

# **MicroShade X**

## **– Upscaling and demonstration of energy saving solar shading technology**

### **Final report for EUDP**

EUDP project file no. 63011-0169  
3XN  
PhotoSolar  
Büfa Glass  
1<sup>st</sup> Mile

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## Dansk resumé

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Projektet "MicroShade - Opskalering og demonstration af energibesparende solafskærmningsteknologi" er blevet udført fra januar 2009 til august 2011 af et konsortium under ledelse af den danske tegnestue 3XN med PhotoSolar og 1st Mile som to andre danske partnere. Den tyske vinduesfabrikant Büfa Glass var den fjerde partner.

Formålet med projektet har været at udvikle MicroShade X-teknologien og demonstrere den som en nem at håndtere, omkostningseffektiv og energibesparende teknologi. Motivationen for projektet har været, at der er meget få eksempler på nye, grønne teknologier, der med succes introduceres på markedet. Projektet har udpeget mulige forklaringer på dette og anvendt dem i udviklingen. Analysen af barrierer og mulige løsninger er blevet gjort gennem workshops med arkitekter, ingeniører, slutbrugere og andre interessenter, samt gennem interviews med eksperter fra branchen og gennem litteraturstudier.

Denne viden er blevet kombineret med workshops, der involverer alle relevante interessenter i beslutningsprocessen i byggebranchen: Arkitekter, ingeniører, konstruktører, osv. En iterativ proces, hvor produktionsomstændigheder vedrørende MicroShade X er blevet udfordret (såsom bredden af fjederstålet, muligheder for farve, osv.), er blevet benyttet. Brugernes behov og designideer blev formuleret og oversat til tekniske specifikationer, der er blevet undersøgt af PhotoSolars ingeniører. Flere tekniske prototyper har løbende afprøvet disse muligheder. Endvidere er kortlagt en analyseproces, hvor produktionsforholdene i MicroShade X' supply chain og leveringskæde er inddraget i brugerdrivne innovationsprocesser. Disse blev omsat til konkrete variable for design.

Disse resultater fra projektet skiller sig ud:

En demonstrationsfacade er blevet udviklet, bygget og installeret hos virksomheden Datagraf, så det er nu muligt at se, hvordan en MicroShade X facade faktisk ser ud, da dette er kritisk, hvis arkitekter skal fremme MicroShade X.

Faktorer, der påvirker beslutningsprocesserne i byggeriet er blevet identificeret, så både PhotoSolar og andre udviklere og leverandører af grøn teknologi kan målrette den rigtige value proposition til de rigtige aktører og dermed øge muligheden for succesfuld markedsindtrængning.

Projektet er et gennembrud for PhotoSolar, som nu har 12 konkrete og specifikke designs og en demonstrator, der kan bruges til at vise de reelle, visuelle konsekvenser og effekter af MicroShade X-teknologi.

Gennem projektet har 3XN vist hvordan en grundlæggende teknologi kan udvikles til en løsning, der appellerer til arkitekter, og som vil åbne døren til arkitekter i almindelighed, ikke kun med hensyn til MicroShade X, men til nye, grønne teknologier generelt.

Til PhotoSolar har projektet givet en teknologi, der kan designes og kommunikeres til industrien. Det forventes nu at give PhotoSolar et markedsgennembrud.

Denne rapport indeholder kun en kort sammenfatning og konklusioner for projektet er beskrevet gennem leverancerne i projektplanen. Bilag kan fås til eftersyn hos 3XN ved at kontakte Kasper Guldager Jørgensen, 3XN, på [kgj@3xn.dk](mailto:kgj@3xn.dk) eller [3xn@3xn.dk](mailto:3xn@3xn.dk). En liste over bilag er tilgængelig fra side 15 i denne rapport.

## Executive summary

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The project "MicroShade – Upscaling and demonstration of energy saving solar shading technology" has been carried out from January 2009 to August 2011 by a consortium headed by the Danish design studio 3XN with PhotoSolar and 1<sup>st</sup> Mile as two other Danish partners. The German window manufacturer Büfa Glass was the fourth partner.

The objective of the project has been to develop the MicroShade X technology and make it a showcase of easy-to-handle, cost-efficient, energy saving technology. The motivation for the project has been that there are very few examples of new, green technologies successfully entering the market. The project has determined possible explanations for this and applied them in the development. The analysis of barriers and possible solutions has been done through workshops involving architects, engineers, end-user and other stakeholders, as well as through interviews with industry experts and literature studies.

This knowledge has been combined with workshops involving all relevant stakeholders in decision-making in the building industry: Architects, engineers, designers, builders, etc. An iterative process where production circumstances regarding MicroShade X have been challenged (such as the width of the spring steel, possibilities for coloring, etc.), has been used. User requirements and design ideas were formulated and translated into technical specifications that have been studied by PhotoSolar's engineers. Several technical prototypes have continuously tested these possibilities. Further, an analysis process where production conditions in MicroShade X' supply chain and delivery chain has been mapped and fed into user-driven innovation processes. These were translated into concrete variables for design.

These results from the project stand out:

A demonstration façade has been developed, built and installed at the company DATAGRAF, so it is now possible to see how a MicroShade X façade actually looks like, as this is critical if architects are to promote MicroShade X

Factors affecting the decision-making processes in the building industry have been identified, enabling both PhotoSolar and other green technology developers and suppliers to target the right stakeholders with the right value proposition and thereby increase the possibility of successful market penetration

The project is a break-through to PhotoSolar, who now has 12 concrete and specific designs and a demonstrator that can be used to show the actual visual impact and effects of the MicroShade X technology.

Through the project 3XN has demonstrated how a basic technology can be developed into a solution which appeals to architects, which will open the door to architects in general, not only with regards to MicroShade X, but to new, green technologies in general.

For PhotoSolar the project has provided a technology that is designable and communicable to the industry, which is now expected to give PhotoSolar a market breakthrough.

This report only contains a brief summary and conclusions for the project described through the deliverables in the project plan. Appendices are available for review at 3XN by contacting Kasper Guldager Jørgensen, 3XN, at [kj@3xn.dk](mailto:kj@3xn.dk) or [3xn@3xn.dk](mailto:3xn@3xn.dk). A list of appendices is available from page 15 in this report.

## Deliverables

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### Overview

Referring to the original application the following deliverables are described in the work package descriptions.

At the end of the report, an overview of documentation relating to all work packages are included.

- D0.1 Reports etc. required by the EUDP guidelines and rules.
- D1.0 Industry analysis - describing the value chain and the user criterias.
- D1.1 Catalogue describing the design constraints and variables in MicroShade X IG.
- D1.2 Prototypes for the 4 chosen building categories.
- D1.3 Selection of a building project and a prototype on which to model the demonstrator fa-çade element.
- D1.4 Resumé of experiences gained through WP1.
- D2.1 Demonstrator; a full scale facade-element with integrated MicroShade X
- D2.2 System description of the IGU's used in the facade element.
- D2.3 Building simulation of energy needs using Be-06 program.
- D2.4 Complete technical drawings of façade elements and the building envelope.
- D2.5 First generation machinery for MicroShade X application on glass panes needed for the realization of the demonstrator facade.
- D2.6 Resumé of the results obtained in WP2 aimed at dissemination (WP3)
- D2.7 Committed consortium for product development phase (outside scope of EUDP project)
- D3.1 Industry analysis report
- D3.2 Virtual Platform for communication
- D3.4 Five evaluation reports
- D3.6 Idea catalogue summarizing Task 3.5

D3.7 Four articles  
 D3.9 Project website

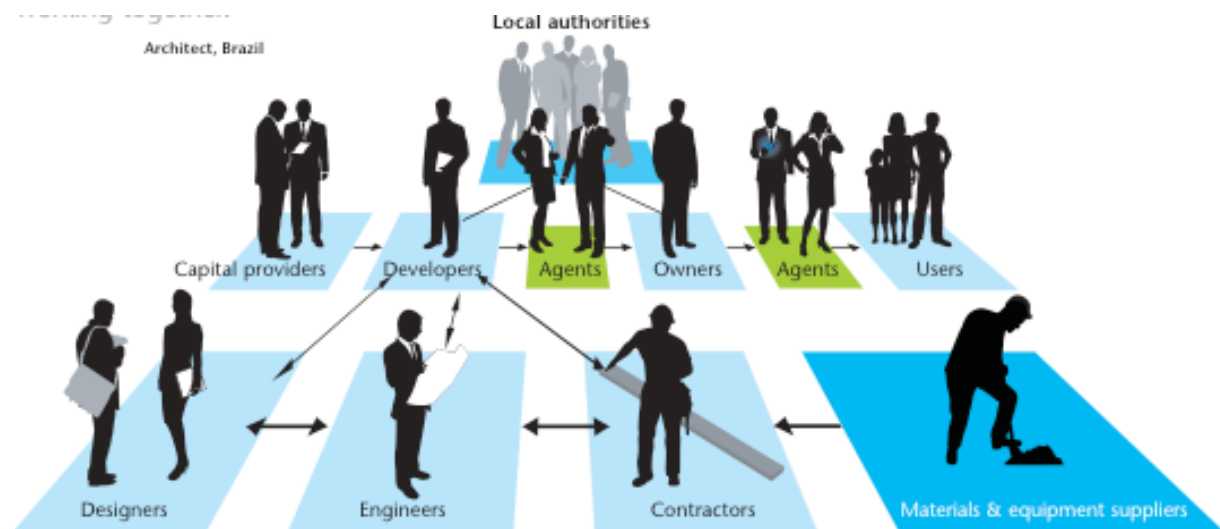
It is noted that the numbering of the deliverables from work package 3 is not sequential. This is due to typing errors in the application. For consistency, the numbering is kept in this final report. Further, deliverable D.0.1 and D.3.1 refer to the same material in the appendices.

### **D0.1 Reports etc. required by the EUDP guidelines and rules**

This deliverable has been delivered throughout the project according to the general terms and conditions provided by the EUDP.

