SUMMARY REPORT - SOLAR*shell*

THE PARAMETRICALLY OPTIMIZED FACADE AS AN ENERGY SOURCE

Background

In Germany, the building standard "low-energy house", that requires alternative energy producers in or near the building, shall become mandatory for all new buildings as early as 2020. In addition, all buildings shall be "climate-neutral" by 2050. This results in a great potential for high-quality building-integrated photovoltaics (BIPV), the yield of which can be significantly optimized through solar alignment.

Subject of Research

SOLARshell examined potentials and possibilities for the development of yield-optimized, architecturally high-quality photovoltaic facades (PV facades) and focused on the use of fragmented PV modules instead of large standard formats. These can be variably combined with a variety of facade materials and provide a performance maximum through parametric-generative alignment with the sun. The simulation algorithms provide direct feedback on the architectural design (Figure 1) and generate a large number of variants in a short time. In the project, the tool was used to evaluate and optimize designs for the solar entry.

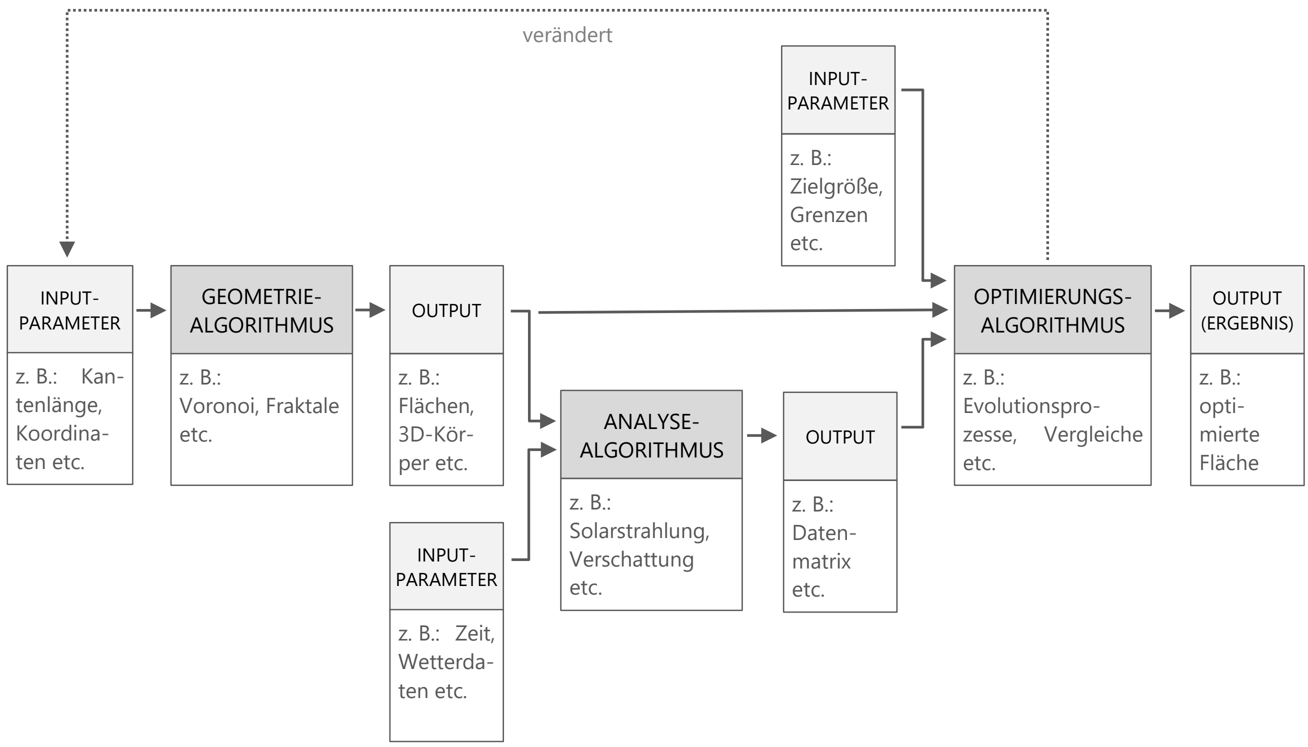
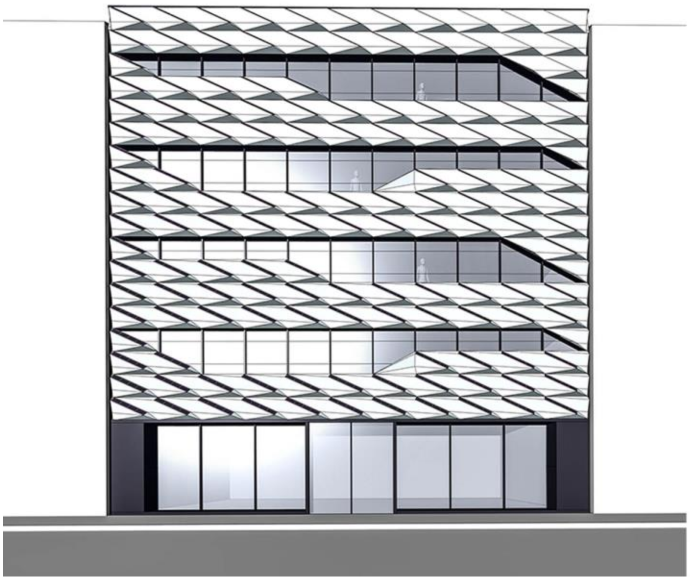


