controllable parts, so realization also involved hinges, pivots or joints for servo motors.



WORKSHOP DAY 4

Thursday 26/11/2015 was the last day of the workshop program. Assembly of the prototypes was completed in the morning. Additionally, electro-technical parts were integrated whenever possible, digitally controlled by an Arduino micro-controller. Servo motors, LED lights and computer fans were also used. In addition to the concept poster and the prototype, documentation of the building process was also part of the workshop task. After completion of the model-making activities, the teams went back to complete or update their layouts, imagery and descriptions. All projects were completed and documented by noon. The two required posters of each team were saved as .pdf files to allow for projector presentation. The room was cleaned and prepared for the presentation event.

Within the framework of the conference week various meetings took place on campus in Detmold. For example, the representatives of the European Facade Networks (EFN) met, and the curator meeting of the Detmold Master programs M-CDC and IFDC took place. After lunch, the teams presented the workshop results to the meeting participants. Also present were Thimo Ebbert and Jens Kochheim as representatives of KAWNEER (of the Alcoa Foundation). Each presentation consisted of a five-minute speech, followed by a discussion during which the guests questioned and commented on the ideas.



7-8 Assembly of laser-cut results

SAMPLE PROJECT

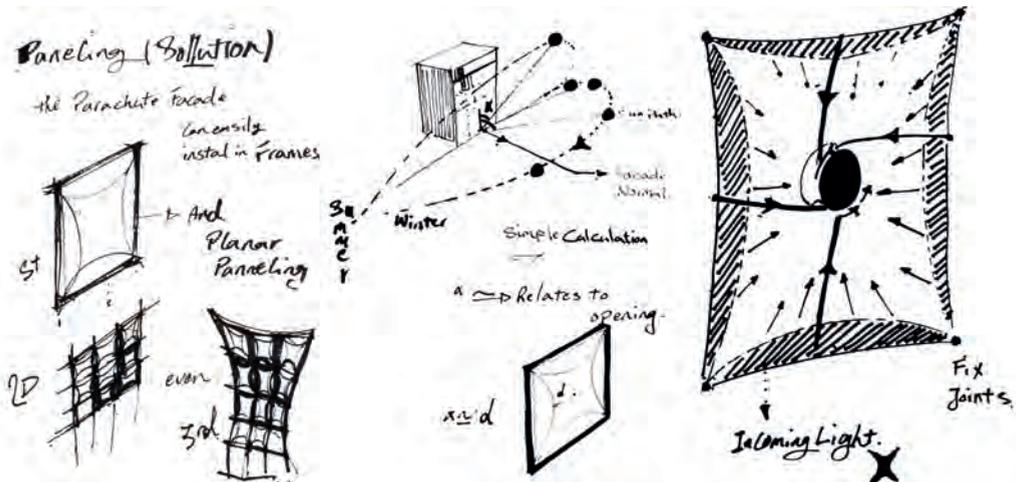
PARACHUTE FACADE

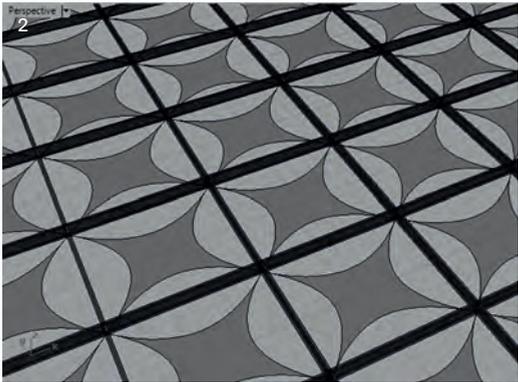
IMAGINED BY Amir Saadat Fard and Bahman Bidmeshki,
SUPPORTED BY Jens Böke and Jan Christoph Kahre Heidemann

The idea of the Parachute Facade project is to create a controllable sun protection system with textile surfaces. Based on the concept of students Amir Saadatfard (Master – Computational Design and Construction) and Bahman Bidmeshki (International Facade Design and Construction), a piece of stretchy fabric was mounted on a frame. Adaptability of the construction is achieved with a stepper motor integrated in the fabric. Depending on the solar radiation, the motor increases or decreases shading by tightening or loosening the fabric. An array of these elements creates an interesting aperture structure with individually controllable components. Depending on its exposition to sunlight, the most suitable degree of opening can be adjusted following the path of the sun.

With their prototype, the students present the technical principle of the concept. Following its introduction, they want to develop the product further to create an autarkic component that could either be integrated into a facade element or mounted on the inside. Variants of the product can be generated by exploiting different material properties of the fabric used. Color, opaqueness and opacity can be varied to create different visual appearances of the building envelope. The frame was conceived with aluminum. Light sensors integrated in the frame could produce a product that responds self-sufficiently. Only a power supply for the sensor, control and stepper motor must be provided.