### **D1.0 Industry analysis - describing the value chain and the user criteria**

The building industry is inherently known as rigid and complex, making it difficult to penetrate new technologies to the market place. As shown in the illustration below, the interactions between the different actors and organisations are complex and require a lot of coordination with regards to deliveries, responsibilities, scheduling, legal issues, etc.



*A complex sector. From Energy Efficiency in Buildings - Business realities and opportunities, World Business Council for Sustainable Development, October 2007*

Through a series of interviews with selected actors in the value chain (both national and international), review of international and national analysis of the construction industry, and through 4 workshops among participants with external guests, the project has conducted an industry analysis to identify key drivers for implementation of new green technologies.

The aim has been to specifically identify the barriers and drivers that are critical to green solutions are selected or deselected for new construction to enable guiding technology development to a greater market orientation.

The analyses conclude the main barriers to be:

- Legislation
  - It is difficult for legislation to deal with multi-function products
  - No requirements in building codes etc. for daylight, but only recommendations
- Collaboration forms
  - Always new partners restricts learning
  - Some continuity may be ensured through preliminary agreements
- Different entities are placing orders in the building process
- Buildings today are based on a lock-in in the common denominator of the quantity of demands
- With new components the traditional interfaces are challenged
- Many components are designed for specific functionalities by engineers
  - The components only solve one, specific issue, but many interfaces may be changed

- Culturally specific needs
- Lack of clear and disseminated references
- Lack of education

Circumstances surrounding pricing can be a barrier:

- Pricing not transparent
  - Can vary greatly
  - The established products / cases already available in the market fixed the price level
  - The profits are made in traditional business models
- Alternative financing models may ensure high transparency with great success for the implementation of new technologies, particularly PPP, partnering and ESCO.

Main identified barriers for green initiatives:

- Lack of knowledge among consultants and suppliers
- The professional advisers assume higher costs and lower power (on the energy balance) on green initiatives than that factually can be seen
- Lack of personal experience and ability to obtain knowledge on the green initiatives
- General lack of acceptance in the sector (building professionals do not generally feel or accept that sustainability is a priority for customers)
- Dependency on green technology enthusiasts

It is important to acknowledge that neither lack of technology nor lack of end-user demands are barriers.

A main purpose of the project has been to establish a collaboration between 3XN and PhotoSolar labelled MicroShade X. Conclusions specifically for the technology and product development of MicroShade X has impacted the project:

- Because of the unwillingness to try new green solutions among consultants and contractors, it is important that MicroShade X is demonstrated thoroughly with clear proof of concept and reference cases
- Architects' approach to new technologies is driven by immediate and quick sensing based on storytelling and aesthetics more than technical specs. Therefore it is important to MicroShade X to act as both a carrier of stories and as a medium for design
- The unique aesthetic dimension is a crucial parameter for the architect's decision. Therefore MicroShade X technology should conform to the requirements for design flexibility.

## **D1.1 Catalogue describing the design constraints and variables in**

### **MicroShade IG**

The progress of the work within the EUDP project is documented in three catalogues. The catalogues produced throughout the process have been used as log-books, to capture the work for the further activities. This means that the catalogues have been developed along with the activities and is finalised after specific periods.

The first catalogue describes the start-up of the project and focuses on knowledge on the technology by challenging it by the design process. This results in a series of pattern designs that works as guidelines for the further work. This selection of the principals for the patterns is based on the actual production conditions and aesthetic reflections.

The second catalogue describes the studies on patterns with a specific relation to natural elements and the ornamentation in architecture. These studies are based on research on the relation between natural elements and human health and behaviour.

The third catalogue contains eight completed pattern designs developed by 3XN. The eight designs are based on the selection from the second catalogue. The designs have been approved by PhotoSolar and evaluated together with architects outside of the consortium.

The first catalogue is to be found in the separate file: [1.7] [3.4] [3.6] [3.2] Casestudy-docs; 40004 log-bog 20100707.pdf

The second catalogue is to be found in the separate file: [1.8] [3.6] Workshopdoc; WS Århus; Att\_02\_091124\_patterns.pdf

The third catalogue is to be found in the separate file: [2.1] [3.11] [3.3] [3.6] Idekatalog-docs; 2011-01-28 Designkatalog MicroShade.pdf

Please note that the three catalogues has been put together in one pdf named D1.1 Catalogue describing the design constraints and variables in MicroShade IG.pdf

## **D1.2 Prototypes for the 4 chosen building categories**

Originally, it was planned to prepare a prototype for four different building categories. During the project it was chosen to move away from the building categories and in stead design a total of eight prototypes applicable to different catagories.

A core challenge in the project has been on the one hand, to challenge existing technological framework for MicroShade, on the other to let these challenge the design process.

This has occurred through two processes (in the mentioned order to maintain the user-driven perspective):

- 1) An iterative process where production circumstances regarding MicroShade X have been challenged (such as the width of the spring steel, possibilities for dyeing, stability for breakthroughs, etc.). Through a series of workshops user requirements and design ideas were formulated and translated into technical specifications that have been studied by PhotoSolars engineers. Several technical prototypes have continuously tested these possibilities.
- 2) An analysis process where production conditions in MicroShade X' supply chain and delivery chain has been mapped and fed into user-driven innovation processes. These are translated into concrete variables for design.

Defining a range of needs and goals for further development completed the benchmarking process.

The technical and design-based analyses resulted in technological and design conditions and requirements that were then forwarded into the idea generation processes as well as mapped against the catalogue of ideas and used as parameters for selection of specific prototypes.

## **D1.3 Selection of a building project and a prototype on which to model the demonstrator façade element**

Advancing analyses done in work packages 1.1 and 1.2 and reviews of a number of specific buildings designed by 3XN, a number of generic building types were defined and analyzed as target groups for MicroShade X with respect to the need for shading, cooling, visibility and avoidance of glare. The process has included:

- Analysis of specific buildings, including The Cube (Berlin), KPMG domicile (Copenhagen), and Saxo Bank-domicile (Copenhagen).
- Analysis of a wide range of building types (both traditional and modern)
- Development of generic building types to the size of windows, room dimensions, the compass orientation
- Design of generic façade

The results sum up to

- Inspiration for development based on needs in different buildings.
- A specific, generic façade to test of conceptual prototypes of MicroShade X.

The choice of using DATAGRAF, the building housing the communication bureau, as a suitable case for testing and demonstrating the new PhotoSolar MicroShade X designs, came in place because of 3XN's earlier work with the building. 3XN was the architects on the expansion of the buildings and the orientation of the building led to the need of solar shading on the facades north and south. With equal windows from floor to ceiling on these facades, the upper parts were blinded with a black 100% shielding foil. With these issues the building was the perfect place to test and challenge the new developments of PhotoSolar MicroShade X.

The two opposite facades, north and south, gave the project the possibility of testing in two phases. First the north facade could be tested with a prototype with only a visual effect. The new designs needed to be tested in a large scale model before implementation in the production. The prototypes



does not have the same energy reducing effect as the real MicroShade X, so it was important that the test could be carried out on a facade without the need of reducing the solar radiation. The prototype was established on two sevenths of the upper north facade equal to an area of 4800mm X 3080mm. By testing the prototype the project experienced the visual effect of the new patterns and it was made possible to evaluate the aesthetics of the design. This was made from an architectural point, through a session with architects outside 3XN. Furthermore the workers at DATAGRAF were interviewed to achieve knowledge from an end user perspective. In relation to the production of the new MicroShade X variants the prototype had the objective to test the assembly of windows with the embedded solar shading. Especially it was necessary to test the method used to place the patterned MicroShade X, which is critical for the quality of the product. The specific design used in the DATAGRAF case is particularly difficult because of the complex design.

The second phase of testing the new MicroShade X design takes place on the south facade, after collecting the data from the north facade. On the south facade it is necessary to have the energy reducing effect of the real MicroShade X. After a complete development of the product, it is implemented in the facade as a final test.

The MicroShade X is established in one seventh of the upper south facade equal to an area of 2400mm X 3080mm. The pattern design is the same on both facades. Outside the south facade there is a parking lot that provides a high reflection of sunlight from the windshields of the cars. Together with a very direct sun exposure on the facade this test is extreme. Since the first test phase the design has been adjusted to the production methods, and even the complex designs are made possible in mass production.

After testing the north facade the design has been approved and by adapting it into a production setup the south facade is used to do a final extreme test of the MicroShade X in a real context.

## **D1.4 Resumé of experiences gained through WP1**

A number of conclusions were obtained through WP1. The activities included:

- Identification of user requirements and specifications for the technology, including requirements for technology's handling of variable widths, colors and patterns.
- Clarification of technical constraints for development opportunities.
- Installation of concrete parameters within which the prototype development could take place.
- Identify the general requirements from business and industry.
- Overall requirements from users (architects) to product.
- Design processes
- Technical experiments
- Development of prototypes
- Tests of prototypes

Technical developments during WP1:

- New width now possible
- Colouring now enabled
- Possible "design configurator"
- Principles for hanging for staggered designs

Design innovations in WP1:

- Organic design
- Geometric design
- Architectural language
- Conversion to design alphabets for possible design configurator

Industry understanding in WP1:

- Knowledge level generally low, thus the demonstration showcases and communication is key
- Dissemination and narrative are decisive factors for technology penetration
- Architect's self-understanding (designer) must be met with design flexibility and own fingerprints to achieve dialogue
- The technology should open opportunities for design flexibility to get to talk to architects
- The technology must work for a design medium, and the final product as a designed product with its own identity as such
- The final products must carry a history / identity
- The psychological effect of different light and light quality



Technical parameters:

