

ALTERNATIVE SOLAR CELL PATTERNS FOR LIGHT-TRANSMISSIVE PV PANELS

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東京大学
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1. Introduction

2. Study approach and aim

3. Solar cell patterns of crystalline silicon cells

4. 'W(e)AVE' – tilted and wave-like cell patterns

5. Conclusion

1. Introduction

From the point of architectural BIPV, however, it seems to be reasonable to distinguish between opaque modules and semi-transparent or translucent modules.

Opaque PV

Paul Horn-Arena, Tübingen, Germany



Fig.1 © Allmann Sattler Wappner Architekten, München

Opaque PV ↔ Light-Transmissive PV

Paul Horn-Arena, Tübingen, Germany



Fig.1 © Allmann Sattler Wappner Architekten, München

Jaume University, Castellon, Spain



Fig.2 © Scheuten Solar

2. Study approach and aim

'light-through'



Fig.3 © BSW-Solar/Langrock

'light-through' ↔

'see-through'



Fig.3 © BSW-Solar/Langrock



Fig.4 © Kaneka Corporation

'light-through'



'see-through'



Fig.3 © BSW-Solar/Langrock



Fig.4 © Kaneka Corporation

3. Solar cell patterns of crystalline silicon cells

*3.1. rectangular PV panels –
homogeneous cell patterns*

round

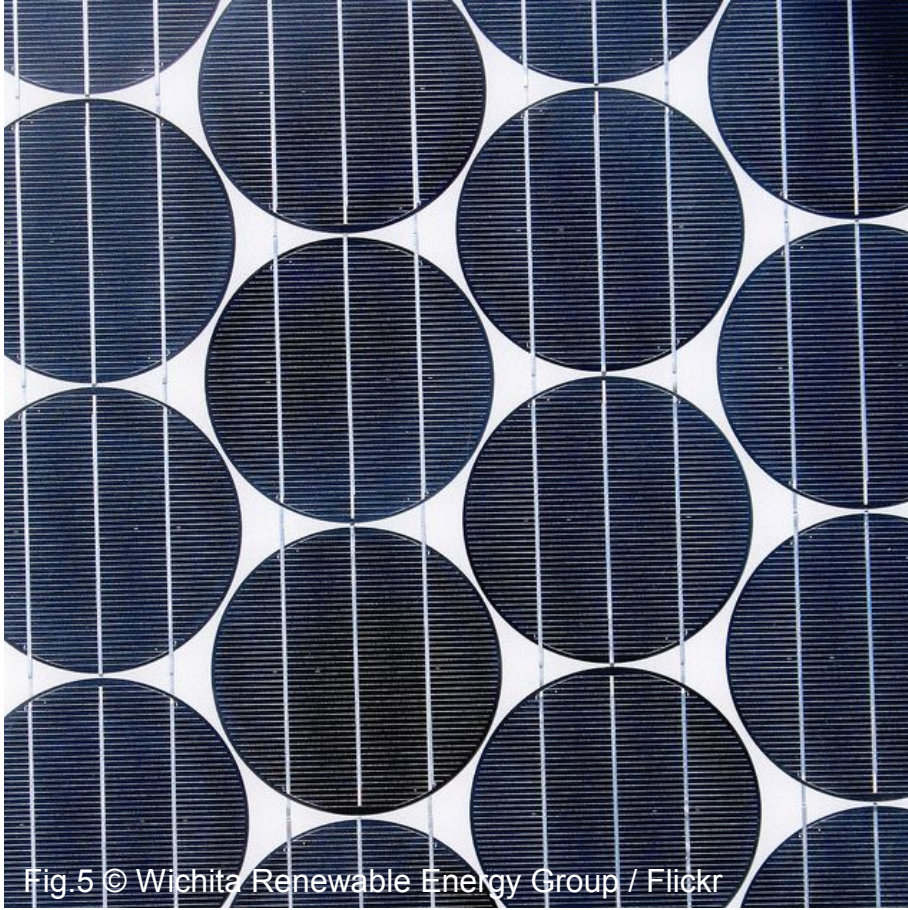
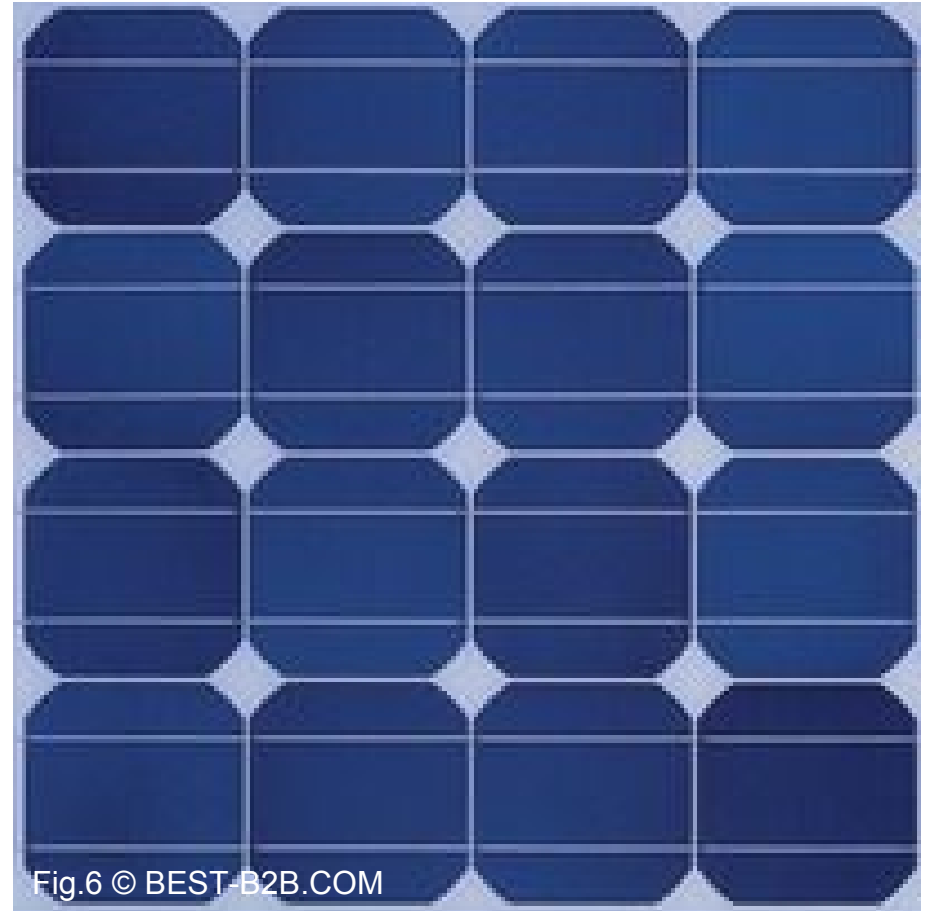
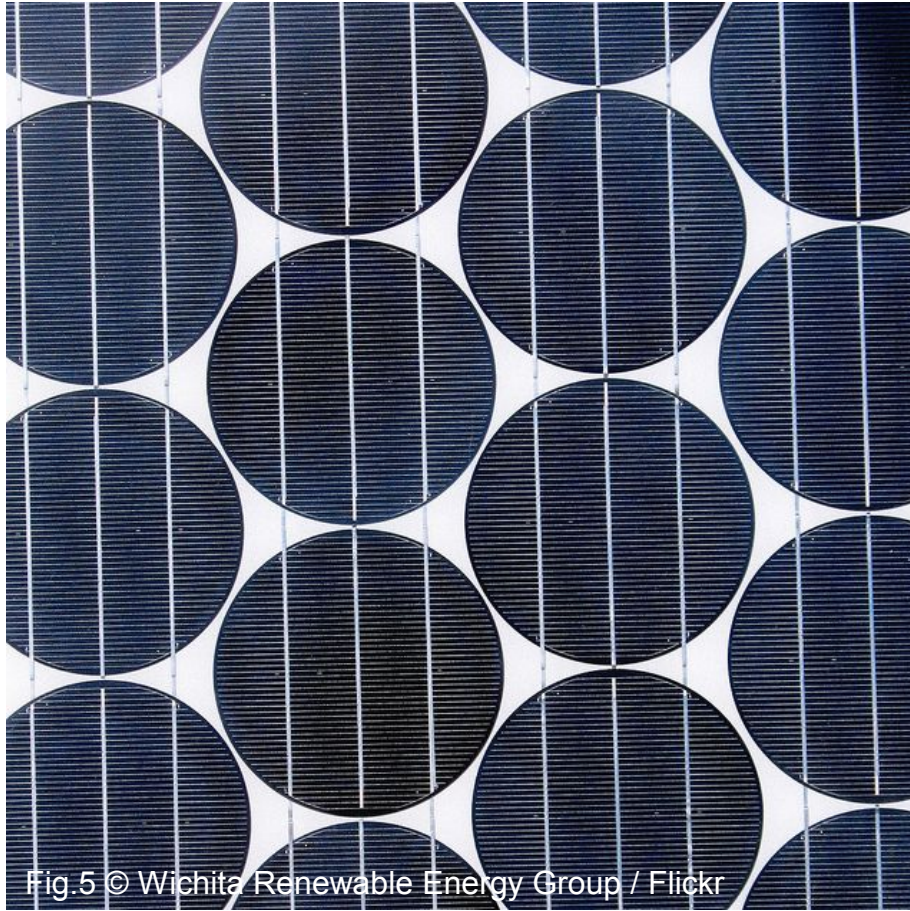