1





1 Parachute facade concept drawings

2-3 Digital design model

4 Realization of the prototype



6. efnMOBILE ON SHOW

efnMOBILE ON SHOW

Mock-ups need to be seen. All the work and enthusiasm that went into them make it imperative that the results are exhibited – otherwise the message can only be sent to the participants. Thus the workshops were organized to generate mock-ups, with which the results can be presented to a larger audience in a very clear manner – and in a larger context. Each workshop ended with an internal presentation for all participants, typically followed by an exhibition as part of a concurrent conference of the European Facade Network (“The Future Envelope” in Bath and Delft, “facadeXX” in Lucerne and Detmold). On these occasions, explanatory posters complemented the exhibited mock-ups. Frame systems made of aluminum profiles were developed for the mock-ups, firstly to offer a degree of comparability between the results, and secondly to limit the dimensions, because without this the didactic layout of the workshops would lack dimensional limitation and thus leave behind a disturbing indefinability. The posters were laid out in such a way that they included the storyline of the particular idea and concept, as well as their development and further future potential – highlighting the process as well as the result.

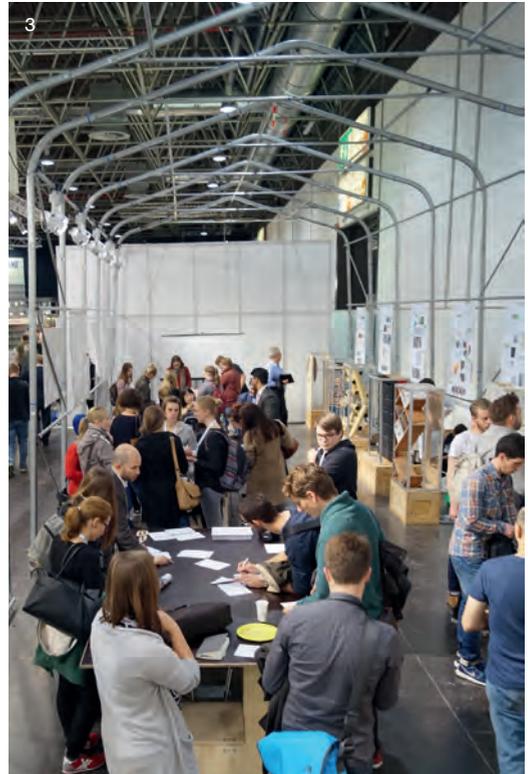
Even though their statutes prevented our sponsor, Alcoa, to exert any influence on the program we did want to involve the company, as well as its local representative, in the project. In some cases, this was very successful in that in addition to direct participation in the

workshops and the consequent necessary supervision with regard to the topic of facades, a broader connection with our students could be established.

Independently of the workshops, the program also participated in the GEVEL Total trade fair in Utrecht in 2014. In the Netherlands this trade fair is the principal convention for building and facade products, and is typically organized in a manner whereby, in addition to the regular exhibitors with their products, there is a central area presenting innovations in science, education and practice. Besides other programs, the mock-ups and posters of the first two workshops in Detmold and Delft were shown here.

Also in 2014, we exhibited our work at Glasstec in Düsseldorf, Germany. Glasstec is the worldwide leading trade fair related to building with glass, an event where manufacturers, planners, processors and scientists meet. Besides the traditional exhibitor program, a comprehensive accompanying program is offered; Glass Technology Live, an exhibition for glass product innovation, as well as a competency center of the glass-processing industry. There are also conferences in the fields of planning and architecture, science and application.

efnMOBILE was presented with its own booth – with the objective of demonstrating its hands-on approach, independent of manufacturers and other relations, as well as to demonstrate education in the field of facade technology and its innovation potential using the



- 1 Team, Detmold 2013
- 2 The teams in discussion in Bath 2014
- 3 Booth in action in Düsseldorf 2014
- 4 Glasstec exhibition 2014

exhibited mock-ups and posters. The concept was to make the process of developing and building visible – not so much the beautiful end-products but rather the roughness of doing was the goal of the presentation. As part of an accompanying program, various universities were invited to participate in ad-hoc workshops, guided by representatives of the supporting industry and the European facade network with the universities of Bath, Delft, Detmold, Lucerne and San Sebastian. The program was rounded off with a small, targeted series of lectures.