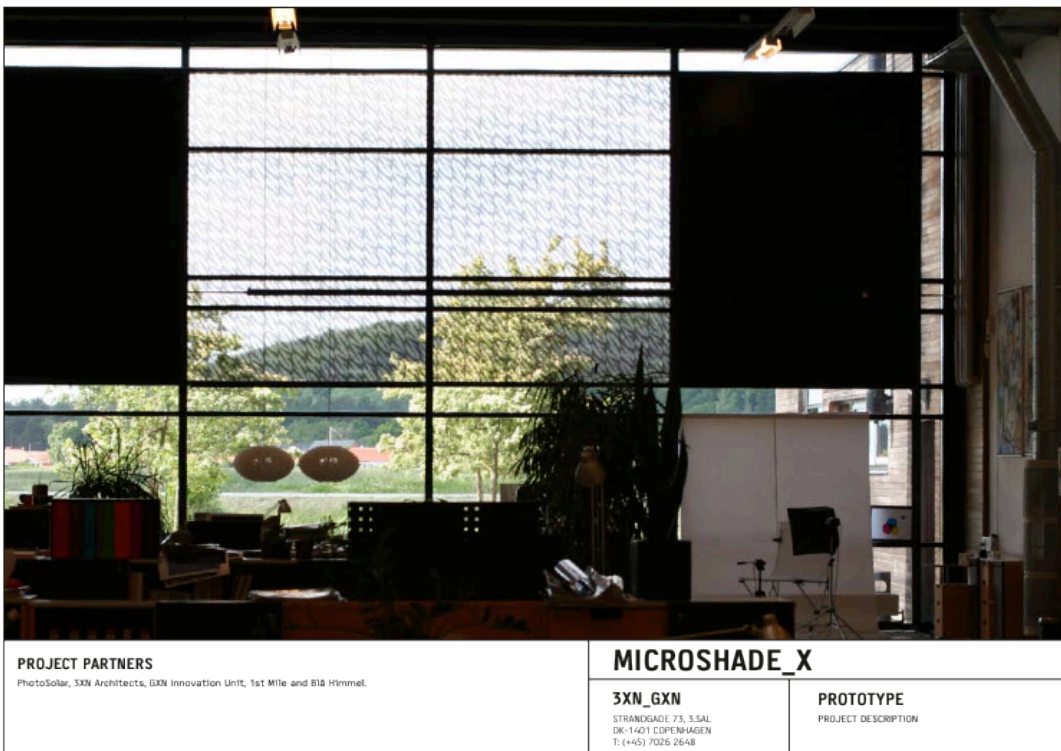
- Material
- Raw material conditions (width, color, stiffness)
- Production constraints (length, width, shackling restrictions)

## **D2.1 Demonstrator; a full scale facade-element with integrated**

### **Microshade**

A primary goal of the project has been to demonstrate a façade element in full scale. Based on the work in WP1 and WP2 the office building of the communication bureau, DATAGRAF, was selected as demonstration site. Below is shown photos of the installed demonstrator. Please refer to appendices for details.





## D2.2 System description of the IGU's used in the facade element

The Datagraf building in Auning was chosen as demonstrator for a MicroShade X prototype. The building has two separate glass facades facing north west and south east respectively. In the project,



an agreement was formed with the building owner that both facades could be used for the demonstration of MicroShade X. In the project, a prototype MicroShade X façade was fitted to the north east façade, and subsequently a redesigned pilot level MicroShade X façade was fitted to the south east façade.

#### Prototype level façade (north west)

The prototype façade installed on the north east façade consists of 8 glazing and the total glazed area is appr. 24 m<sup>2</sup>.

The glazing is double layer low-E glazing with warm edge spacer profiles. As usual, the glazing feature tempered glass on the outermost pane and float on the inside. The MicroShade X strips used for the prototype façade are made in a prototype process and are made in slabs. The slabs are mounted on the glazing manually according the design developed by the projects design team.

The MicroShade X prototype slabs demonstrate the novel design developed whereas they do not feature the correct micro structure that characterize a MicroShade X glazing. As a consequence, the shading of the prototype façade installed is less efficient.

For technical reasons, it was decided that the prototype MicroShade X slabs were not colored and instead they were installed in raw steel color. The increased reflectivity of the prototype MicroShade X gives the prototype façade a very distinct appearance, both from the inside and outside.



*Prototype façade Datagraf NW from the outside.*

#### Pilot level façade (south east)

The pilot level façade contains 4 glazing and a total glazed area of appr. 12 m<sup>2</sup>.

The glazing is double layer low-E glazing with warm edge spacer profiles. As usual, the glazing feature tempered glass on the outermost pane and float on the inside. The MicroShade X strips used for

the prototype façade is produced in the regular MicroShade process and contain a MicroShade X micro structure with full shading functionality.

The MicroShade X strip is produced in coils and during the production of the glazing, the developed lay-up sequence and procedure as well as the cutting procedure were used and tested.

The slabs are mounted on the glazing manually according the design developed by the projects design team.

It was decided to apply the standard anthracite color to the pilot façade MicroShade X and as consequence the appearance of the SE façade is less significant than that of the NW façade.

### **D2.3 Building simulation of energy needs using Be-06 program**

Simulation of the energy need in a building begins with an analysis of the optical and thermal properties of the MicroShade X and the glazing in which it is installed. As MicroShade X is based on the same basic shading technology as any MicroShade product, the optical properties can be quantified using the models which PhotoSolar have validated for use with their standard MicroShade product.

Because of the three dimensional structure of the shading structure, the MicroShade X will show a progressive shading character allowing high transmittance at low solar angles and low transmittance at high solar angle.

The progressive nature of the shading is reflected in the effective g-value changing over the year. Table 1 below shows the monthly average effective g-value for a two layer MicroShade X glazing similar to that used for the two Datagraf NW and SE facades. The table contains similar values for the MicroShade MS-A included as reference. As shown in the table, the effective g-value of the MS-X design used in Datagraf is similar to that of MS-A.

Effective g-value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MS-A (Ref.)	0.34	0.30	0.25	0.17	0.12	0.09	0.10	0.15	0.22	0.27	0.33	0.35
MS-X (Datagraf)	0.34	0.30	0.25	0.17	0.12	0.09	0.10	0.15	0.22	0.27	0.33	0.35

*Effective g-values (direct irradiation only) of MicroShade MS-A and MS-X (DATAGRAF).*

The table below shows the light transmittance normal to the glazing surface of MS-A and MS-X datagraf respectively.

Light transmittance	LT <sub>0</sub>
MS-A (Ref.)	0.48
MS-X (Datagraf)	0.39

*Light transmission normal to the glazing of MicroShade MS-A and MS-X.*

Based on the analysis of effective g-value a model has been developed that enables the MicroShade X to be modeled in Be06 (Be10). Furthermore, a data package has been developed for simulation of MicroShade X using the simulation platform BSIM. MicroShade MS-A has been implemented as a standard product in the BSIM materials database, and MicroShade X will be implemented also in BSIM before the product is launched commercially.

### **D2.4 Complete technical drawings of façade elements and the building envelope**

A collection of drawings and related material is found in the appendix.

[2.5] Casestudy-docs; EUDP Datagraf 100210 200.pdf

[2.5] Casestudy-docs; EUDP Datagraf 101028 sydfacade.pdf

[2.5] Casestudy-docs; EUDP Datagraf 101028\_opstalt nordvest\_003.pdf

[2.5] Casestudy-docs; EUDP Datagraf 101028\_opstalt\_sydst\_002.pdf

## **D2.5 First generation machinery for MicroShade X application on glass panes needed for the realization of the demonstrator facade**

The complexity of the investigated MicroShade X designs is increased compared to that of the basic MicroShade MS-A type. The primary concern of the more complicated designs is that such designs require a different lay-up technique and perhaps even different lay-up tools than the existing MicroShade standard product. As the lay-up time is important to the total cost of the final product, the project team found it vital to evaluate carefully the designs with respect to lay-up complexity. As a consequence, several of the designs investigated have been re-worked several times in order to achieve a sufficient lay-up speed and procedure without compromising the core values in the design.

The project team followed the strategy that MicroShade X prototypes should be handled and processed in the lay-up process using the same tools and equipment as the MicroShade standard product. The advantage of this approach is that MicroShade X products can be manufactured by a number of suppliers already equipped for MicroShade production. Hence, time to market is small and there are no extra barriers related to manufacturing for the MicroShade X than to the MicroShade standard product.

However, the lay-up procedure for MicroShade X is different and requires extensive planning. In particular this is true for the MicroShade X versions which involve the use of a pattern which need to be carefully aligned during lay-up. The MicroShade X demonstrated on the Datagraf building is an example of such a design, and during the project a substantial amount of work has been dedicated to development of lay-up calculations and defining the safest and most effective procedures.

MicroShade X is like other MicroShade products going to be produced in strips of 100 m or more. The strips are coiled and the lay-up procedure involves the following base operations:

1. The MicroShade strips are cut from the coil to a length defined by the size of the glazing.
2. The strips are positioned on the glass using a guided lay-up routine and manual handling.
3. The strips are fastened to the glass using a pre-mounted adhesive strip found on the MicroShade X strip.

As the MicroShade X for the Datagraf building involves a pattern which requires precise alignment between individual strips, a method was developed to secure precise cutting and lay-up of the strips. Also, the method developed enables the manufacturer or the architect to decide specific pattern combinations for the design. In the project, a standard lay-up sequence was developed for the pattern used at the Datagraf building.

Another important parameter to the final cost of a MicroShade X glazing is the amount of waste material produced in the process. As glazing are always made to building specific measures and MicroShade X strips are supplied in standard width only, some strips need to be cut in order to flush a given glazing with MicroShade X and in this cutting process some waste material is produced. As the MicroShade X patterns require an even more controlled lay-up, the amount of waste material increases.

In order to minimize the amount of waste material (and the cost of the glazing), a procedure was developed to translate the lay-up sequence into an optimized cutting sequence for any given pattern. The algorithm was implemented into a simple calculation software and this tool was used in the manufacturing of the glazing for the Datagraf south east facade.

## **D2.6 Resumé of the results obtained in WP2 aimed at dissemination**

### **(WP3)**

A number of conclusions were obtained through WP2. The activities included:

- The production technology was adapted to enable basic manufacturing of MicroShade X.
- A technology overview and a roadmap for technology development was made.
- Façades of respectively MicroShade X prototypes and pilot series were produced and installed.
- Lay-up tools and techniques for handling the MicroShade X series was developed and demonstrated.

