A SUN SKINS

Adaptive Façade Systems for Building Integrated Organic Photovoltaics (OBIPV)

Climate change increases the demand for renewable energy sources, like photovoltaics. However, the search for appropriate areas often results in a competition for installation space (e.g. food productions vs. energy harvesting). At the same time, all the building envelopes in our cities offer an extensive area reserve for sustainable energy production. To unlock these surfaces, requires better building integrated photovoltaic systems. Ideally, these should be multifunctional, lightweight, designable, and adaptable to different installation requirements.

Therefore, this research explores the potential of thin, folded polycarbonate sheets for the integration of organic photovoltaics (OPV). The resulting Sun Skins façade systems combine industrial thermoforming processes with glass laminating techniques to create lightweight three-dimensional solar façade panels with increased material stiffness and minimal weight.

→ B Sun Skins en Détail

Using a computational workflow, integrates structural and solar analysis directly into the geometry generation of the Sun Skins panels. By developing a tool set based on the easily accessible Rhino© / Grasshopper© platform, helps architects to break down planning complexity and to optimize and design a variety of different Sun Skins solutions.

→ C Sun Skins Computational Approach

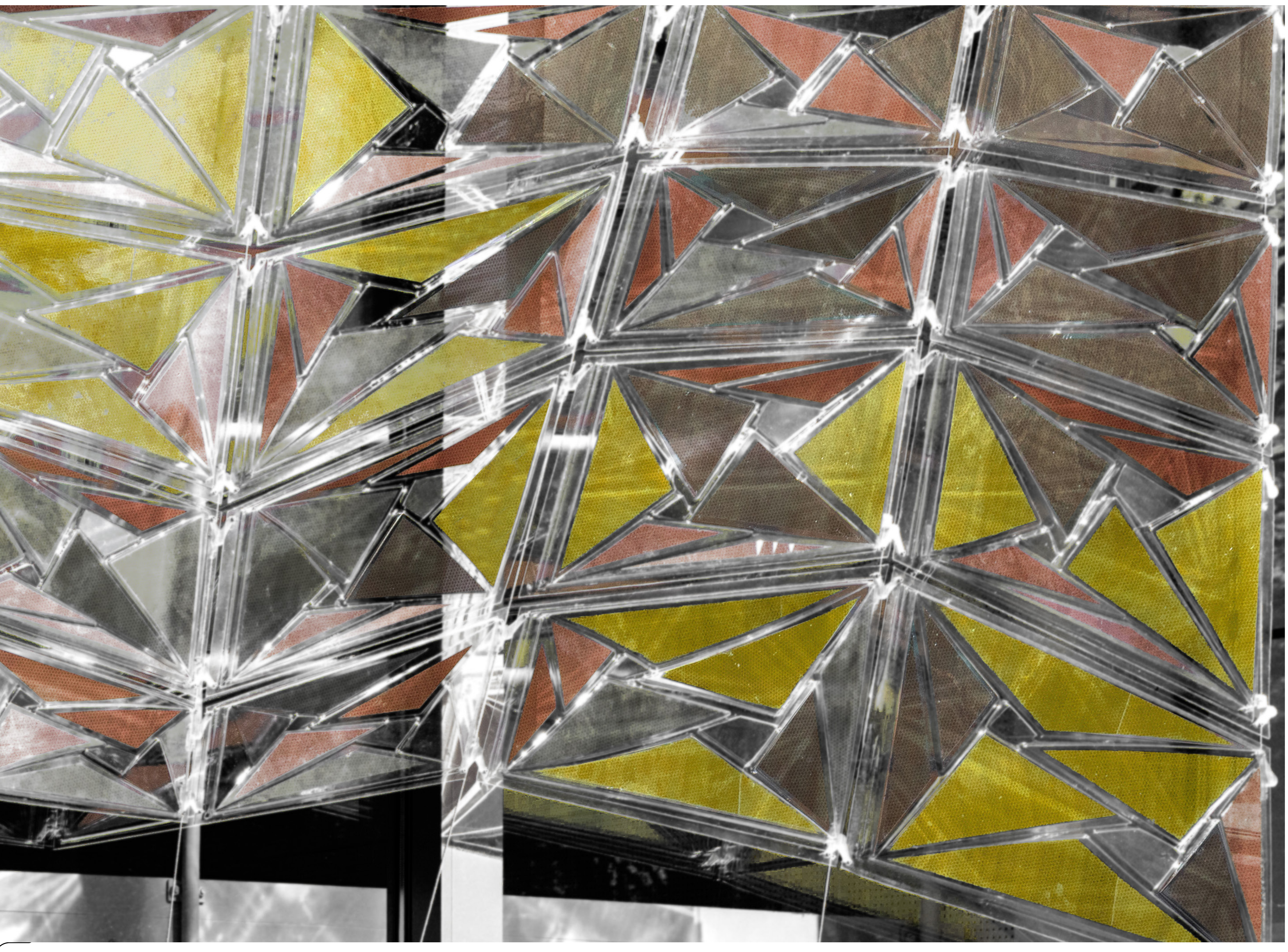


Fig. 1 - Sun Skins Prototype with Cable Net Integration

B SUN SKINS EN DÉTAIL

Integrating Organic PV into Transparent and Folded Lightweight Components

The appropriate manufacturing of three-dimensional components necessitates suitable fabrication processes and materials. In accordance with the lightness of the organic PV (OPV) technology, the project Sun Skins explores thin plastic sheet materials for their potential use in photovoltaic façade components.

Adapting traditional processes of industrial thermoforming proofed successful for transforming flat polycarbonate sheet geometries into three-dimensional shapes with shell-like load-bearing capacities. Further tests on a detail geometry level with locally introduced ribs and beads resulted in additional stiffness and an further increase in material efficiency.