Of course, the activities of efnMOBILE also need to be represented in other media: the program was often publicized in various specialized media, and the two responsible professors Uta Pottgiesser and Ulrich Knaack presented the program regularly at conferences and events. And it was distributed via social media, via the homepages of the two main universities as well as in various blogs (imagine – the blog, facadeworld.com etc.) and the alumni group of the facade studies of the EFN network (facades.ning.com). And lastly, this book contributes to its publication.





5-6 Workshops at Glasstec exhibition, Düsseldorf 2014
7-8 GEVEL Total exhibition, Utrecht 2014



APPENDIX

CVs

PROF. DR. ING. ULRICH KNAACK (*1964) was trained as an architect at the RWTH Aachen in Germany. After earning his degree, he worked at the university as a researcher in the field of structural use of glass and completed his studies with a PhD. In his professional career Knaack worked as an architect and general planner in Düsseldorf, Germany, winning several national and international competitions. His projects include high-rise and office buildings, commercial buildings and stadiums. In his academic career Knaack has been professor of Design and Construction at the Hochschule OWL, Germany. He also was and still is appointed professor for Design of Construction at Delft University of Technology (Faculty of Architecture), Netherlands, where he established the Facade Research Group. In parallel he is professor in Facade Technology at TU Darmstadt (Faculty of Civil Engineering), Germany, where he participates in the Institute of Structural Mechanics + Design. He organizes interdisciplinary design workshops and symposiums in the field of facades and is the author of several well-known reference books, articles and lectures.

PROF. DR. UTA POTTGIESSER (*1964) was trained as an architect at TU Berlin, subsequently obtaining her PhD in the field of "Multilayered Glass Constructions: Energy and Construction" at TU Dresden. Today, she is Professor of Building Construction and Materials at Detmold School of Architecture and Interior Architecture, Germany. She is spokesperson for the research platform ConstructionLab and a member of the research platform PerceptionLab. Her multidisciplinary background is in architecture, civil engineering and interior architecture. Besides her academic career she has worked as a practicing architect

– especially for office and administration buildings – and acts as a jury member in architectural competitions. As secretary of the Docomomo International Scientific Committee of Technology (ISC-T) she is concerned with the protection and adaptive reuse of Modern Movement Architecture. Pottgiesser is internationally active as a board member and reviewer of international journals (e.g. JFDE, JID, Strategic Design Journal) and in PhD commissions.

JENS BÖKE (*1984) is Project Director and Research Associate at the ConstructionLab of Ostwestfalen-Lippe University of Applied Sciences, Detmold School of Architecture and Interior Architecture. In 2012 he began work on his doctoral thesis "ThinkingSkins" at Delft University of Technology. Since then he is a member of the Delft-based Facade Research Group. Until summer 2014, Jens Böke was coordinator of the postgraduate Master degree course Computational Design and Construction at Detmold University of Applied Sciences, where he also holds a teaching post. He earned a BA degree in architecture at the Detmold University of Applied Sciences in summer 2009 and, in the same year won the competition "BDA Masters 2009". He continued his education with the Master's program of the MSA (Münster School of Architecture) where early in 2012 he was awarded the degree Master of Arts in architecture. Jens Böke was a trainee at the Dutch architectural design office UNStudio in Amsterdam.

MAX ERNST (*1988) completed his Master studies in architecture at Detmold School of Architecture and Interior Architecture in 2014 with the degree Excellent. During this time, he worked as scientific assistant at the chair of

Building in Context, led by Prof. Thomas Werner and Prof. Martin Schneider, as well as that of Design and Construction, led by Prof. Ulrich Knaack.

Since the beginning of 2014 he has been coordinator of the continuing education Master's program "MCDC – Master of Computational Design and Construction" at werkstatt.emilie-GmbH. Also since 2014 he has worked as scientific assistant at Detmold School of Architecture and Interior Architecture, first with Prof. Bernadette Heiermann and later with Prof. Norbert Hanenberg.

Since the beginning of 2015, Max Ernst has been a member of the research group "Resource Equitable Construction" at RWTH Aachen and is working on his doctoral degree under guidance of Prof. Linda Hildebrand (RWTH Aachen) and Ulrich Knaack (TU Darmstadt) at the chair of Cycle Oriented Construction at the Faculty of Architecture, RWTH Aachen.

In 2015 he became a member of the research project "Development of strategies to implement embedded energy consumption in the iterative integrated design process of buildings" in cooperation with TU Munich, TU Darmstadt and RWTH-Aachen. In addition, he is a teacher of efefnMOBILE and at MCDC.