## **D2.7 Committed consortium for product development phase (outside scope of EUDP project)**

A comprehensive agreement between 3XN and PhotoSolar has been devised to regulate the collaboration between PhotoSolar (IP rights holder and producer) and 3XN (designer). The agreement sets out a long-term collaboration path for the parties and is signed and in effect.

The collaboration agreement is confidential.

## **D3.1 Industry analysis report**

Please refer to the description and appendices in the section D1.0 Industry analysis - describing the value chain and the user criteria from page 5.

## **D3.2 Virtual Platform for communication**

Two virtual platforms have been used to communicate and share files during the project. The intranet of 3XN has been used internally in 3XN and a virtual platform with access for all partners has been set up using the service Hoist.

## **D3.4 Five evaluation reports**

Due to the new process (described under D1.2) evaluations cannot be made on the four building categories. Instead, extensive evaluations have been carried out on all prototypes during WP1, and furthermore a final evaluation has been made.

The EUDP MicroShade X project was started with a series of workshops where the aim was primarily to learn about the technological possibilities and to challenge this in relation to design. This means that discussions that could describe the opportunities for the development of the product were opened up (see D1.1).

The workshops gave thus a wide variety of designs that were tried and tested in relation to production conditions. The project team has allowed this open approach which has led to development of both technology and design, not just in the beginning but also ongoing in the project.

In the subsequent design process a variety of designs with many different properties were developed. These designs were categorized and reviewed according to a selection in relation to aesthetics, technical characteristics and production conditions.

Among those selected were a few designs developed and tested both in terms of technical specifications and architectural qualities. It was partly based on digital manufacturing and renderings and drawing on the specific buildings and constructions. Of the further developed design was a design selected for a physical prototype testing, which was installed at Datagraf in Auning, the building north facade. Subsequently, the design has matured for production and a final version is installed on the building's southern facade. (See description of Datagraf Demonstrator-shortfall D1.3).

During test run at Datagraf and development of the selected designs the product has been evaluated by the architects of 3XN both and external architects during a workshop at Datagraf. Here, technology and designs presented on various prototype levels, which gave a clear picture of the challenges and possibilities of the product in the market in the future. Furthermore, design psychologist Rune Nørager and a group of students at Aalborg University in terms of product impact on the end user evaluated the different designs. The results have shown that some designs have some human qualities, which supports the project team's assumptions through the process. This knowledge is extremely valuable for the further development of future MicroShade X designs.

With the Datagraf case the first actual production of the new MicroShade X designs has commenced and the project has given knowledge and experience to the next series of PhotoSolar MicroShade X.

Relevant files in appendix:

D1.1 and D1.1 Samlet.pdf Description of discussion and prioritization parameters for selection, as well as drawings and pictures:

D1.3 (Description of prototype and testing process, including pictures / drawings)

D2.1 (Design Directory)



D2.6 (Description of feedback from designers / users / technicians on prototype)  
 [1.3] [1.6] [3.4] Casestudy-docs; 40004\_100421\_evalueringsskema.pdf  
 [1.3] [1.6] [3.4] [2.3] [3.6] Idekatalog-docs; 40004\_100518\_evalueringsskema3.pdf  
 [2.3] [2.2] [1.4] Design Group Meetings; EUDP MicroShade XN Attachment #1 Minutes of meeting  
 no11 15 july 2010\_Technical rating of MicroShade XN design proposals.pdf

### **D3.6 Idea catalogue summarizing Task 3.5**

*It was decided not to gather the number of competing technologies identified and discussed during workshops in a separate catalogue.*

### **D3.7 Four articles**

It was soon clear that it made only little sense to publish articles before the project was complete. Hence, the articles are written, but not yet published. The titles are:

- Arkitekten som produktdesignere (Architects as product designers)
- Hvad er problemet med tegnestuer idag? (What is the problem with studios today?)
- Byggebranchens innovationsproblemer (The innovation problems facing the building industry)

Please refer to appendices for drafts of the articles.

Besides these articles a workshop at Dansk Arkitektur Center, DAC, on November 2, 2011, will communicate the findings of the project.

### **D3.9 Project website**

The project and its results are described at <http://www.3xn.dk>. Click GXN, Projects, Technology Design.

## **List of appendices**

The following file list includes documentation for tasks and deliverables concluded in the project. The numbering system for the project files, is such that numbers refer to task-numbers in the original application. Thus for instance: Files with the designation [1.6] are related to "Task 1.6 Production of pilot prototypes". Note that several files are related to more than one task. In the time line shown below the list below, the documentation is placed accordingly to task completion.

All documents are available for review upon request at 3XN.

[3.11] Grundlag; 20101216\_Microshade X\_rettighedserklæring.pdf  
 [0.0] Grundlag; Full EUDP application MicroShades.pdf  
 [0.1] Grundlag; Proces timeline 03.pdf  
 [0.2] Rapportering; 2010\_03 Årsrapport EUDP maj10 (2).doc  
 [1.7] [3.4] [3.6] [3.2] Casestudy-docs; 40004 log-bog 20100707.pdf  
 [1.3] [1.6] [3.4] Casestudy-docs; 40004\_100421\_evalueringsskema.pdf  
 [2.1] [3.10] [1.10] [3.11] Casestudy-docs; 40004\_101207\_MicroshadeX\_møde vedr. salgsseance MsX\_PS CLL 3XN.pdf  
 [2.1] Casestudy-docs; Datagraf\_100510.pdf  
 [2.5] Casestudy-docs; EUDP Datagraf 100210 200.pdf  
 [2.5] Casestudy-docs; EUDP Datagraf 101028 sydfacade.pdf  
 [2.5] Casestudy-docs; EUDP Datagraf 101028\_opstalt nordvest\_003.pdf  
 [2.5] Casestudy-docs; EUDP Datagraf 101028\_opstalt\_syddøst\_002.pdf  
 [2.5] [2.4] Casestudy-docs; EUDP\_101213\_SKA-areal fordeling på Datagraf design.pdf  
 [2.5] [2.4] [2.6] Casestudy-docs; Workshop\_opsamling\_140311.pdf  
 [3.4] [3.6] [2.2] [1.4] [1.7] Casestudy-docs; microshade booklet version 0.1 WEB.pdf  
 [2.2] [2.5] Casestudy-docs; microshadeXN\_101201\_minutes\_12.pdf  
 [2.1] [3.11] [3.3] [3.6] Idekatalog-docs; 2011-01-28 Designkatalog MicroShade.pdf  
 [1.3] [1.6] [3.4] [2.3] [3.6] Idekatalog-docs; 40004\_100518\_evalueringsskema3.pdf  
 [1.2] [1.3] [1.6] [1.7] [2.3] [3.6] Idekatalog-docs; Design vejledning 1 0 3XN MicroShade.pdf  
 [2.3] [2.2] [1.4] Design Group Meetings; EUDP MicroShade XN Attachment #1 Minutes of meeting no11 15 july 2010\_Technical rating of MicroShade XN design proposals.pdf

[2.1] [2.2] [2.3] [1.10] Design Group Meetings; EUDP MicroShadeXN Attachment #2 Minutes of meeting no 11 15 july 2010\_workingproces incl Datagraf.pdf  
 [1.4] [1.7] [1.8] [1.9] Design Group Meetings; microshadeXN\_010105\_minutes\_08.pdf  
 [1.9] [1.8] Design Group Meetings; microshadeXN\_010128\_minutes\_09.docx  
 [1.8.] [1.9] Design Group Meetings; microshadeXN\_091001\_minutes\_03.doc  
 [1.8] Design Group Meetings; microshadeXN\_091013\_minutes\_04.msg  
 [1.8] Design Group Meetings; microshadeXN\_091023\_minutes\_05.msg  
 [0.1] [1.6] [1.9] Design Group Meetings; microshadeXN\_091202\_minutes\_07.pdf  
 [1.8] [1.9] [2.2] [2.3] Design Group Meetings; microshadeXN\_100809\_minutes\_11.pdf  
 [1.8] [3.2] Workshopdoc, Opstartsmøde. Minutes; Christian Wamberg notater.pdf  
 [1.8] [1.4] Workshopdoc, Opstartsmøde; Lars Lundbye proces notater.pptx  
 [1.8] [1.4] Workshopdoc, Opstartsmøde; Micro Shade\_090618\_A\_workshop\_ENG.docx  
 [0.3] Workshopdoc; 3XN\_Statusmøde EUDP\_3 december\_reduction.pptx  
 [0.3] Workshopdoc; 3XN\_Statusmøde EUDP\_3 december.pptx  
 [1.8] [1.3] Workshopdoc; 3XN Facade 090924.pptx  
 [1.8] Workshopdoc; Att\_01\_090925\_Agenda.pdf  
 [1.8] [1.3] [1.4] Workshopdoc; Att\_02\_090925\_Mindmap.pdf  
 [1.8] [1.3] [1.4] [1.7] [1.8] Workshopdoc; Att\_03\_090925\_Catalogue.pdf  
 [1.8] Workshopdoc; BÜFA Glas Presentation English 2009-01.pdf  
 [1.2] [1.1] [1.3] Workshopdoc; BÜFA References Integrated Blinds.pdf  
 [1.8] [1.1] Workshopdoc; BÜFA Structure inkl. 2 UP-JVs.pdf  
 [2.3] [1.1] [1.8] Workshopdoc; EUDP workshop 24-25 (1) september 2009.pdf  
 [1.8] [2.2] Workshopdoc; EUDP\_100714\_Dagsorden 15 juli\_designmøde.pdf  
 [1.1] Workshopdoc; industrien4.pptx  
 [1.3] [1.6] [1.7] Workshopdoc; Lars noter fra workshop231109.pdf  
 [1.8] [1.1] [1.2] [1.8] [3.1] Workshopdoc; Lars om mass customization (eksempler).pdf  
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 [1.3] [1.2] [1.8] [1.6] Workshopdoc; Noter fra brainstorm 240909.pdf  
 [1.8] Workshopdoc; Oldenburg Agenda.docx  
 [1.8] [1.1] [1.3] Workshopdoc; PhotoSolar EUDP workshop 240909.pptx  
 [1.2] [1.3] [1.8] Workshopdoc; Torben om arabiske vinduer mv.pdf  
 [1.8] [3.3] [3.4] [3.6] Workshopdoc; WS Datagraf; 2011-01-28 Designkatalog MicroShade-1.pdf;  
 [1.8] Workshopdoc; WS Datagraf; DELTAGERE.docx;  
 [1.8] Workshopdoc; WS Århus; Præsentationer; workshop 23.11.09.pdf  
 [1.8] [1.1] [1.2] Workshopdoc; WS Århus; Præsentationer; 3XN Facade 090924.pptx  
 [1.8] Workshopdoc; WS Århus; 091106\_oplæg Agenda.docx;  
 [1.8] [1.7] Workshopdoc; WS Århus; workshop 23.11.09.pdf;  
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 [1.8] [3.6] Workshopdoc; WS Århus; Att\_05\_091124\_catalogue\_small.pdf;  
 [1.8] [3.6] [1.3] [1.6] Workshopdoc; WS Århus; Att\_03\_091124\_drawings.pdf;  
 [1.8] [3.6] Workshopdoc; WS Århus; Att\_05\_091124\_catalogue.pdf;  
 [1.8] [3.3] [1.4] Workshopdoc; WS Århus; microshadeXN\_091124\_minutes\_06.pdf;  
 [1.8] Workshopdoc; WS Århus; eudp\_091123\_ref\_dtb.docx;  
 [1.8] [3.6] Workshopdoc; WS Århus; Att\_04\_091124\_mindmap.pdf;  
 [1.8] Workshopdoc; WS Århus; Att\_01\_091124\_Agenda.pdf;  
 [1.8] Workshopdoc; WS Århus; EUDP\_091123\_Aarhus Agenda.doc;  
 [1.8] [3.6] Workshopdoc; WS Århus; Att\_02\_091124\_patterns.pdf;  
 [1.8] Workshopdoc; WS Århus; 091110\_Århus Agenda.docx  
 [1.10] [3.3] Workshopdoc; 2011 – 3XN – Whitepaperpræsentation.pdf