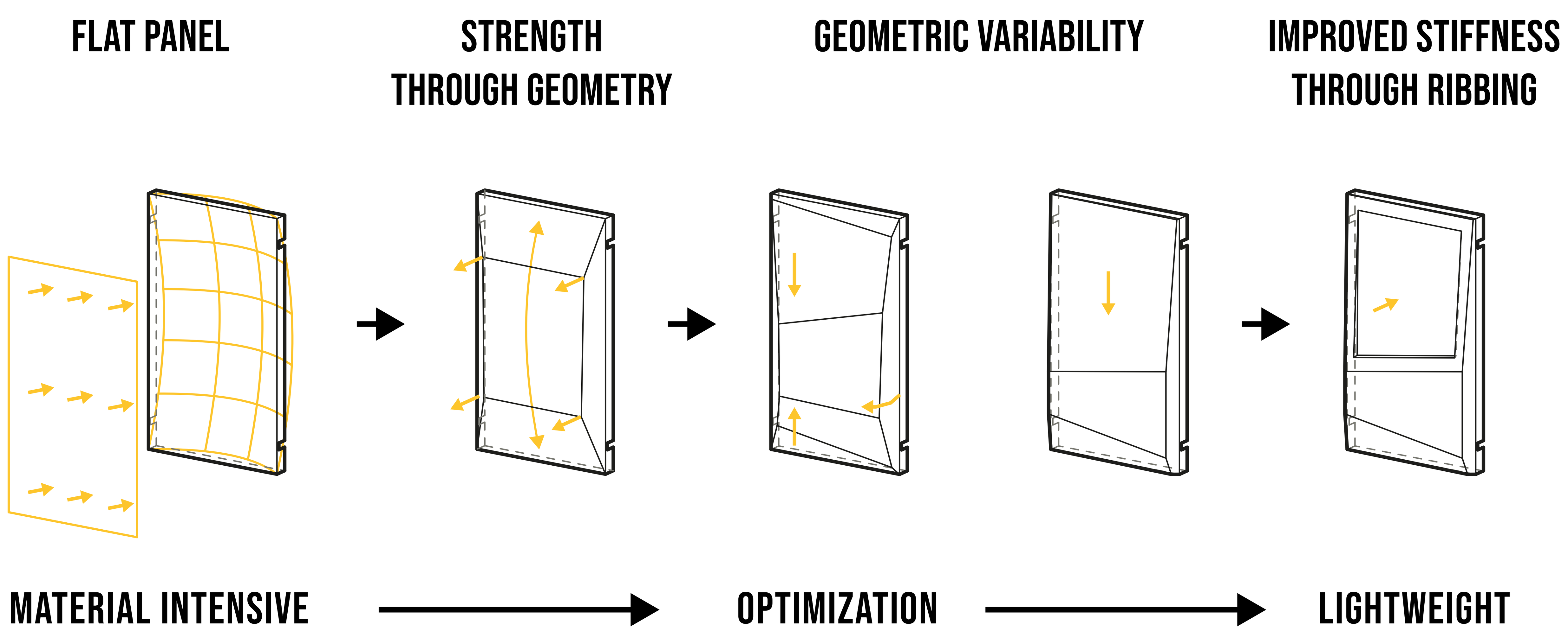


Fig. 2 - Formactive Geometry Development

The thermoforming process is both precise and flexible enough to produce lightweight components for the integration of OPV modules in a sandwich component. The durable bonding of the different layers is achieved appropriating techniques from glass lamination using hot melts.