Figure 1: Interaction of parameters & algorithms in the parametrical generative design process of SOLAR*she ll* Leipzig

Initially, suitable parametric-generative optimization principles were determined in the project. Also, facade materials, facade systems and PV technologies were examined with regard to their suitability for BIPV and their combinability was assessed. Among others, ventilated curtain facades from metal, concrete and plastics as well as veneers made of brick turned out to be advantageous and thus were elaborated in the following as optimized facade designs:

Folded metal facade

A folded metal facade with integrated PV blades (Figure 2) offers a potentially broad field of application due to its high adaptability. The facade consists of folded cassette-like modules. In the digital design process, the PV blades are movable in 2 axes by rotation. In the specific application scenario a solar-optimized, fixed alignment is determined. The 3D folding enables a clean transition between the elements with diagonal PV blades and those with horizontal PV blades. In order to maximize yields, monocrystalline high-performance cells were envisaged.



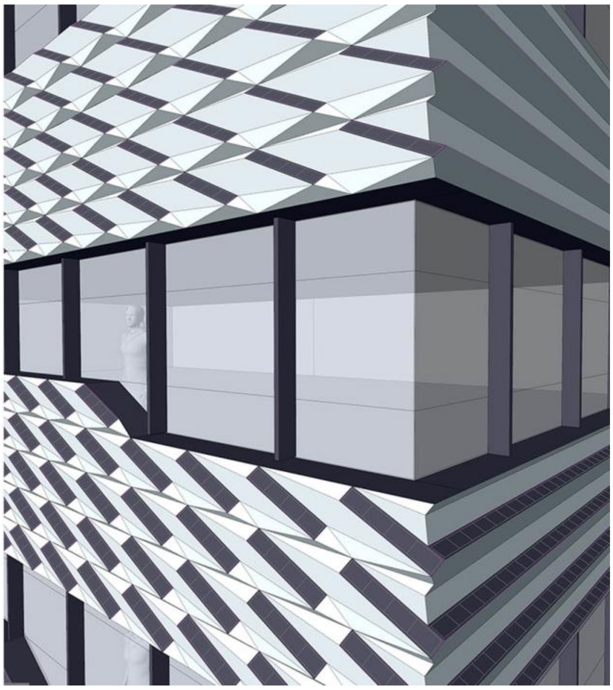


Figure 2: Folded metal facade | front view & corner detail

Solar brick facade

Due to their small size, "solar bricks" offer great flexibility to control solar yields. Pushing out the bricks from the facade level creates areas that can be covered and activated with crystalline or organic PV. Depending on how the facade is aligned the bricks rotate more or less far. Even with a uniaxial alignment optimization (Figure 3) high yields can be achieved over the course of the year. Due to the large individualisation potential of the facade, a corner can be implemented without any yield restrictions.