For D1.1 two master docs have been produced including the files:

D1.1 Catalogue describing the design constraints and variables in MicroShade IG.pdf:  
 - [1.7] [3.4] [3.6] [3.2] Casestudy-docs; 40004 log-bog 20100707.pdf  
 - [1.8] [3.6] Workshopdoc; WS Å rhus; Att\_02\_091124\_patterns.pdf  
 - [2.1] [3.11] [3.3] [3.6] Idekatalog-docs; 2011-01-28 Designkatalog MicroShade.pdf

D1.1 Samlet.pdf:

- [1.3] [1.6] [1.7] [2.3] [3.6] Idekatalog-docs; Design vejledning 1 0 3XN MicroShade.pdf  
 - [2.3] [2.2] [1.4] Design Group Meetings; EUDP MicroShade XN Attachment #1 Minutes of meeting no11 15 july 2010\_Technical rating of MicroShade XN design proposals.pdf

- [1.3] [1.6] [3.4] [2.3] [3.6] Idekatalog-docs; 40004\_100518\_evelueringskema3.pdf

## **Time line and visual project presentation**

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Below is an overall time line with produced documents. It can be seen in the document archive by contacting 3XN. On the following pages is a visual presentation of the project – from the first designs to the installed demonstrator is shown.







## **MICROSHADE\_X**

### **3XN\_GXN**

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### **PROJECT DESCRIPTION**





About the **MICROSHADE\_X**

GXN and Photosolar are working together to develop micro perforated solar shading technology. This booklet describes the process to change a working technology into an architectural product.

Starting with material experiments the research also implemented both physical and digital experiments. Designing research resulted in numerous patterns, exploring the influence on light transmittance, shadow casting and the view both ways.

One of the designs is implemented in an existing office building for further research. The comments of the user and the knowledge gained by on site testing will be used for further development of the product.

**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

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**CONCEPT**

PROJECT DESCRIPTION





**PROJECT PARTNERS**

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**MICROSHADE\_X**

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**MATERIAL RESEARCH**

PROJECT DESCRIPTION



## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

## MICROSHADE\_X

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### MATERIAL RESEARCH

PROJECT DESCRIPTION



**PROJECT PARTNERS**

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**MICROSHADE\_X**

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**MATERIAL RESEARCH**

PROJECT DESCRIPTION





**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

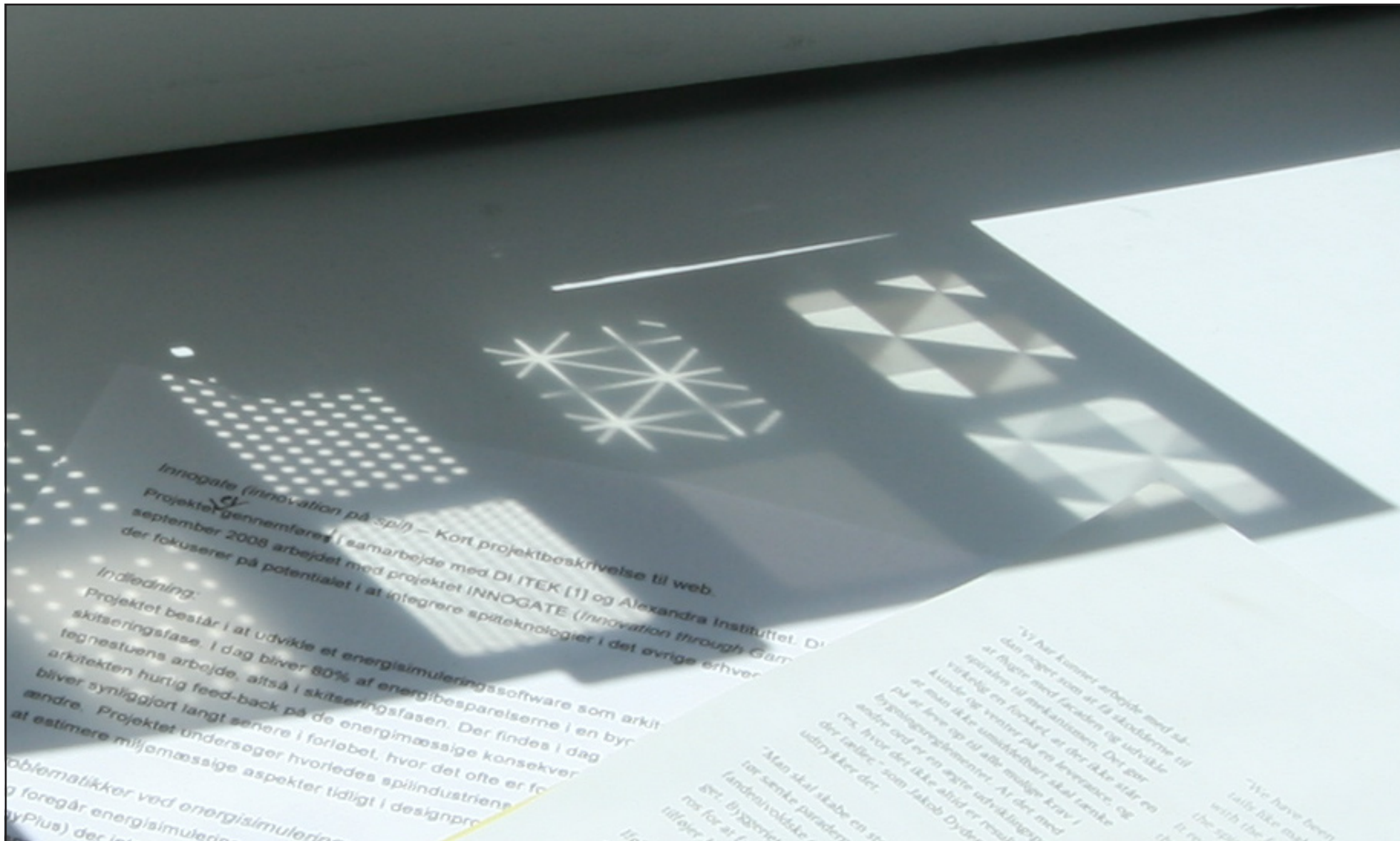
**MICROSHADE\_X**

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**MATERIAL RESEARCH**

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

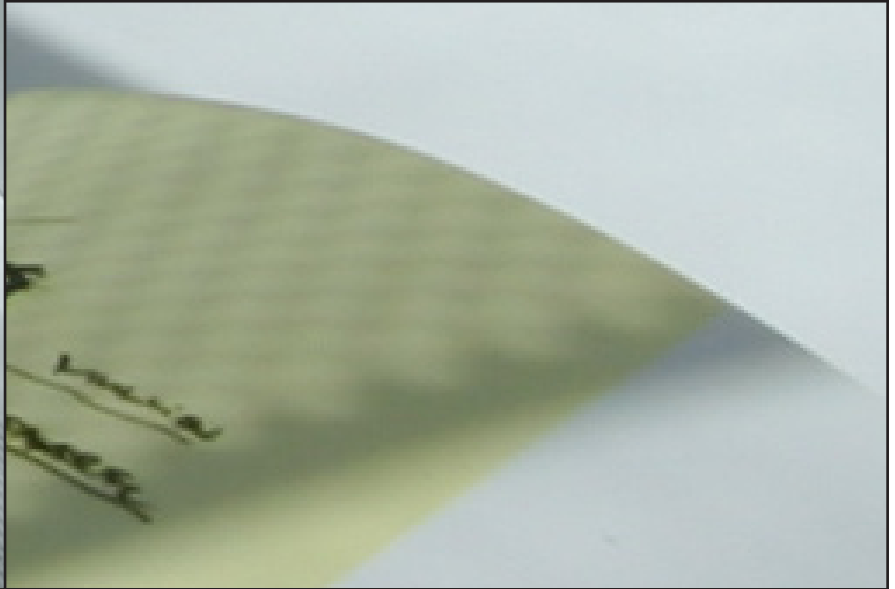
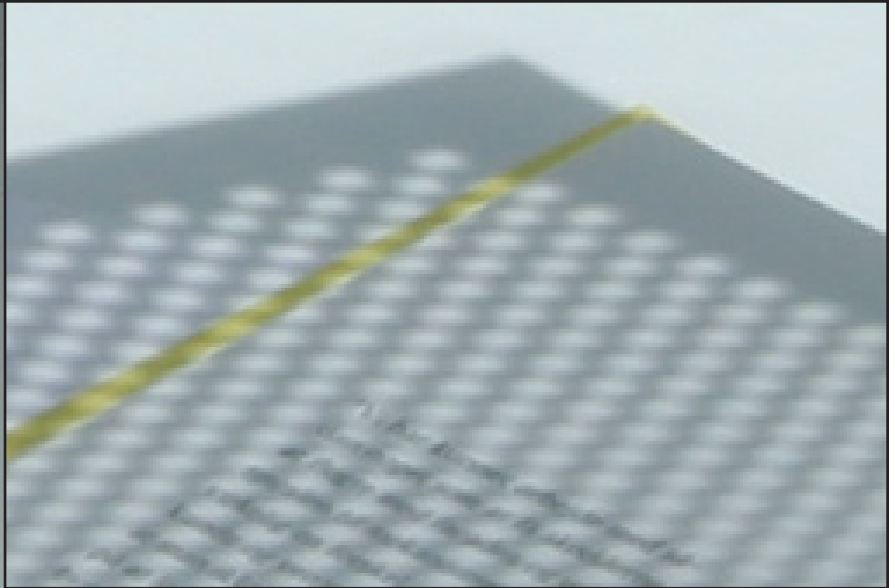
**MICROSHADE\_X**