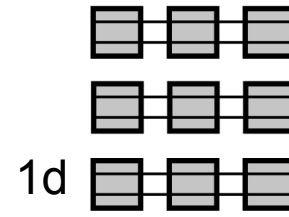
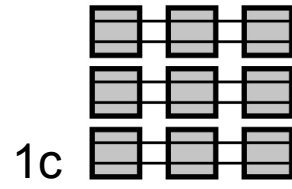
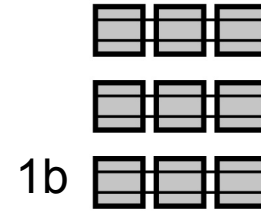
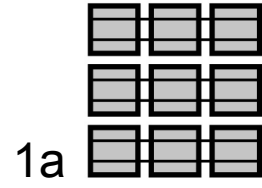
Fig.5 © Wichita Renewable Energy Group / Flickr

round



pseudo-square





Tobias Grau GmbH
Hamburg, Germany, 2001
architect: BRT

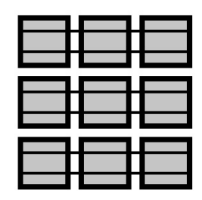


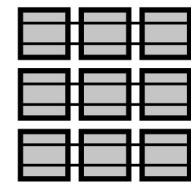
Fig.7 © Schüco International KG



Fig.8 © Tobias Grau GmbH



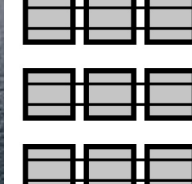
Fig.8 © Tobias Grau GmbH



Opera House Oslo, Norway, 2007 architect: Snøhetta



Fig.9 © Christopher Hagelund / The Telegraph



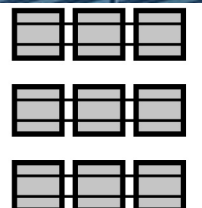
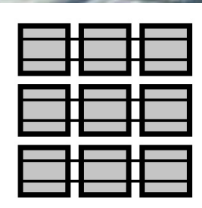




Fig.8 © Tobias Grau GmbH

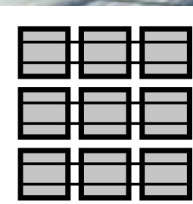


Fig.10 © n.a.

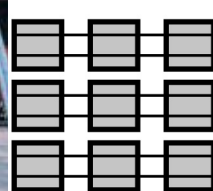


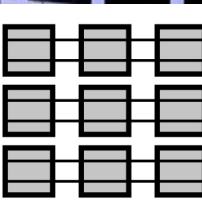
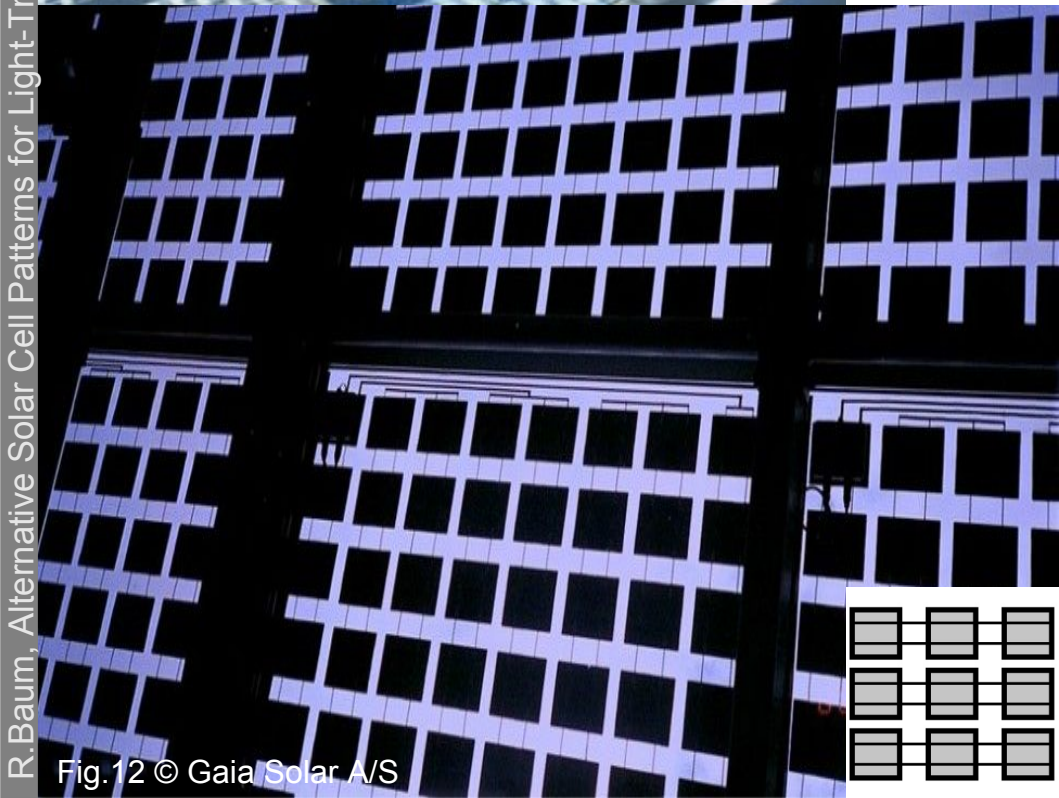
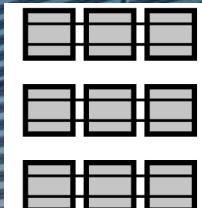
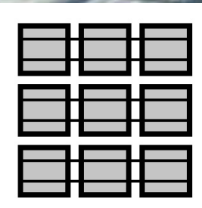
Fire Station

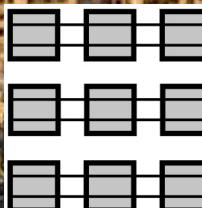
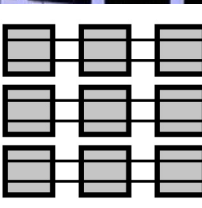
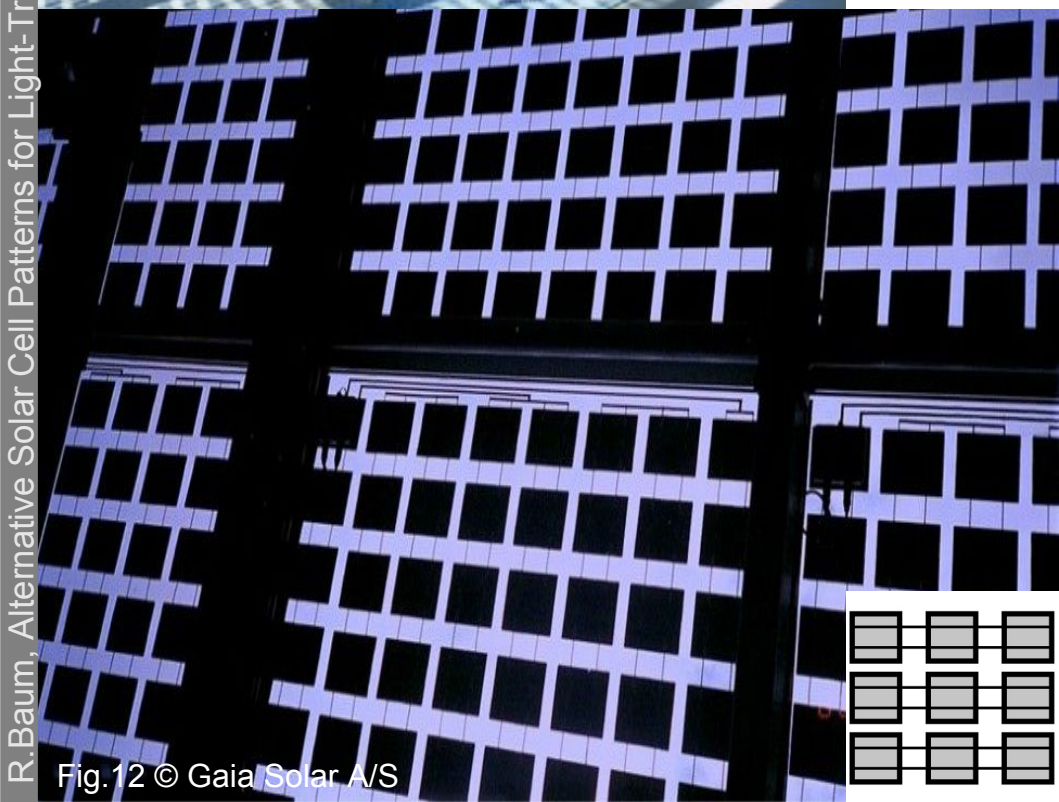
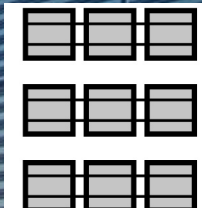
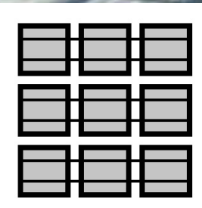
Houten, the Netherlands, 2000
architect: Samyn & Partners