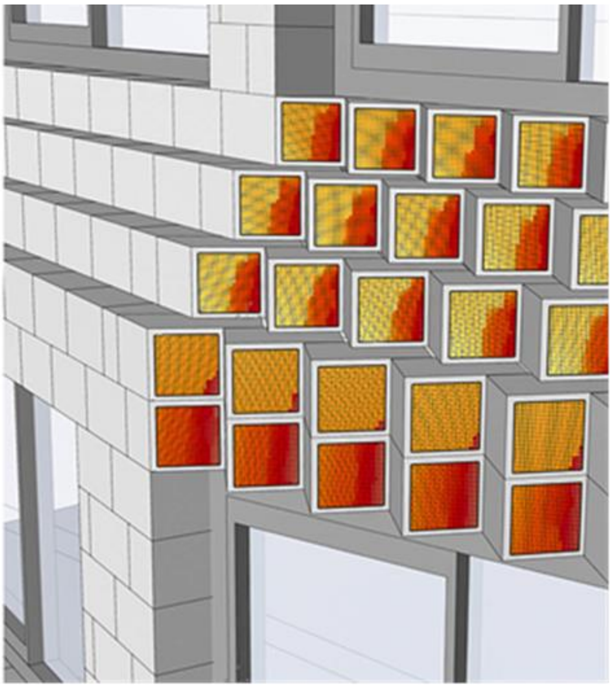


Figure 3: Solar brick facade | front view & corner detail with false color rendering of the solar entries

<u>Gill structure facade</u>

Facade-high gills are aligned optimally over rotation in the vertical axis (Figure 4). Because the gills are ending curved at the upper and lower edge of the facade the use of flexible organic PV makes sense. The design principle can be used sensibly only with one-sided west or east-oriented facades but can be extended on the roof surfaces in order to increase the potential. As a slim and freely formable facade material, textile concrete, sheet metals or plastics can be used.