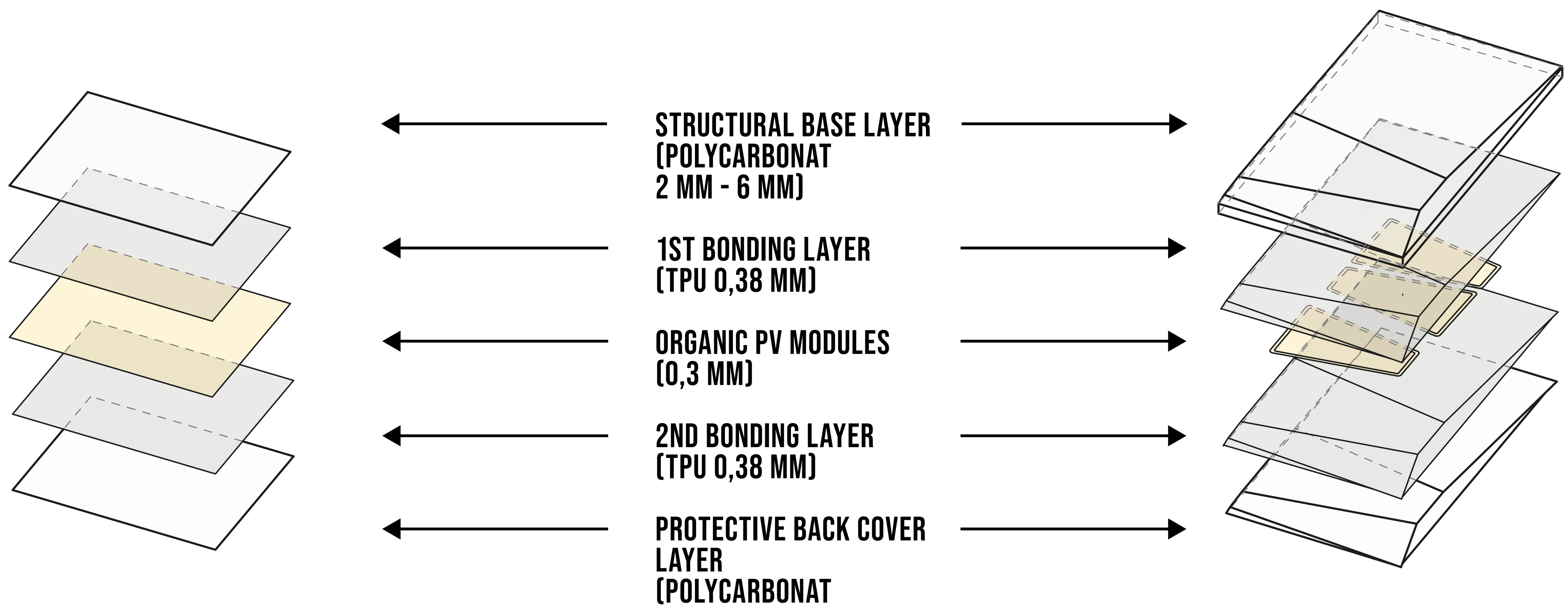


Fig. 3 - Layers of a Sun Skin Component

Next, the key learnings from the fabrication and material tests are formalized within a parametric geometry generation. This allows for a quick generation and evaluation of various design options.