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**RESEARCH TRANSMITTANCE**

PROJECT DESCRIPTION



## PROJECT PARTNERS

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## MICROSHADE\_X

### 3XN\_GXN

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### SHADOW CASTING

PROJECT DESCRIPTION





## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

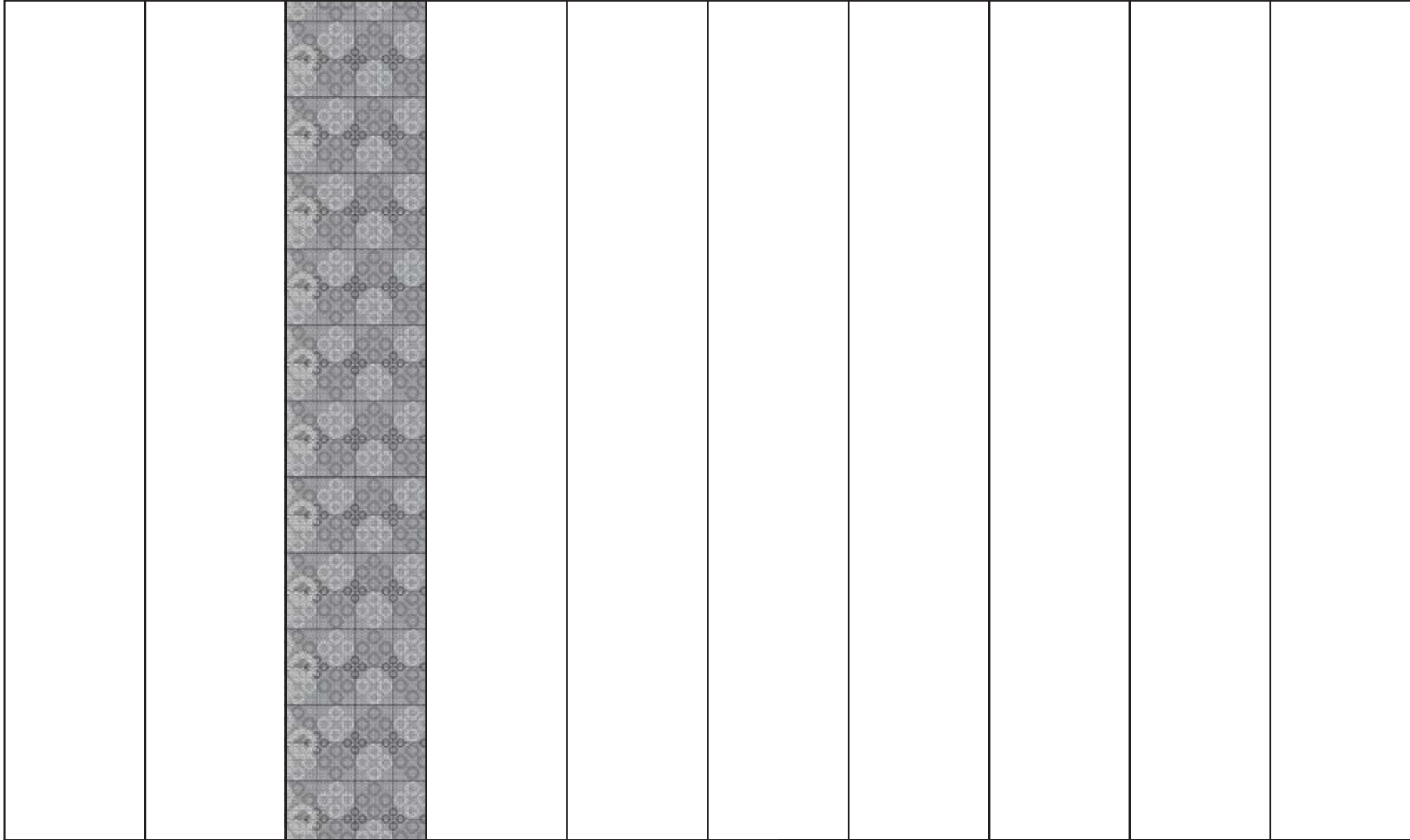
## MICROSHADE\_X

### 3XN\_GXN

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### VIEW SIMULATION

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

**3XN\_GXN**

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**PATTERN RESEARCH**

PROJECT DESCRIPTION

a	b	a	a	b	a	b	a	a	b
a	b	a	a	b	a	b	a	a	b

a	a	b	a	b	a	a	b	a	b	a	a	b	a	a	b	
a	b	a	b	a	a	b	a	b	a	a	b	a	b	a	a	b

a	b	a	a	b	a	b	a	a	b
a	b	a	a	b	a	b	a	a	b

a	b	a	a	b	a	b	a	a	b	a	b	a	a	b	a	b	a	a	b
a	b	a	a	b	a	b	a	a	b	a	b	a	a	b	a	b	a	a	b

a	b	a	a	b	a	b	a	a	b
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a	b	a	a	b	a	b	a	a	b	a	b	a	a	b	a	b	a	a	b
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a	b	a	a	b	a	b	a	a	b
a	b	a	a	b	a	b	a	a	b

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a	b	a	a	b	a	b	a	a	b	a	b	a	a	b	a	b	a	a	b

**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

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**PATTERN SLIDING**

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

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**PATTERN TESTS**

PROJECT DESCRIPTION





## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

## MICROSHADE\_X

### 3XN\_GXN

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### VIEW TESTING

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

**MICROSHADE\_X**

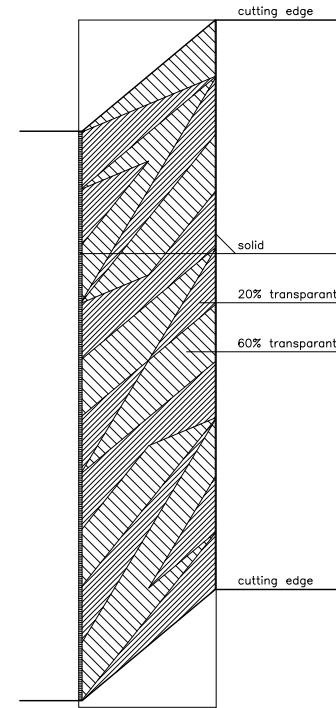
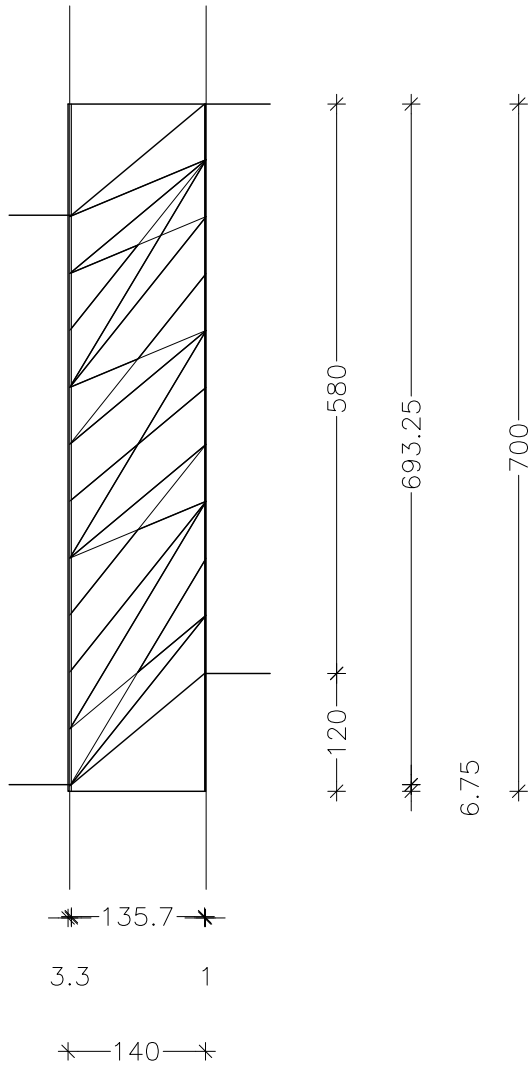
**3XN\_GXN**