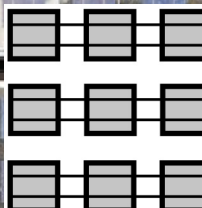
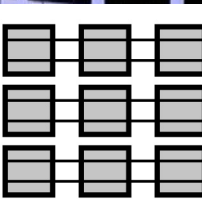
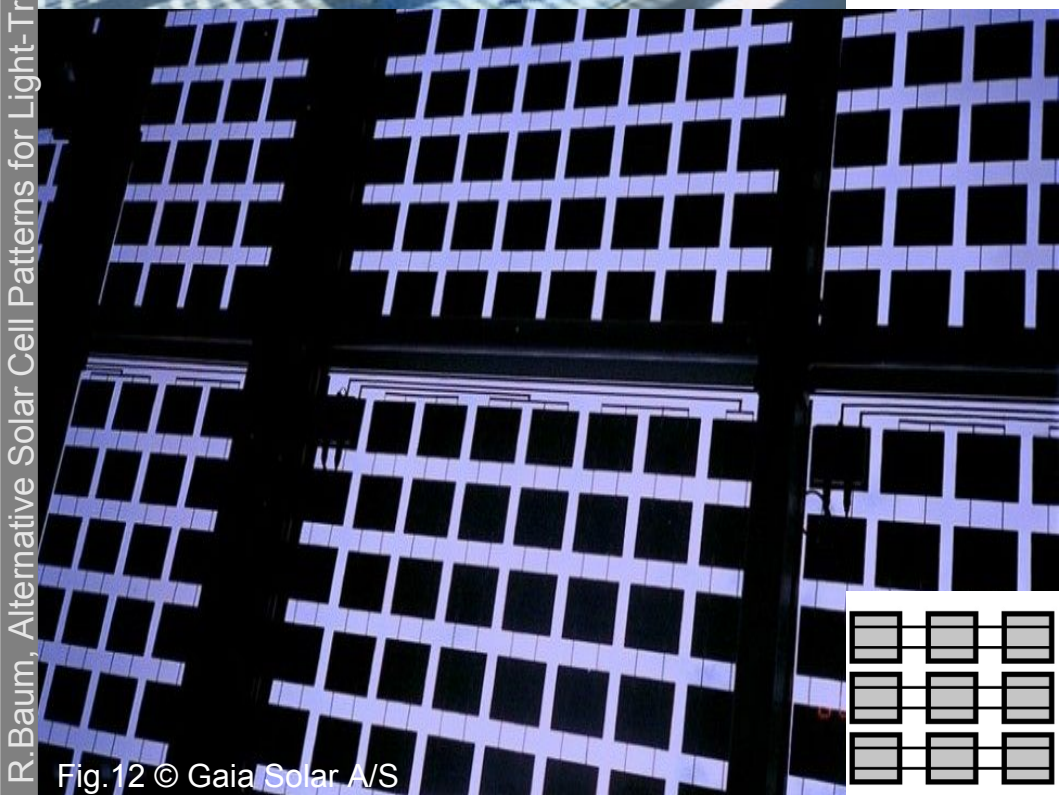
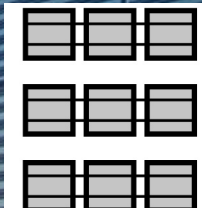
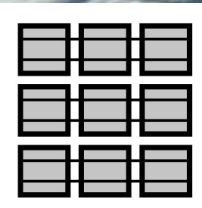


Fig.11 © Ch. Richters









Tobias Grau GmbH
Hamburg, Germany, 2001
architect: BRT



Fig.7 © Schüco International KG

Opera House
Oslo, Norway, 2007
architect: Snøhetta



Fig.9 © Christopher Hagelund / The Telegraph

Fire Station
Houten, the Netherlands, 2000
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Fig.11 © Ch. Richters

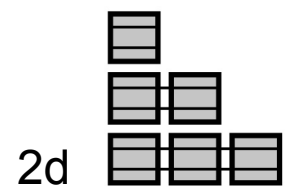
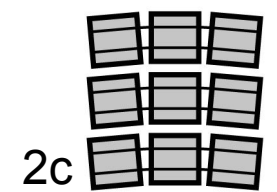
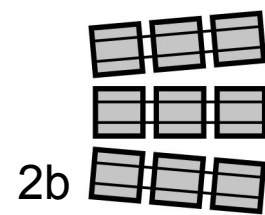
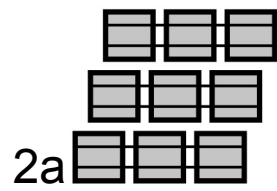
Heron Tower
London, UK, 2011
architect: Kohn Pederson Fox



Fig.13 © Heron International

3. Solar cell patterns of crystalline silicon cells

3.2. non-rectangular PV panels – homogeneous cell patterns



The Core, Eden Project

Bodelva, Cornwall, UK, 2005
architect: Nicholas Grimshaw & P



Fig.15 © copperconcept.org

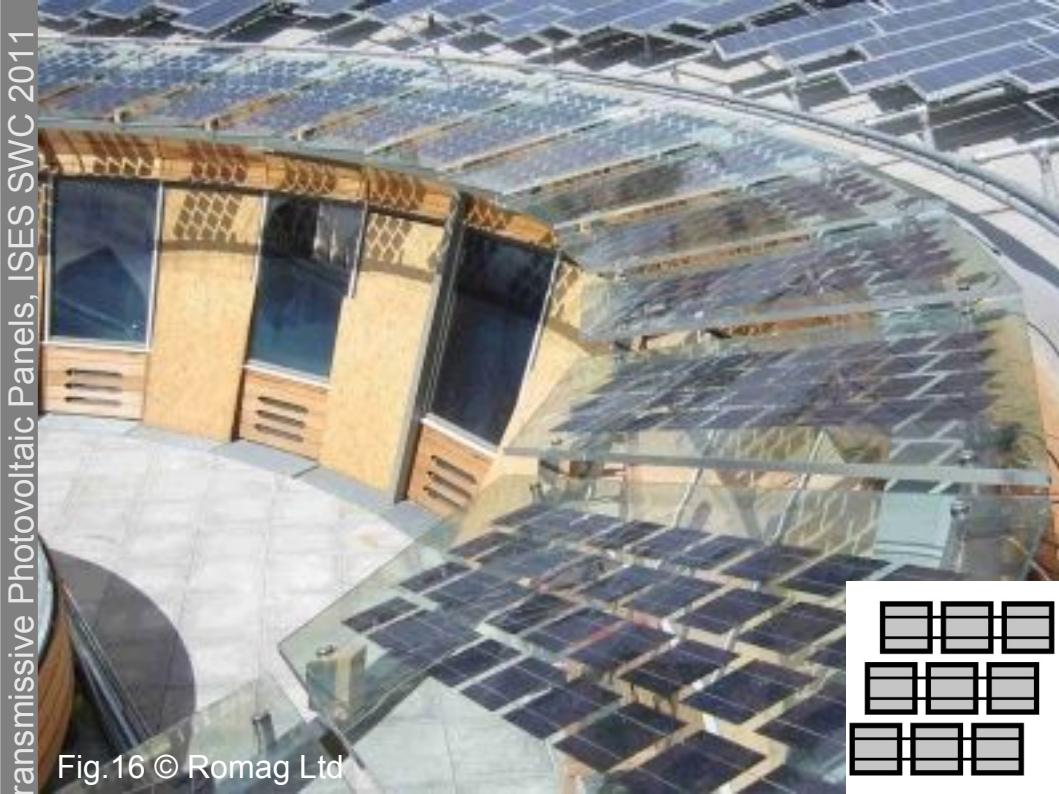
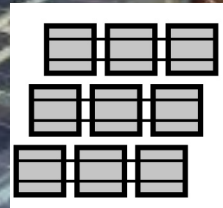