C SUN SKINS COMPUTATIONAL APPROACH

Formalizing 'Key Learnings´ into an Easy to Use Tool Set

To allow for an easy to use and fast design of various Sun Skin geometries, we developed a parametric tool set, based on our material tests. The user can quickly adapt relevant geometric parameters, such as the height and rotation of the component surfaces, as well as the angles of attack of the side surface.

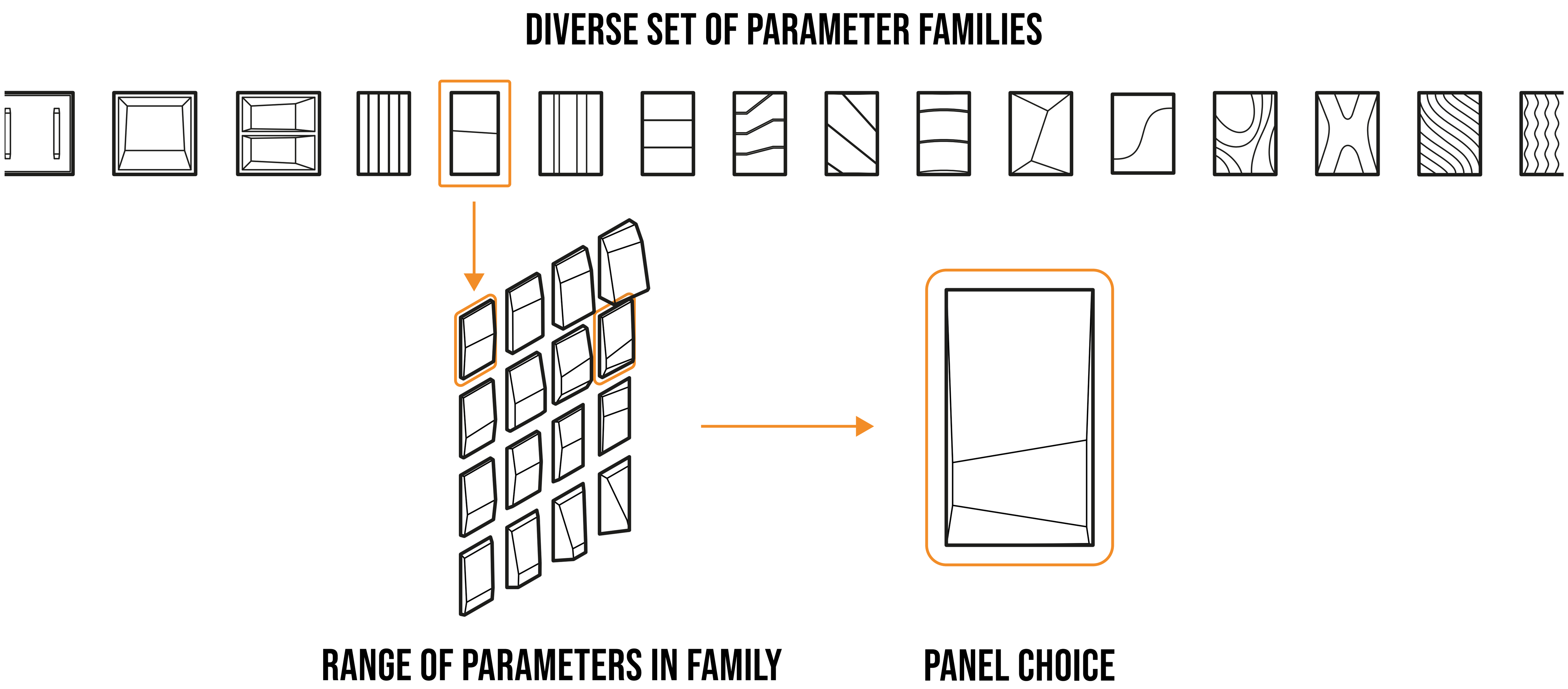


Fig. 4 - Geometric Variation within a Single Component Type

Preset prototype geometries that are already optimized, tested and validated are included in the tool to facilitate very fast designs solutions. Future users are also able to explore their own designs within the Rhino© and Grasshopper© platforms, using a pre-programmed simulation and optimization system.