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**PROTOTYPE DESIGN**

PROJECT DESCRIPTION





## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

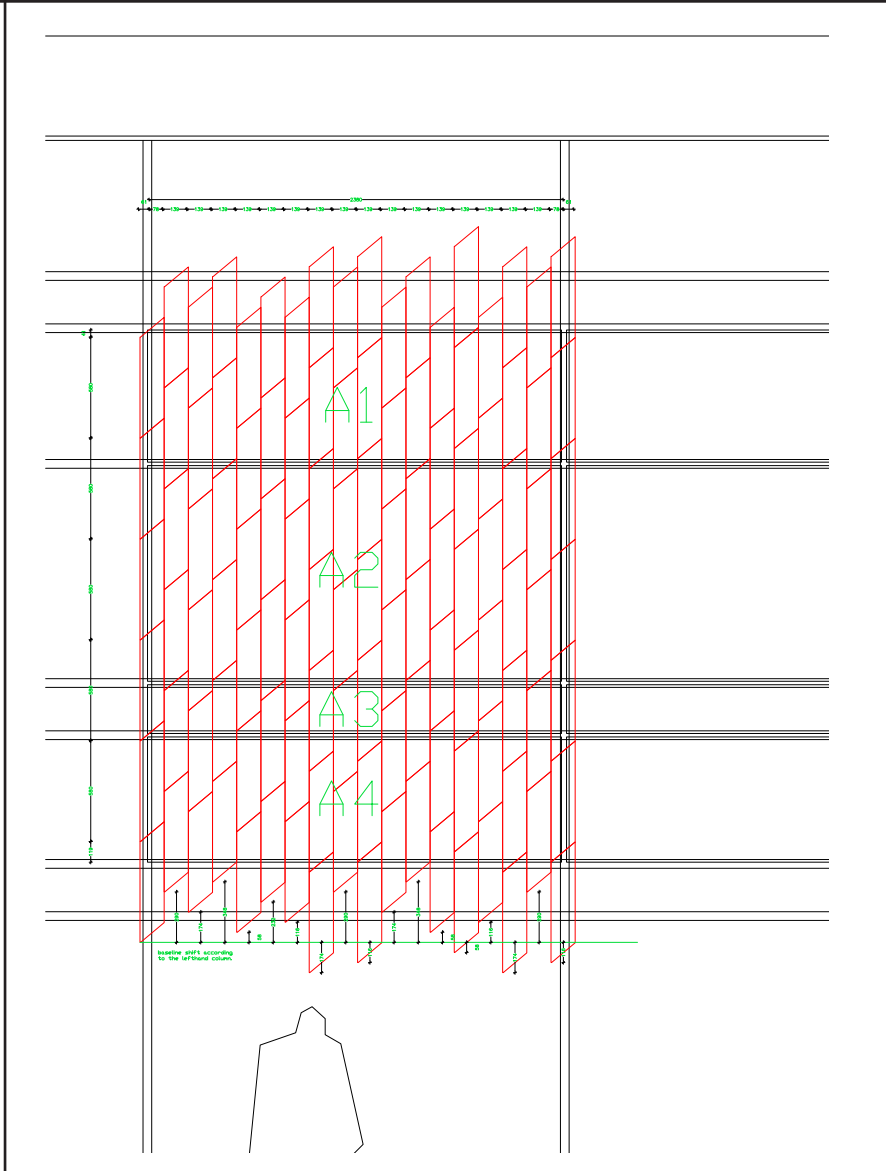
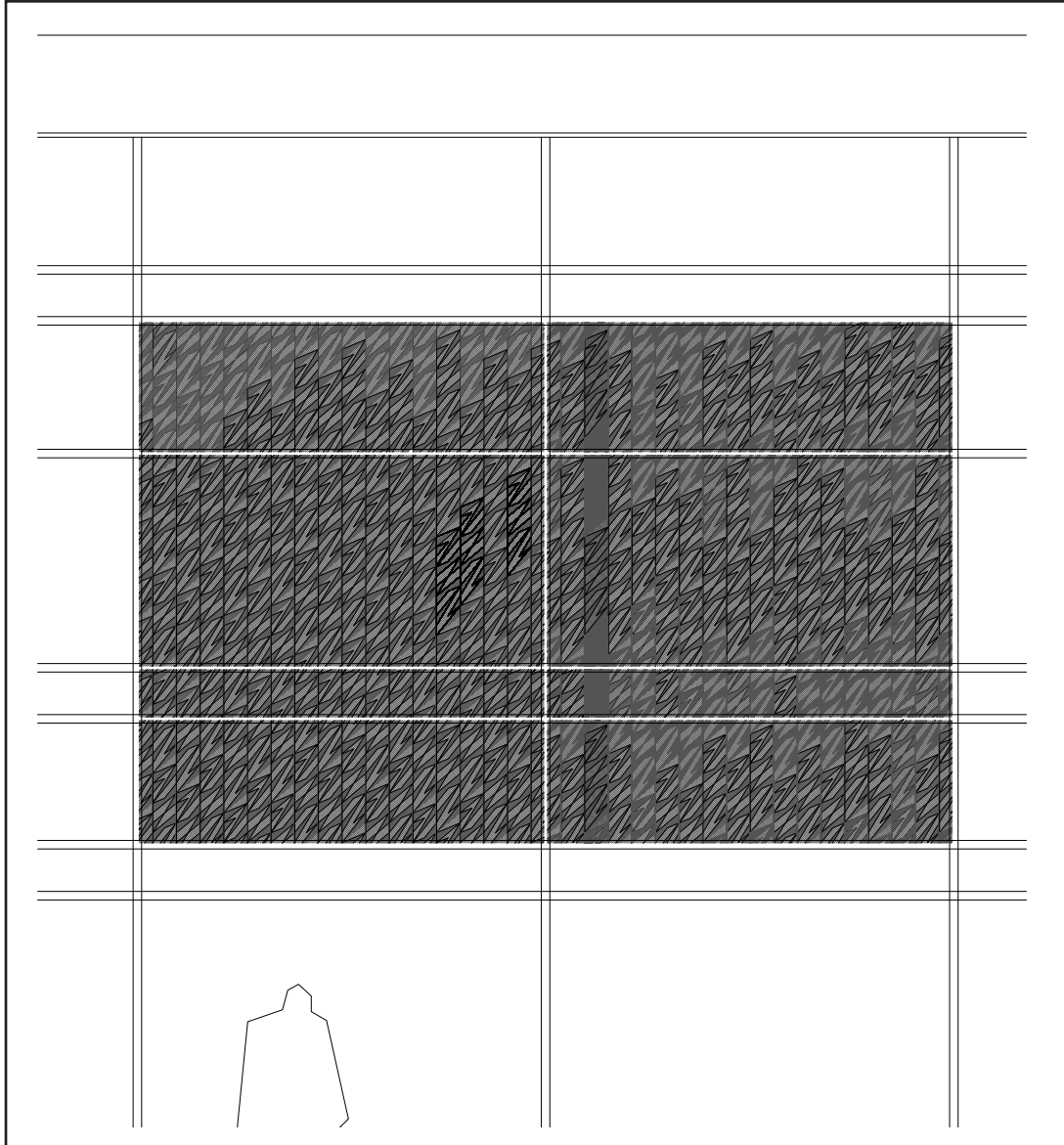
## MICROSHADE\_X

### 3XN\_GXN

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### PRODUCTION DRAWINGS

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

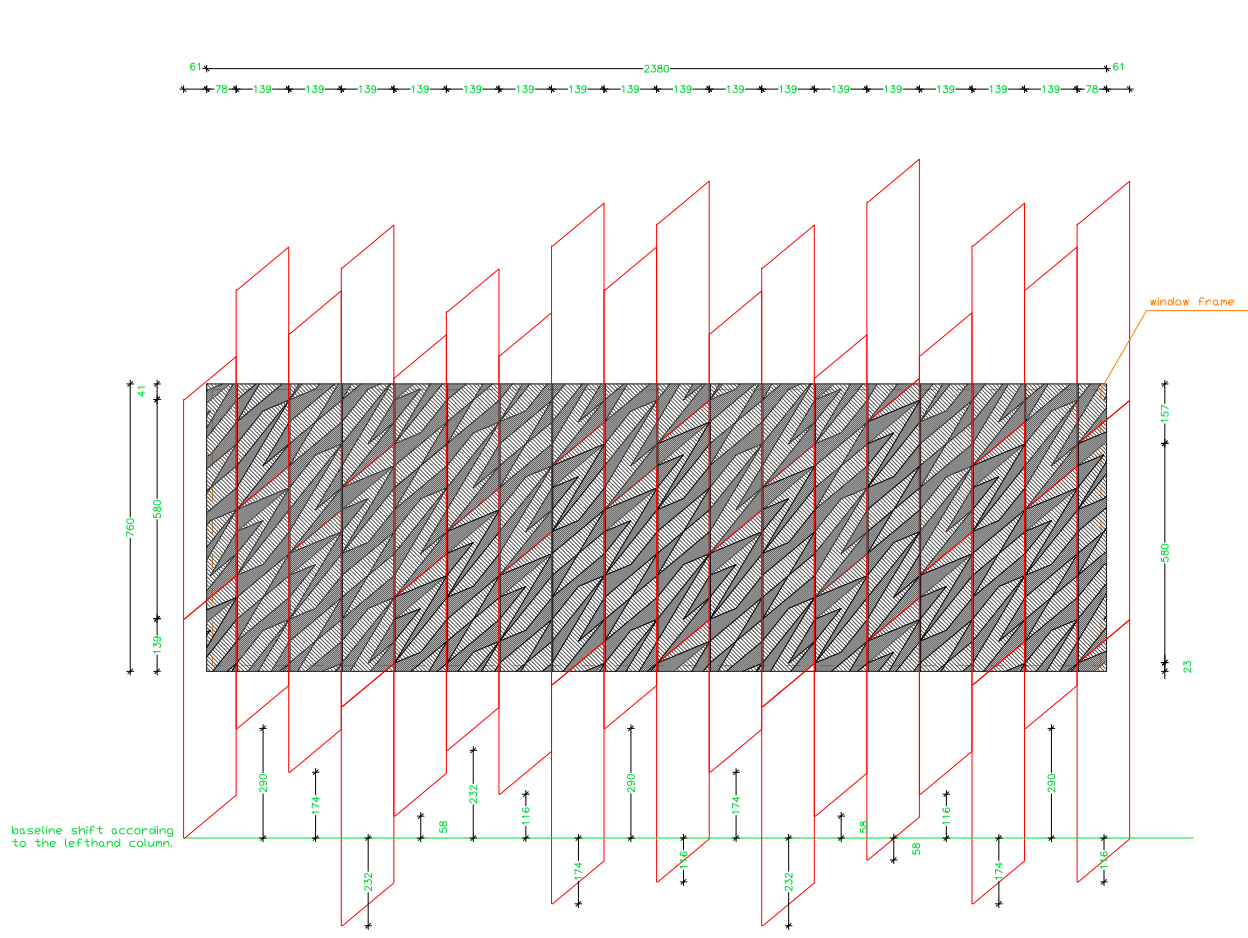
**MICROSHADE\_X**

**3XN\_GXN**

STRANDGADE 73, 3.SAL  
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**LAYOUT OVERVIEW**