Fig.16 © Romag Ltd

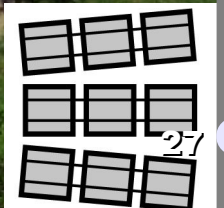


Fig.16 © Romag Ltd



Café Ambiente
Bremen, Germany, 1997
architect: Mencke + Tegtmeier

Fig.17 © BSW-Solar / www.solar-integration.de



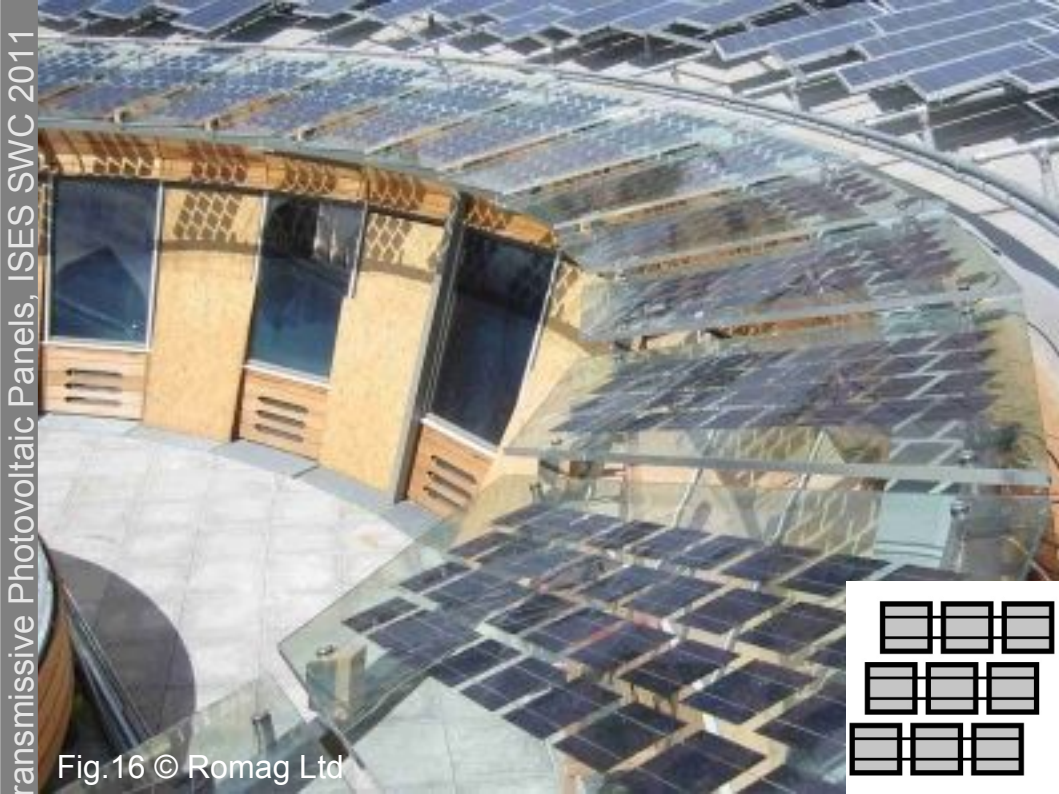


Fig.16 © Romag Ltd



Fig.18 © solarnova
Produktions- und Vertriebsgesellschaft mbH



Fig.16 © Romag Ltd

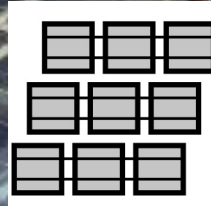
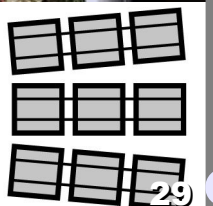


Fig.18 © solarnova Produktions- und Vertriebsgesellschaft mbH



Gemini House

Weiz, Austria, 2001
architect: Erwin Kaltenegger



Fig.19 © Energie-Schau-Straße

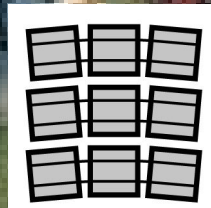




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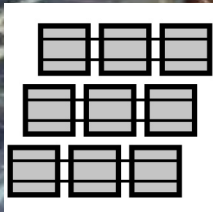


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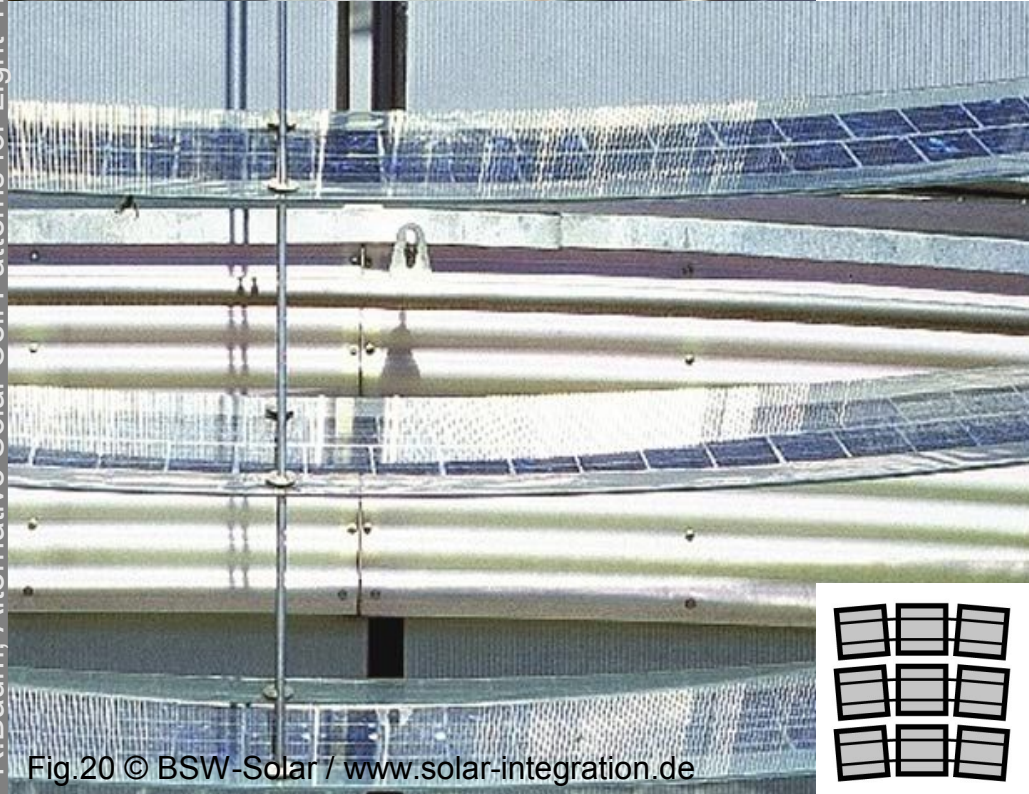
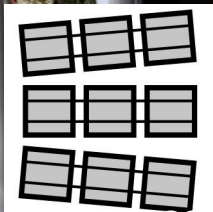


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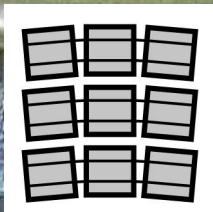




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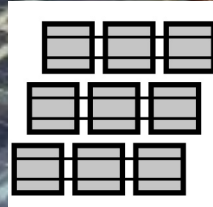


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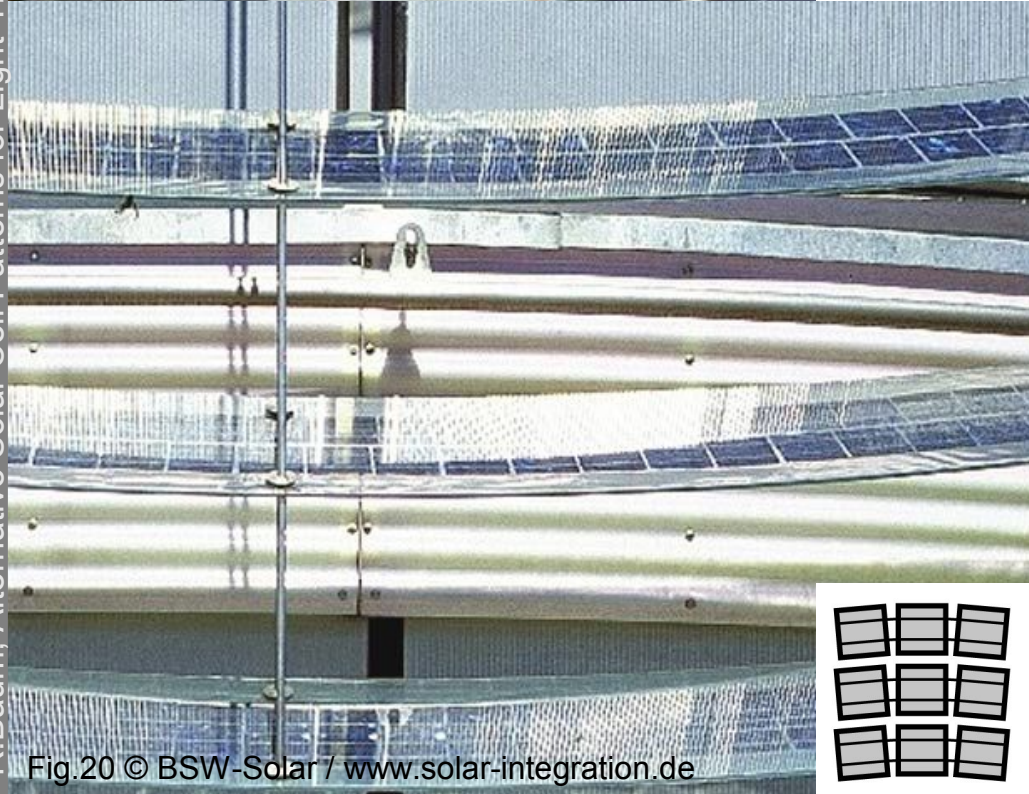
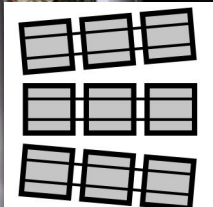