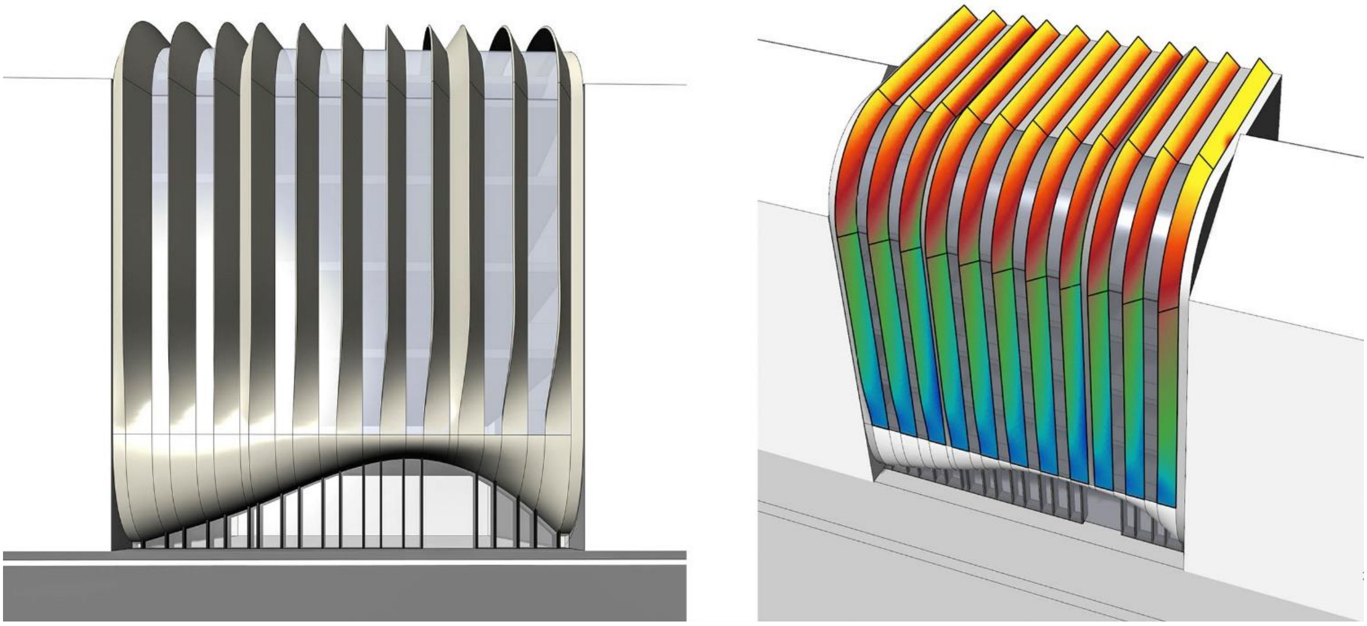


Figure 4: Gill structure facade | front view & perspective with false color rendering of the solar entries

<u>Comparison of the facade variants</u>

The following table compares the simulation results of the 3 facade variants. It turned out that the folded facade makes the most efficient use of the installed PV, the gill version allows for maximum total yields due to the largest usable surface.

Tab. 1: comparison of facade variants

Variant	Size of PV module [m²]	No. of PV modules	PV surface size [m²]	Overall yields of PV surface [kWh/a]	Overall yields per m² PV surface [$kWh/m^2_{pv}*a$]
Folded facade	0,24	166	40	25.372	637
Solar brick	0,08	1009	82	28.448	349
Gill structure a)	16,37	11	180	99.041	550
Gill structure b)*	23,75	11	261	180.517	691

* variant incl. roof surface

<u>Demonstrator</u>

The design variant "folded metal facade" was developed technically and constructively up to the demonstrator, which shows a section of the metal facade on a west- and south-facing building corner on a scale of 1:2 (Figure 5). The facade elements consist of folded aluminium composite panels, in which glass-foil micro PV modules are inserted. It demonstrates the fusion of architectural aesthetics and yield maximization through shape and orientation optimization, as can be achieved with parametric-generative design methods.