PROJECT DESCRIPTION



A1		B1
A2		B2
A3		B3
A4		B4

<b>EUDP - MICROSHADES</b> <b>SKITSE</b> Datagraf / Prototype Production Drawing / North Facade Glass Panel A1		3XN A/S STRANDGADE 73 1401 KØBENHAVN K T: +45 7026 2648	
FILE	EUDP-SKA-046	UDARB.	evl
DATO	20.04.2010	MAL	1:10
		TECN. NR.	EUDP_SKA_049

**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B1å Himmel.

**MICROSHADE\_X**

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**LAYOUT**

PRODUCT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

**3XN\_GXN**

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**PROTOTYPE**

PROJECT DESCRIPTION





## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

## MICROSHADE\_X

### 3XN\_GXN

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### PROTOTYPE

PROJECT DESCRIPTION



**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and B18 Himmel.

**MICROSHADE\_X**

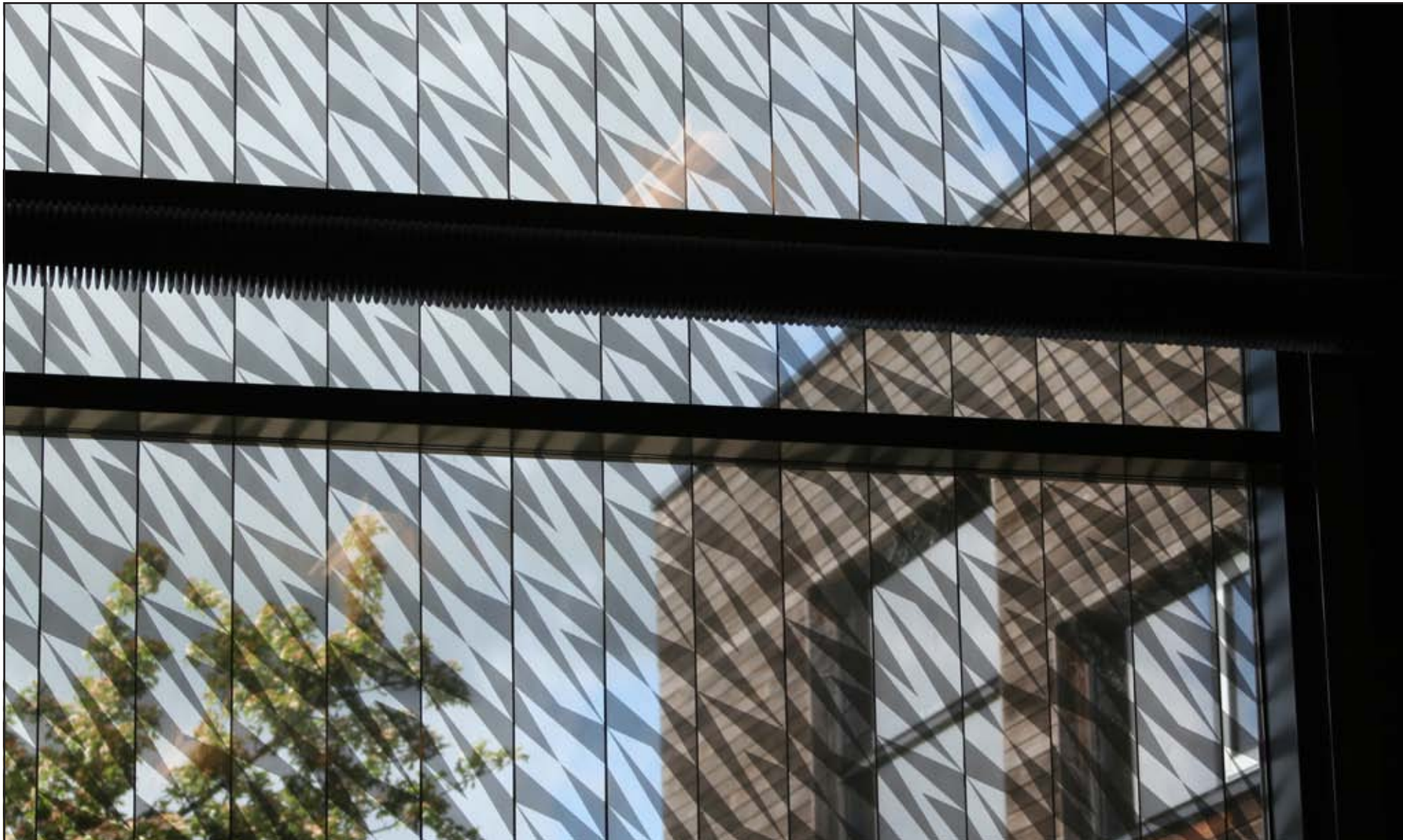
**3XN\_GXN**

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**PROTOTYPE**

PROJECT DESCRIPTION





## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

## MICROSHADE\_X

### 3XN\_GXN

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### PROTOTYPE

PROJECT DESCRIPTION



## PROJECT PARTNERS

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

## MICROSHADE\_X

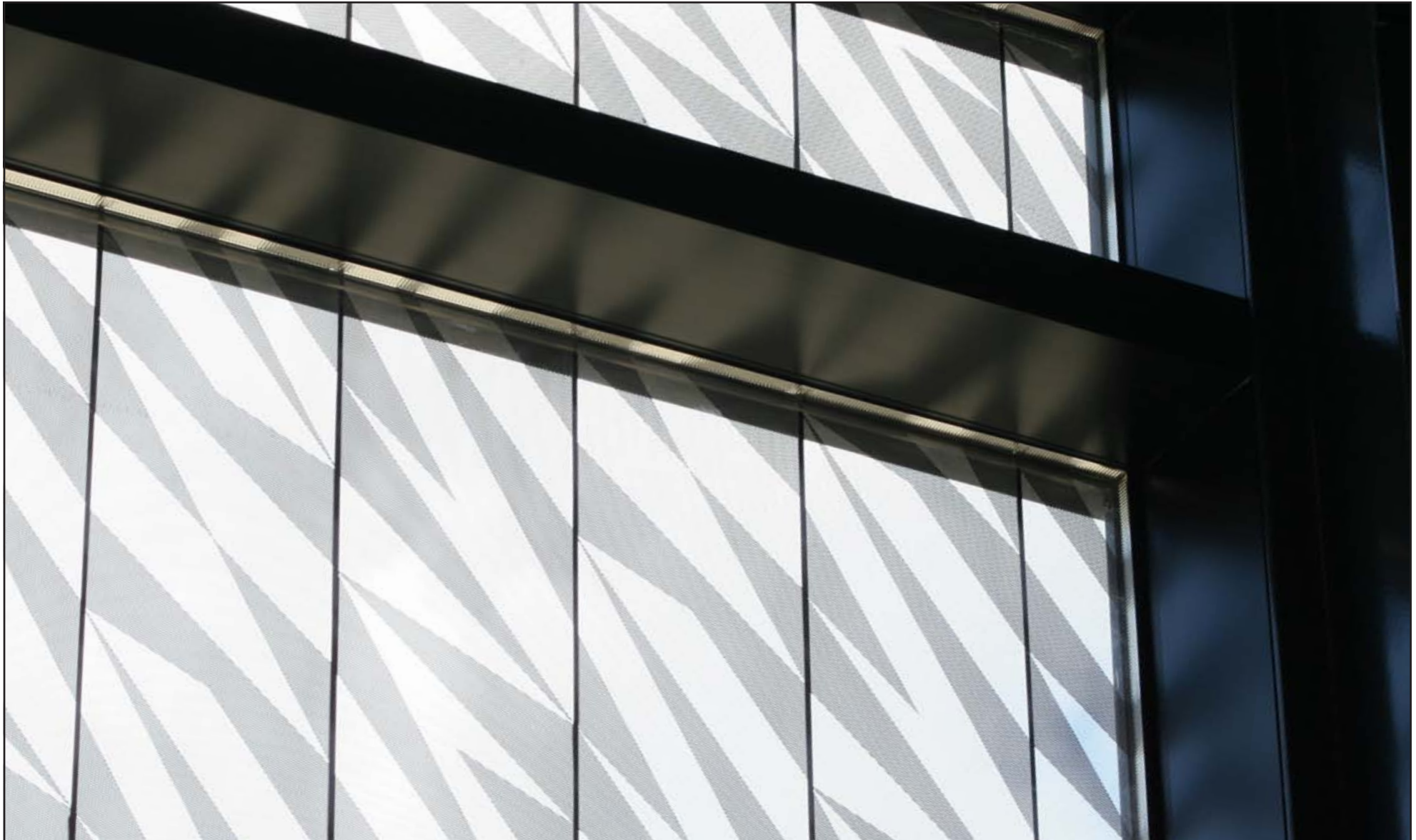
### 3XN\_GXN

STRANDGADE 73, 3.SAL  
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### PROTOTYPE

PROJECT DESCRIPTION





**PROJECT PARTNERS**

PhotoSolar, 3XN Architects, GXN Innovation Unit, 1st Mile and Blå Himmel.

**MICROSHADE\_X**

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**PROTOTYPE**

PROJECT DESCRIPTION



## PROJECT PARTNERS

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