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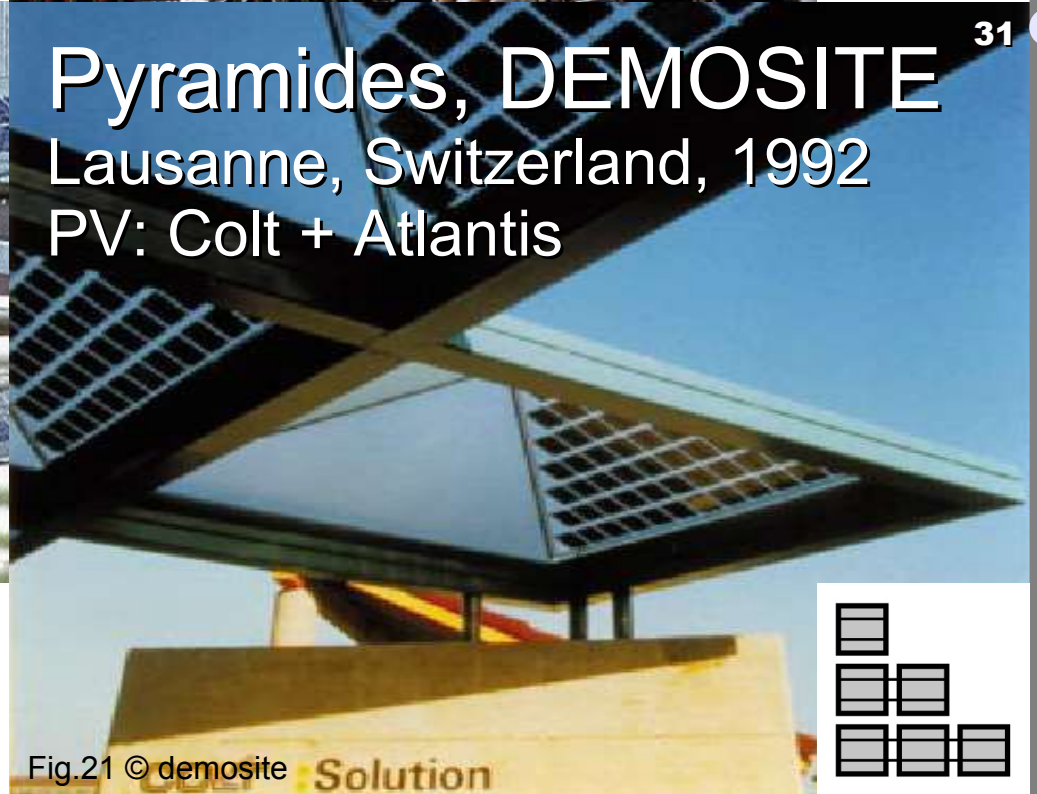
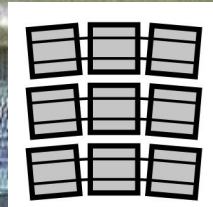
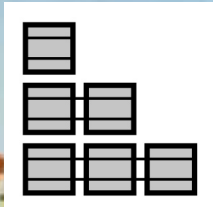


Fig.21 © demosite



Pyramides, DEMOSITE

Lausanne, Switzerland, 1992
PV: Colt + Atlantis



Fig.16 © Romag Ltd



Fig.18 © solarnova Produktions- und Vertriebsgesellschaft mbH

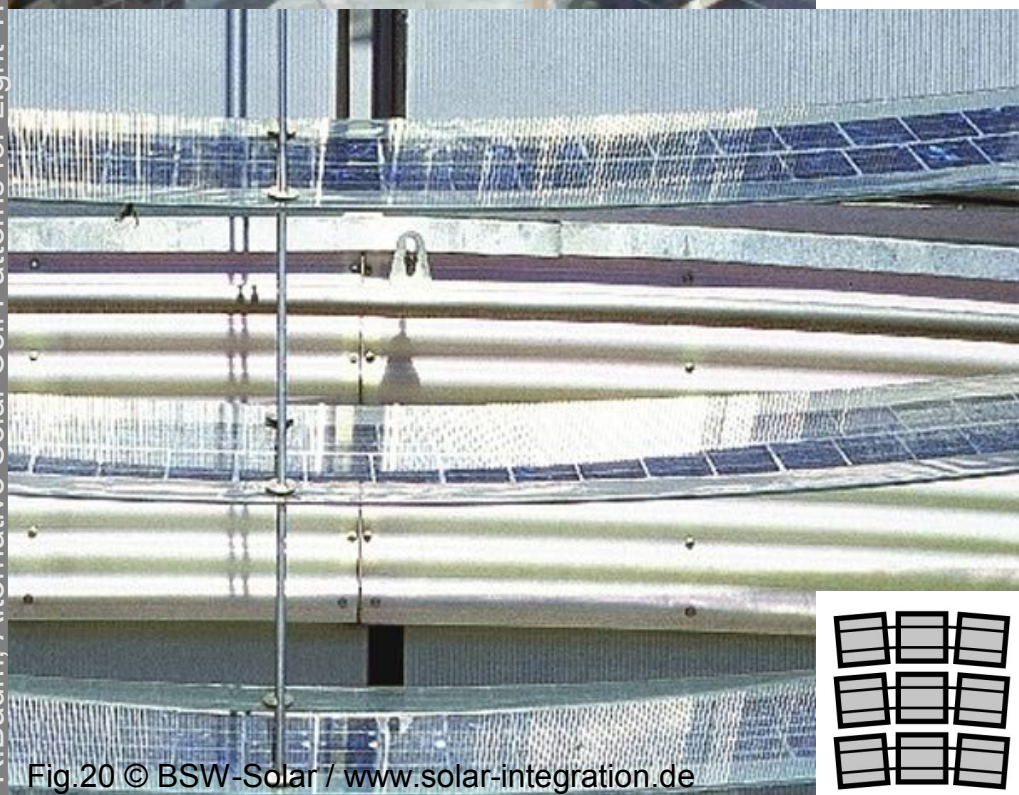


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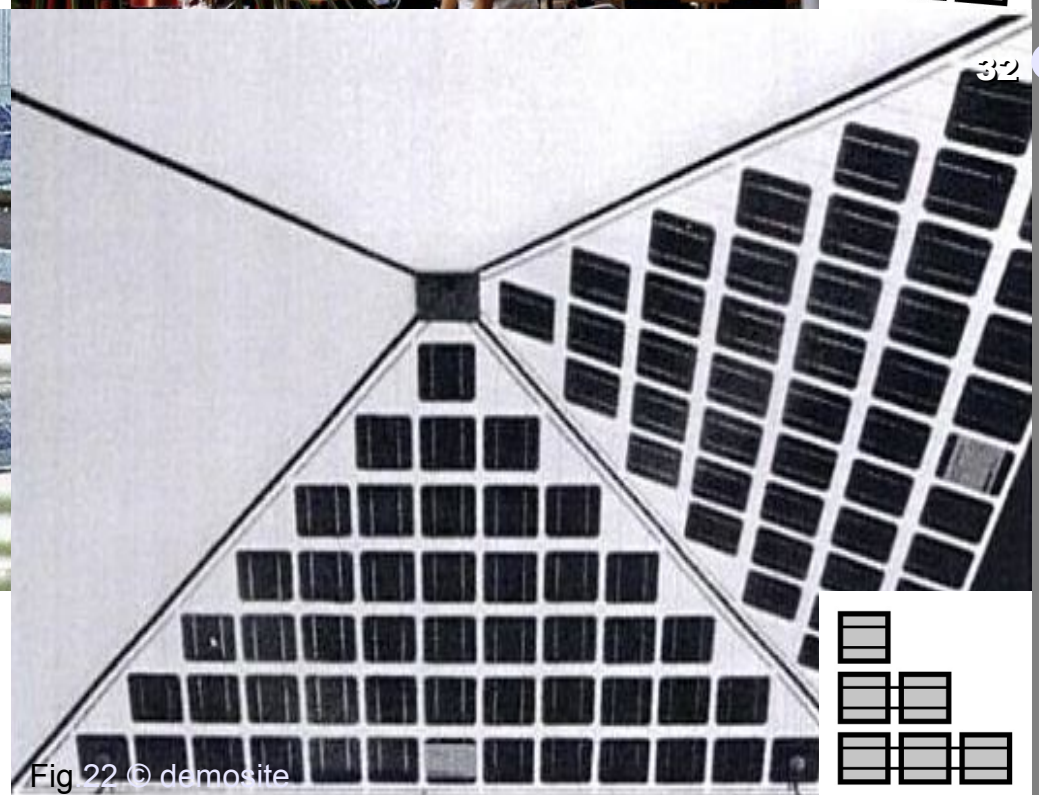
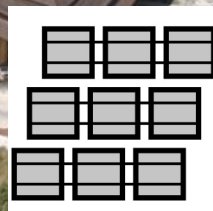


Fig.22 © demosite

The Core, Eden Project
Bodelua, Cornwall, UK, 2005
architect: Nicholas Grimshaw & P