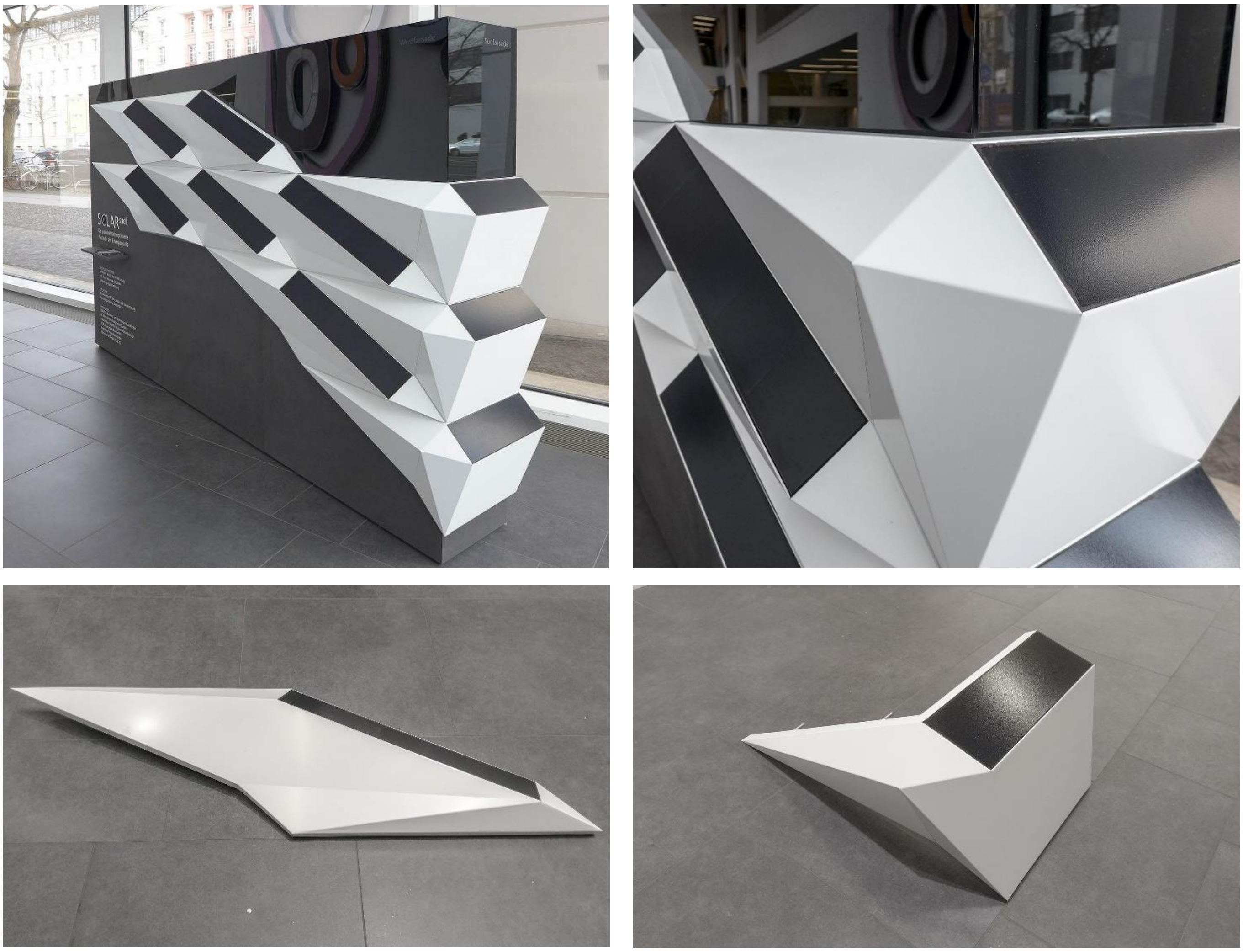


Figure 5: Realized SOLARshell demonstrator | facade, corner detail & west and south facade element

Conclusion

The set project goals (evaluation of parametrical generative principles, PV technologies, facade materials & systems | constructive development of solar optimized architectural facades | realization of a demonstrator) were fully achieved and the general feasibility of solar optimized facades in a high-quality design diversity could be demonstrated. By optimizing the alignment of the inserted small-scale PV, the yields per m² of PV area could be increased by between 40 and 55 % compared to vertically installed modules.

Key Data

Short title:	SOLARshell
Researchers:	Dipl.-Ing. (FH) Adrian Heller | Stefan Huth, M.A., Architekt | Sarah Knechtges, M. Sc. | Dipl.-Ing. (FH) Jana Reise | Project management: Prof. Frank Hülsmeier, Architekt
Total costs:	200.249,57 €
Grant:	138.789,57 €

IMAGES/ ILLUSTRATIONS:

Illustration 1
File name: abb_1_solar.shell_parametrisches entwerfen.tif
Caption: Interaction of parameters & algorithms in the parametrical generative design process of SOLARshell
Image rights: Architektur-Institut Leipzig ai:L

Illustration 2
File name: abb_2_solar.shell_gefaltete fassade.tif
Caption: Folded metal facade | front view & corner detail
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Illustration 3
File name: abb_3_solar.shell_solarziegelfassade.tif
Caption: Solar brick facade | front view & corner detail with false color rendering of the solar entries
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Illustration 4
File name: abb_4_solar.shell_kiemenfassade.tif
Caption: Gill structure facade | front view & perspective with false color rendering of the solar entries
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Illustration 5a
File name: abb_5a_solar.shell_demonstrator.tif
Caption: SOLARshell demonstrator | facade
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Illustration 5b
File name: abb_5b_solar.shell_demonstrator_ecke.tif
Caption: SOLARshell demonstrator | corner detail
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Illustration 5c
File name: abb_5c_solar.shell_demonstrator_westelement.tif
Caption: SOLARshell demonstrator | west facade element
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Illustration 5d
File name: abb_5d_solar.shell_demonstrator_südelement.tif
Caption: SOLARshell-Demonstrator | south facade element
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