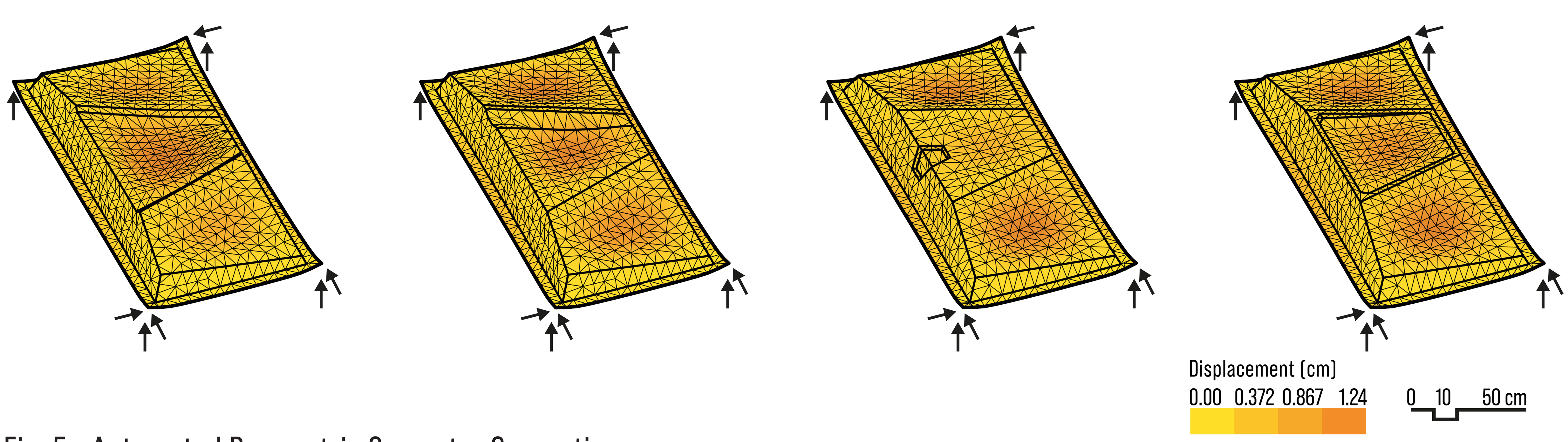


Fig. 5 - Automated Parametric Geometry Generation

Accordingly, the research team utilized a combination of computational methods, including 2D FEM (finite element) and detailed 3D FEM analysis, solar analysis as well as genetic algorithms. The computational models and structural assumptions of the tool set were calibrated with the help of a series of 1:1 bending-tension-compression tests.