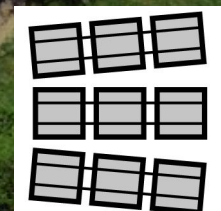
Fig.15 © copperconcept.org



Café Ambiente
Bremen, Germany, 1997
architect: Mencke + Tegtmeyer



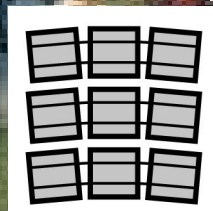
Fig.17 © BSW-Solar / www.solar-integration.de



Gemini House
Weiz, Austria, 2001
architect: Erwin Kaltenegger



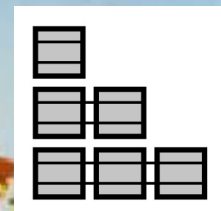
Fig.19 © Energie-Schau-Straße



Pyramides, DEMOSITE 33
Lausanne, Switzerland, 1992
PV: Colt + Atlantis

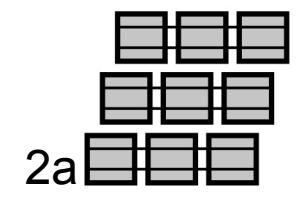
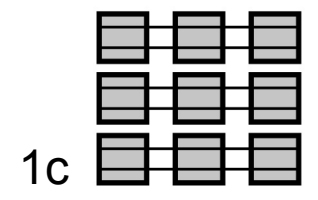
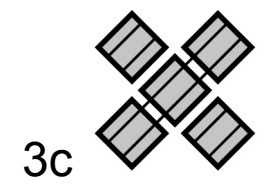
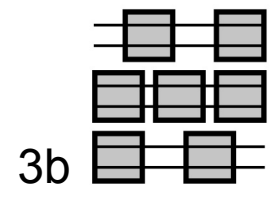
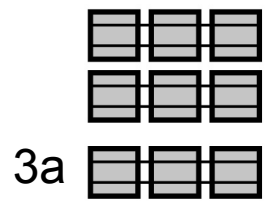


Fig.21 © demosite Solution



3. Solar cell patterns of crystalline silicon cells

3.3. *emerging heterogeneous cell patterns*



Solar Office Doxford

Sunderland, UK, 1998
architect: Studio E Architects



Fig.23 © Schüco International KG

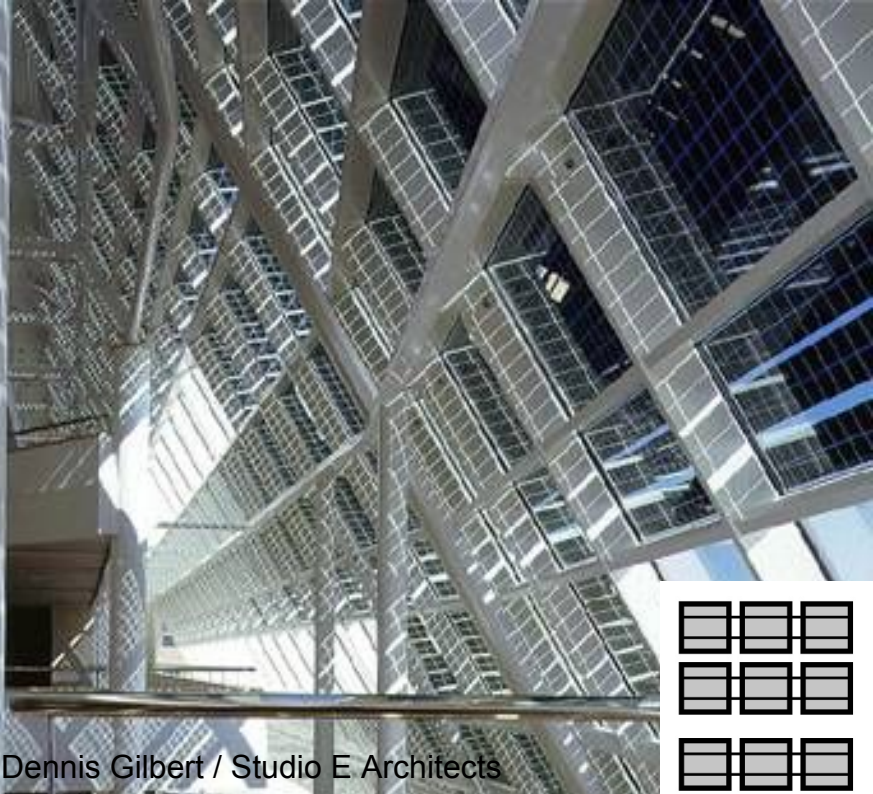


Fig.24 © Dennis Gilbert / Studio E Architects

Christian Kindergarten Dresden, Germany, 2003 architect: Reifer & Rentzsch



Fig.24 © Dennis Gilbert / Studio E Architects

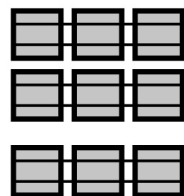
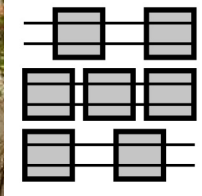


Fig.25 © Lothar Sprenger / Reifer & Rentzsch



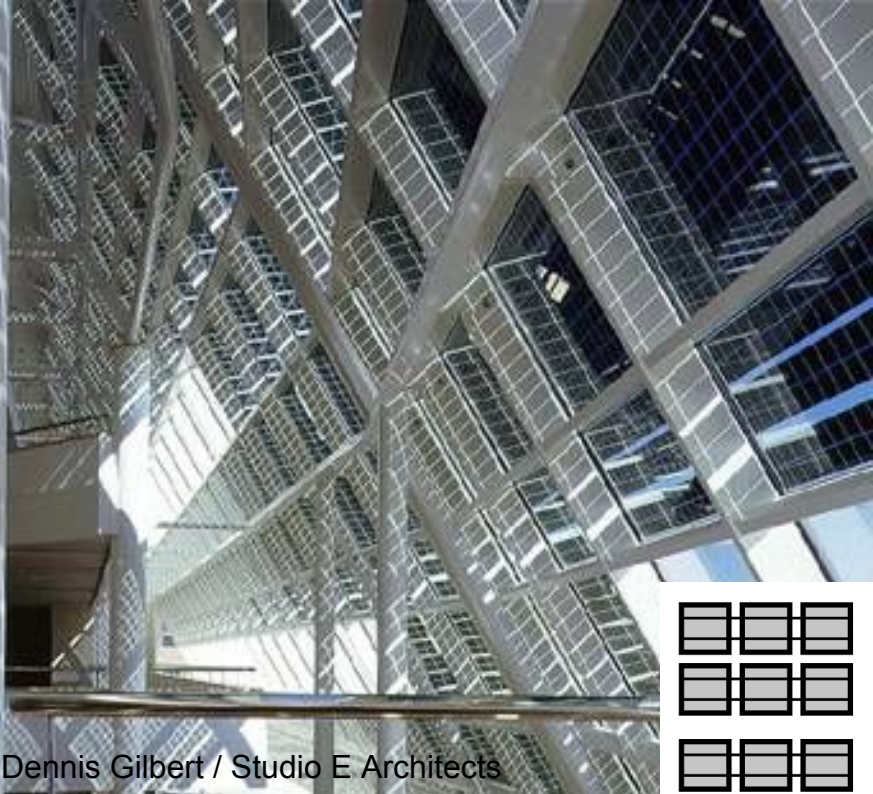


Fig.24 © Dennis Gilbert / Studio E Architects

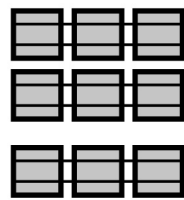


Fig.26 © Joe Morrissey / Atlantis Energy Systems

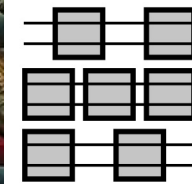




Fig.24 © Dennis Gilbert / Studio E Architects

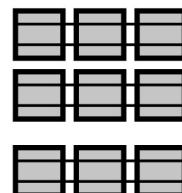
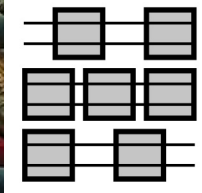


Fig.26 © Joe Morrissey / Atlantis Energy Systems



Ménara Airport

Marrakech, Morocco, 2008
architect: E2A architecture



Fig.27 © Benjamin Edwards / Flickr

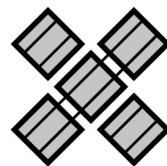




Fig.24 © Dennis Gilbert / Studio E Architects

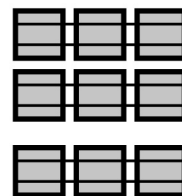


Fig.26 © Joe Morrissey / Atlantis Energy Systems

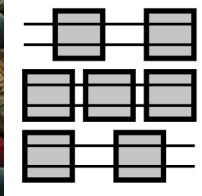
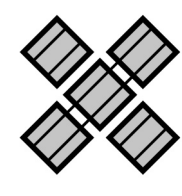