LINDA HILDEBRAND (*1983) completed her studies in architecture at the Detmold School of Architecture and Interior Architecture (Germany) in 2008. Having written her diploma thesis about green certificates in the building industry, she started her career by applying the German DGNB certificate in the pilot phase. The same year she started her PhD research at TU Delft analyzing the relevance of embodied energy for the building sector as well as teaching Sustainable Construction at Detmold. She is a

member of TU Delft's Facade Research Group and involved in several publications including the "imagine" book series. Next to activities in different research projects she works for the Rotterdam office "imagine envelope" as consultant for ecological design. She completed her PhD in 2014 and was appointed Junior Professor for Recyclable Construction at RWTH Aachen the same year. She is a board member of AktivPlus e.V. particularizing the concept of resource efficiency.

ANAN ASHOUR (*1984) is a trained architect and Master of Engineering in Facade Design and Construction from Amman in Jordan. After completing his degree in 2007, he was hired by Sahel Al Hiyari & Partners architectural office, where he developed a delicate sense of design, space, materials and concepts. Anan's first contact with the facade industry was during his work for Petra Aluminium, where his interest in industrial design and business grew.

He started seeking new challenges, and decided to move to Germany to participate in the Master's program "International Facade Design and Construction" in 2011. After obtaining his master's degree he did freelance consultancy for future products at Schüco in Bielefeld, taught Facade Master courses and organized the overall Master program.

Today, Anan Ashour is part of the "iam glass" team, being one of the co-founders and working as business coordinator of the company.

REFERENCES

- Cooper, R.G. 1999.
From Experience: The Invisible Success Factors In Product Innovation. In: Journal of Product Innovation Management, 16, 2, April 1999, pp. 115 – 133
- Gassmann, O. & Enkel, E. (2006).
“Open Innovation. Die Öffnung des Innovationsprozesses erhöht das Innovationspotential”.
In: zfo, 3/2006 (75. Jg.), pp. 132 – 138
- Hansen, M.T. & Birkinshaw, J. 2007.
“The Innovation Value Chain”. Harvard *Business Review*. Retrieved on 2015-11-09: hbr.org/2007/06/the-innovation-value-chain#
- Jacoby, R. & Rodriguez, D. 2007.
“Innovation, Growth, and Getting to Where You Want to Go”. *Design Management Review* vol. 18 no. 1, pp. 10 – 15
- Jain, V. 2015.
Innovation Without Borders: Six Best Practices to Improve Innovation Success Rates. Report. Retrieved on 2015-10-24: www.innovationmanagement.se/2015/06/17/innovation-without-borders-six-best-practices-to-improve-innovation-success-rates/
- Kelley, T. & Littman, J. 2001.
The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm. New York: Random House
- Klein, T. 2013.
“Integral Facade Construction. Towards a new product architecture for curtain walls”. Dissertation. TU Delft
- Knaack, U., 2010.
The Future Envelope 2: Architecture - Climate - Skin, IOS Press, US
- Knaack, U. 2011.
“Future Facades in Research and Education”. Lecture at Meeting of the Society of Façade Engineers, London, April 14, 2011
- Kumar, V. 2012.
101 Design Methods: A Structured Approach for Driving Innovation in Your Organization. Hoboken: John Wiley & Sons
- Norman, D.A. 2013.
The Design of Everyday Things. New York: Basic Books
- Norman, D.A. & Verganti, R. 2014.
Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change. In: Design Issues Winter 2014, Vol. 30, No. 1, pp. 78 – 96
- Pottgiesser, U. & Ashour, A. 2013.
“Design vs. Development: neue Ansätze”. In: *Innovative Fassadentechnik 2013*. Berlin: Ernst & Sohn Special, July 2013
- Pottgiesser, U. & Strauß, H. (eds) 2013.
Product Development and Architecture. Visions, Methods, Innovations. Basel, Boston, Berlin: Birkhäuser
- Sawhney, N. 2003.
“Cooperative innovation in the commons: rethinking distributed collaboration and intellectual property for sustainable design innovation”. Dissertation. MIT Boston

World Economic Forum. 2015.
 “Collaborative Innovation. Transforming
 Business, Driving Growth”.
 Regional Agenda. Geneva: WEF

Knaack, U., Klein, T., Bilow, M. & Auer, T. (2014).
Facades: Principles of Construction.
 Basel, Boston, Berlin: Birkhäuser

Knaack, U., Chung-Klatte, S. & Hasselbach, R.
 (2012). *Systembau (Prinzipien der Konstruktion)*.
 Basle, Boston, Berlin: Birkhäuser

Meijs, M.H. & Knaack, U. (2009).
Components and Connections.
 Basle, Boston, Berlin: Birkhäuser

Ratti, C. & Claudel, M. 2015.
 Open Source Architecture.
 London: Thames & Hudson

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