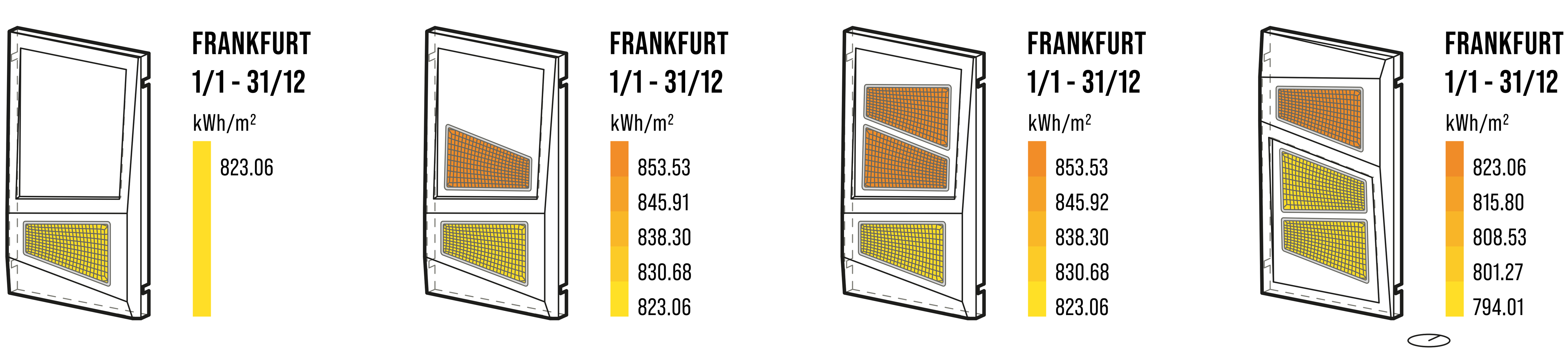
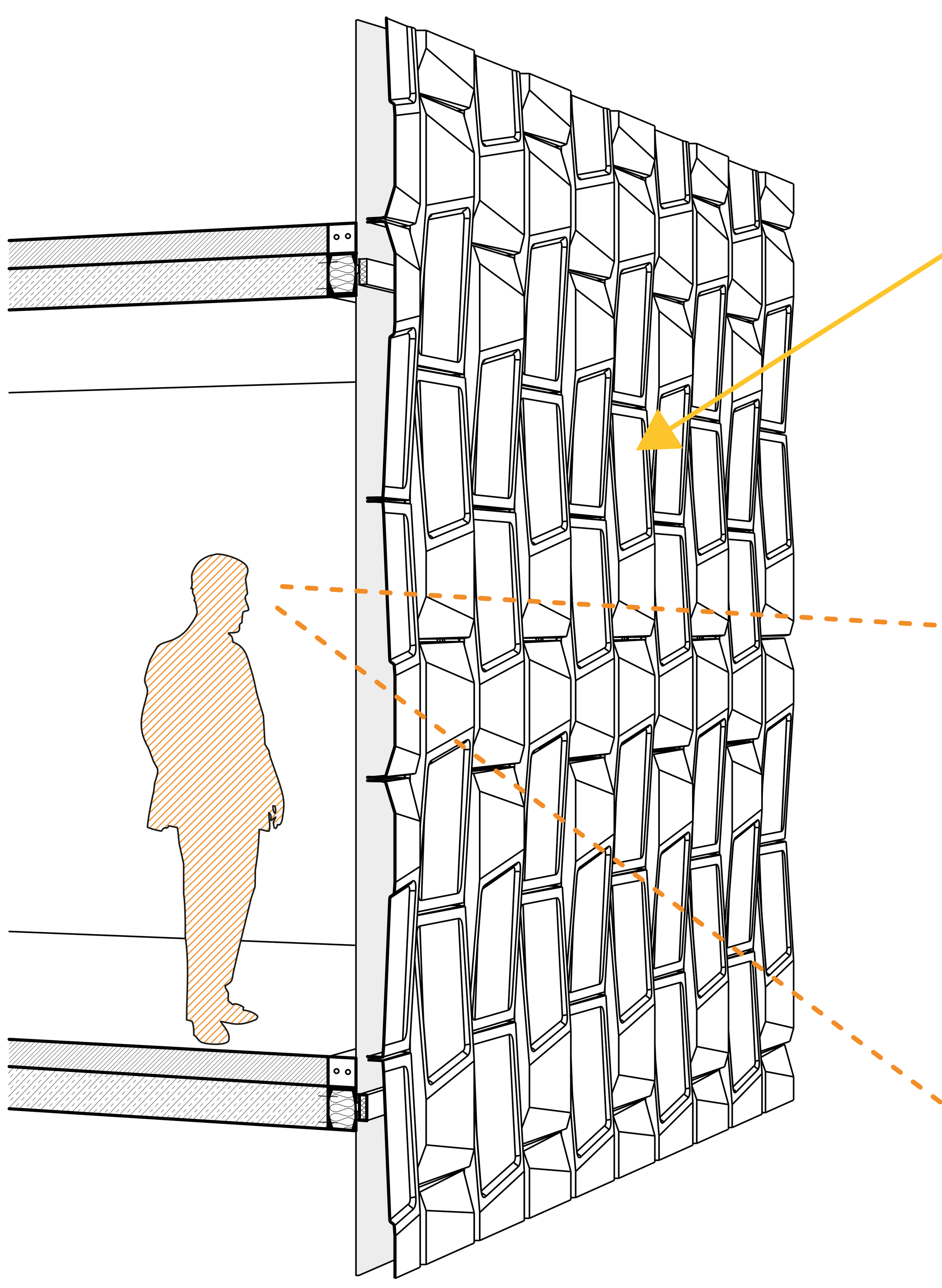


Fig. 6 - Structural- and Solar Simulations

The results of the simulations demonstrate a substantial improvement of the structural performance and material efficiency in comparison to flat façade building integrated photovoltaic panels.