Fig.28 © junglepunk / Flickr



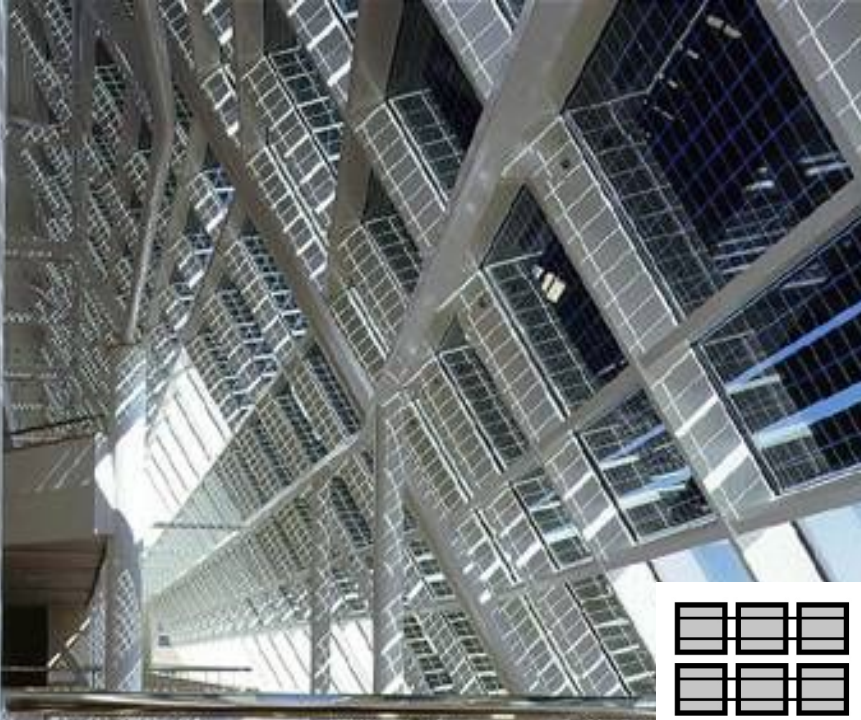


Fig.24 © Dennis Gilbert / Studio E Architects

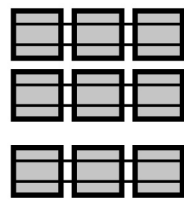


Fig.26 © Joe Morrissey / Atlantis Energy Systems

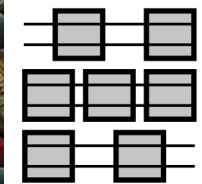
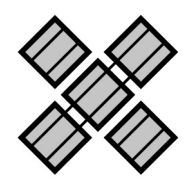


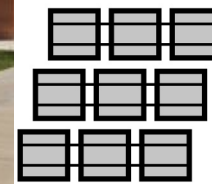
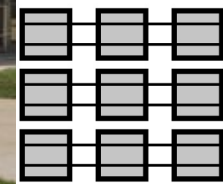
Fig.28 © junglepunk / Flickr



Community College Kankakee, IL, USA architect: Legat Architects



Fig.29 © Legat Architects



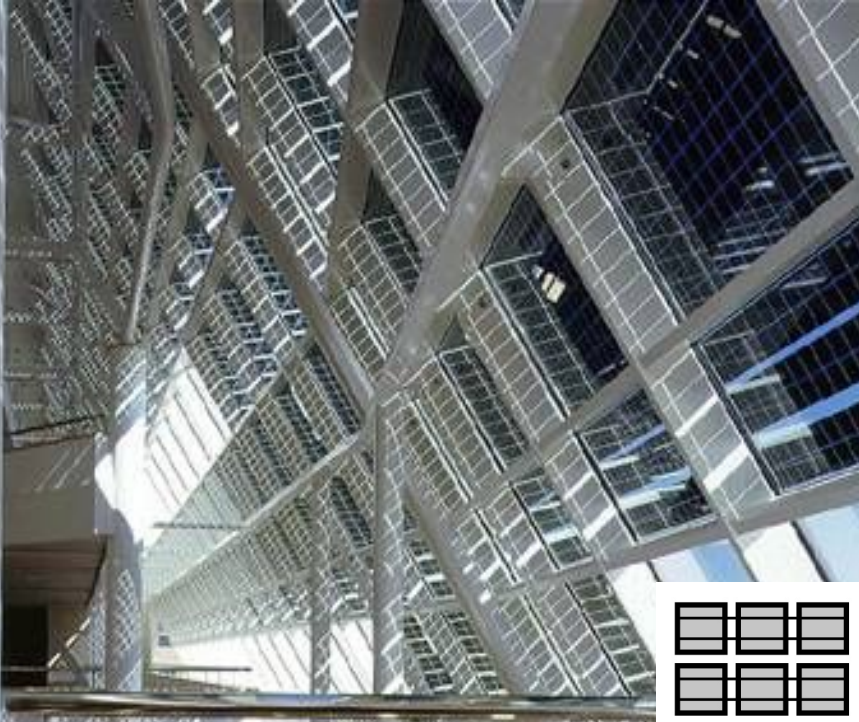


Fig.24 © Dennis Gilbert / Studio E Architects

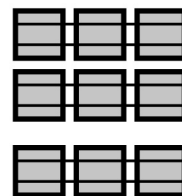


Fig.26 © Joe Morrissey / Atlantis Energy Systems

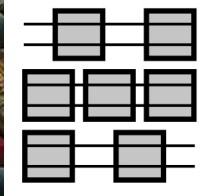


Fig.28 © junglepunk / Flickr

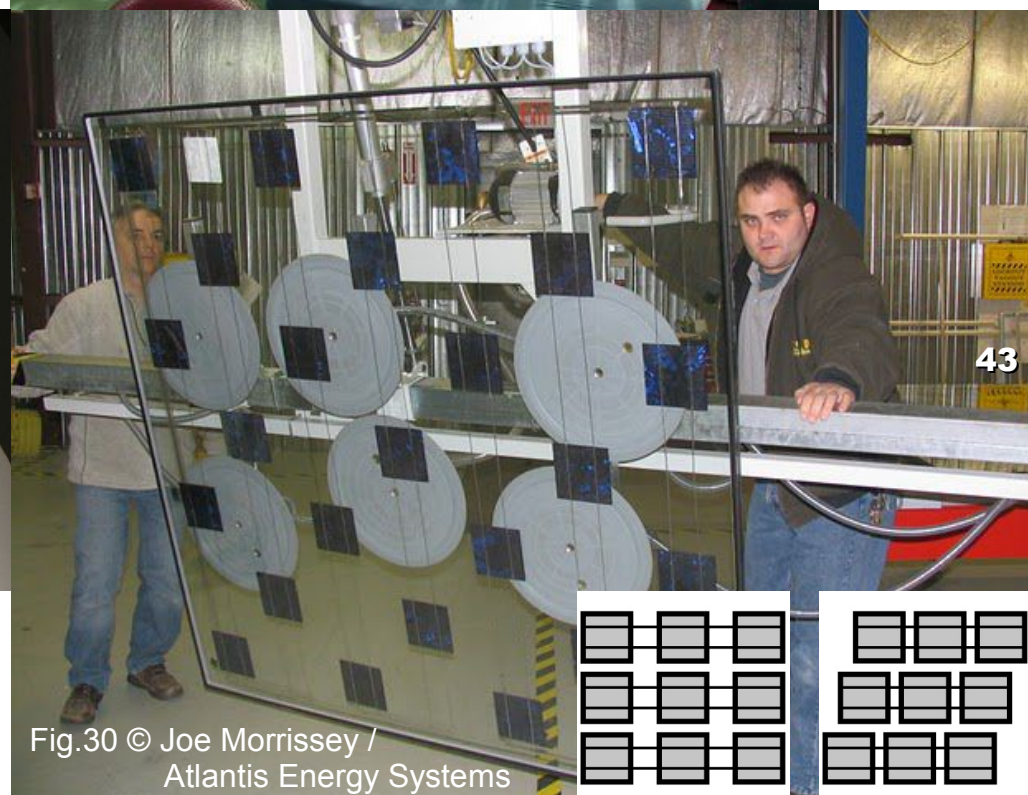
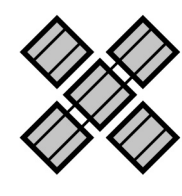
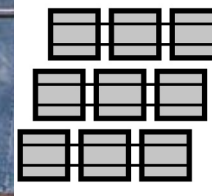
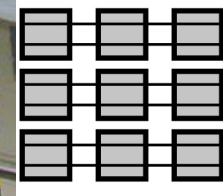