For further insides, this Sun Skins façade mock-up hopes to inspire visitors to imagine their own design approach and personal solar aesthetic.

SUN SKINS



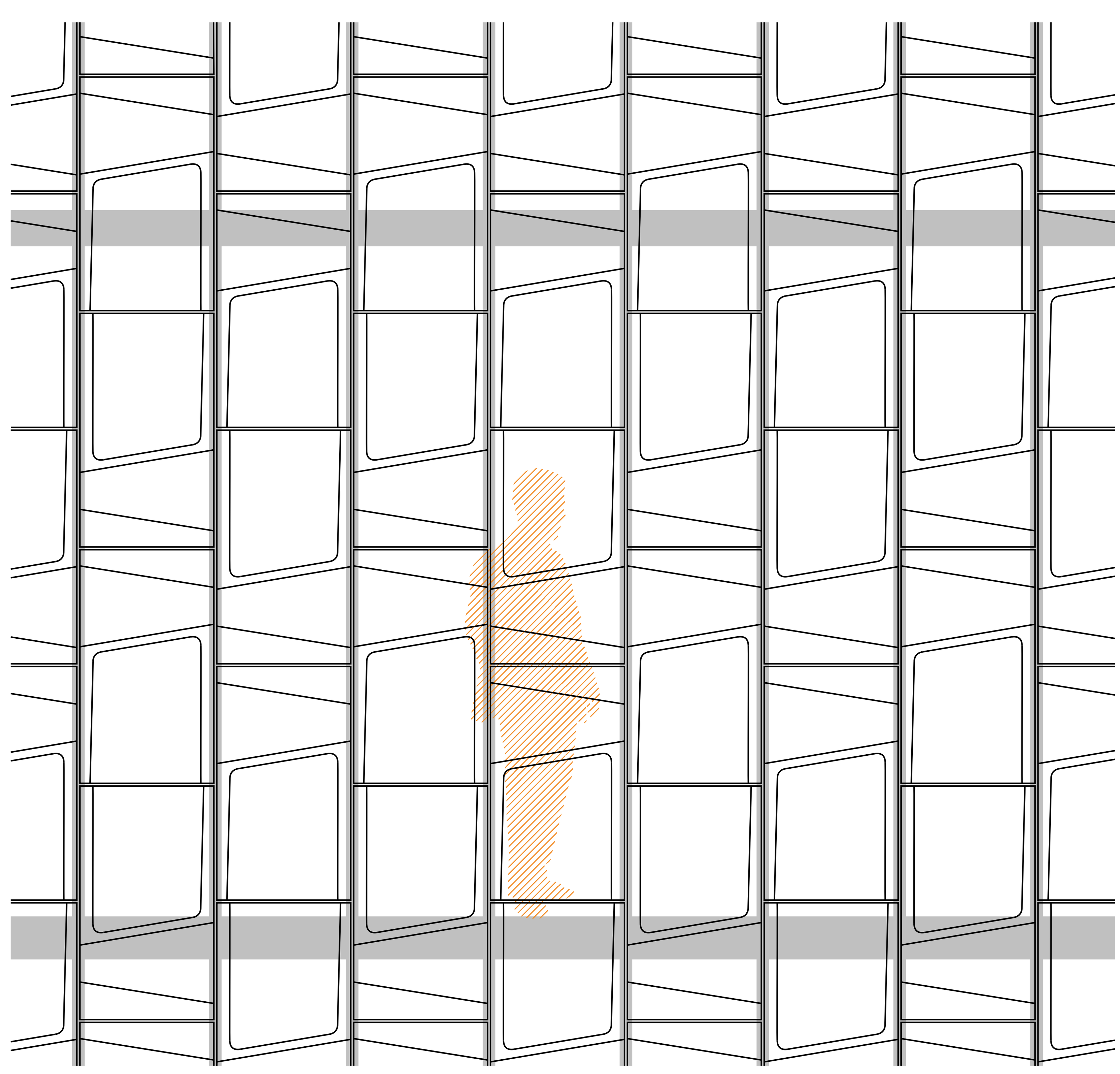


Fig. 7 - Potential Façade Cladding with Sun Skins Components

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