Fig.30 © Joe Morrissey / Atlantis Energy Systems



Solar Office Doxford
Sunderland, UK, 1998
architect: Studio E Architects

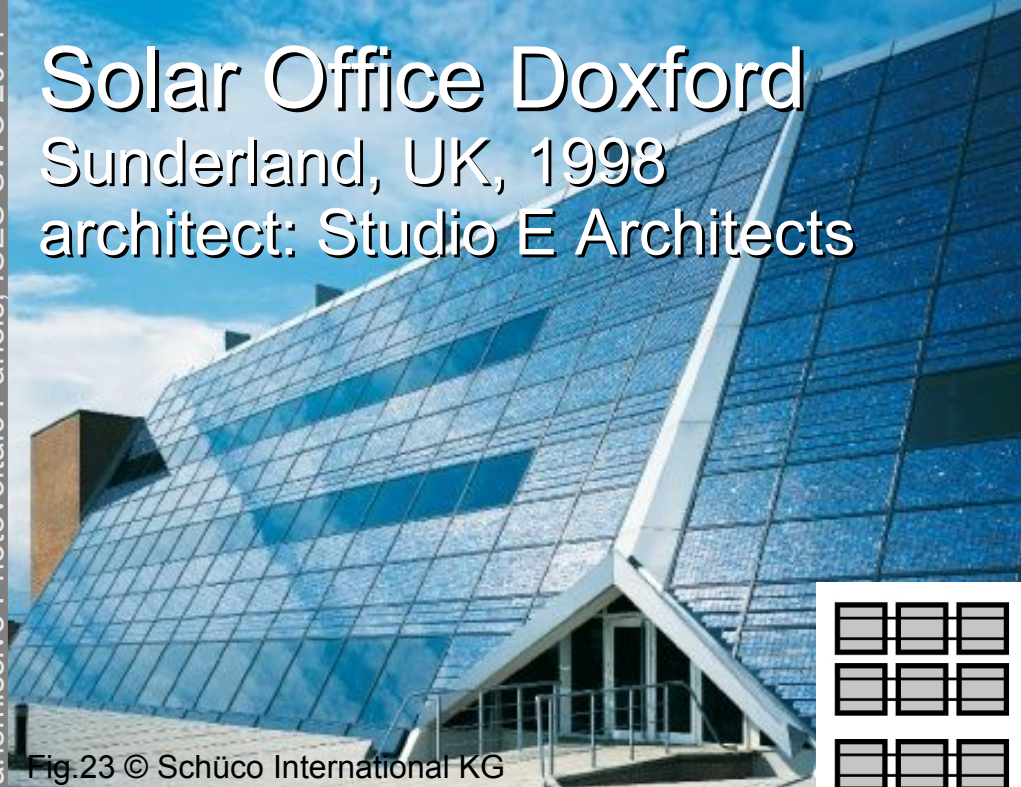


Fig.23 © Schüco International KG

Christian Kindergarten
Dresden, Germany, 2003
architect: Reiter & Rentzsch



Fig.25 © Lothar Sprenger / Reiter & Rentzsch

Ménara Airport
Marrakech, Morocco, 2008
architect: E2A architecture



Fig.27 © Benjamin Edwards / Flickr

Community College
Kankakee, IL, USA
architect: Legat Architects



Fig.29 © Legat Architects

3. Solar cell patterns of crystalline silicon cells

3.4. the quest for designed, parametric patterns

Patterns are

“a potent device for architectural articulation”
(Schumacher, 2009),

“critical expressive devices” (Zaera-Polo, 2009).

“it is usually disguised by introducing an overlapped pattern or a 3-D manipulation of the surface”
(Zaera-Polo, 2009)

“substituting orthogonal matrixes with innovative geometries developed by means of complex generative processes, based on casualness”
(Scognamiglio et al., 2006)

4. 'W(e)AVE' – tilted and wave-like cell patterns

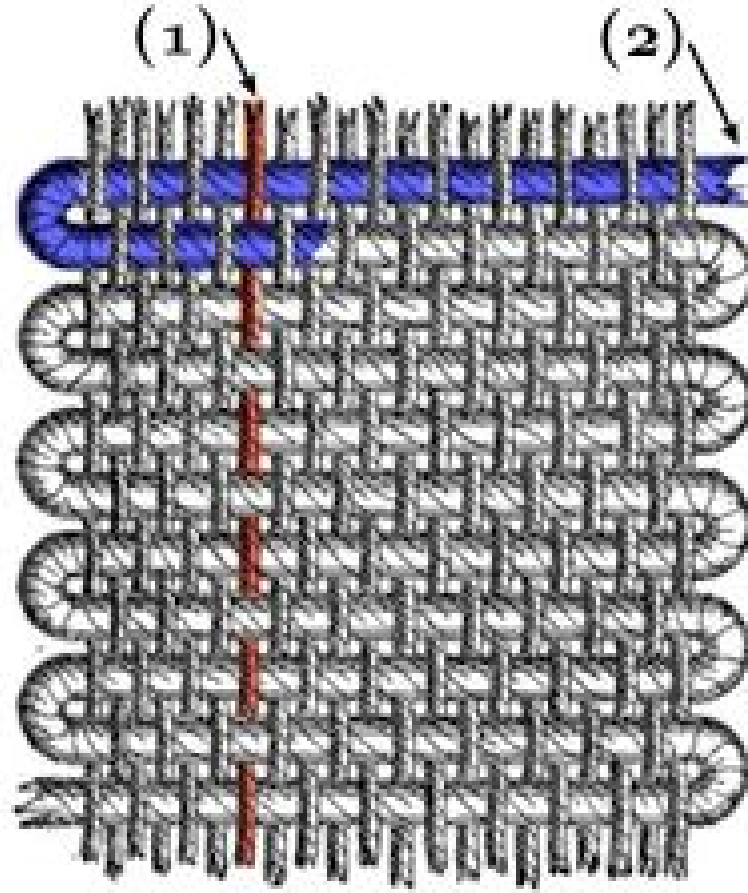


Fig.31 Wikipedia

standard pattern

parallel cell-strings

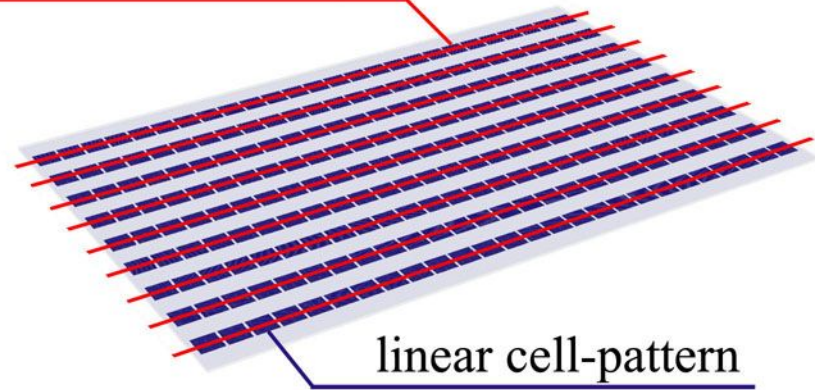


Fig.32 © Robert Baum

'W(e)AVE' pattern

parallel cell-strings

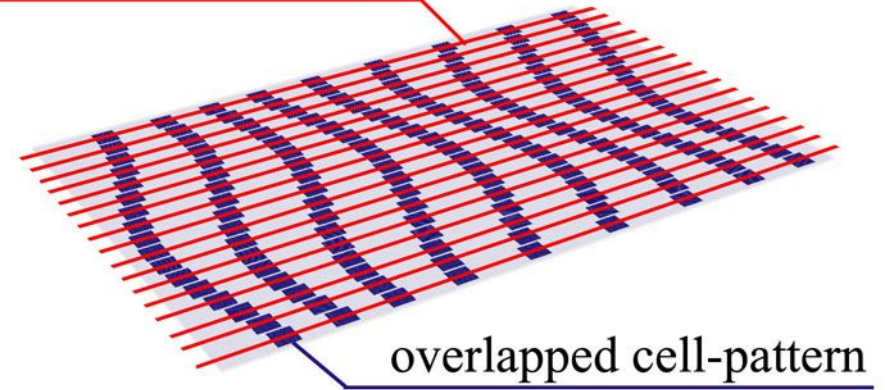


Fig.33 © Robert Baum

To make this approach operational,
' W(e)AVE' is based on two parameters:

First, the spacing of the solar cells in cell-strings
can have **more than one distance**.

However, linearity is kept in cell-strings.

Second, interconnection between neighbouring
cell-strings doesn't require the cells to lie exactly
side by side, **an offset between cells is possible**.
However, parallel position of cell-strings is kept.

Case study I

tilted pattern, rendering of a two-panel BIPV

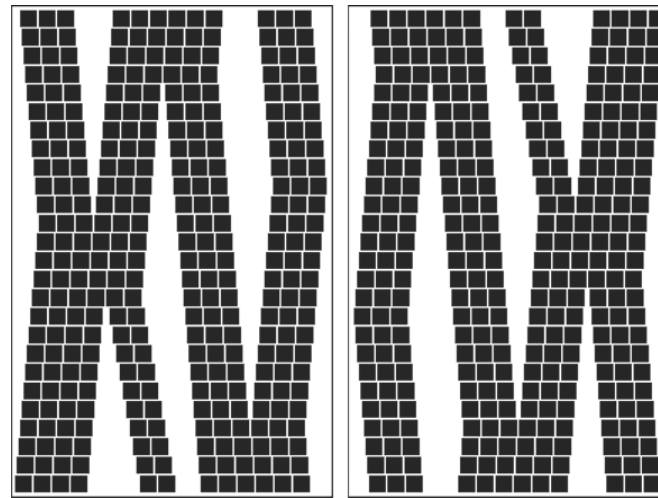


Fig.34 © Robert Baum

Case study II

sinusoidal patterns

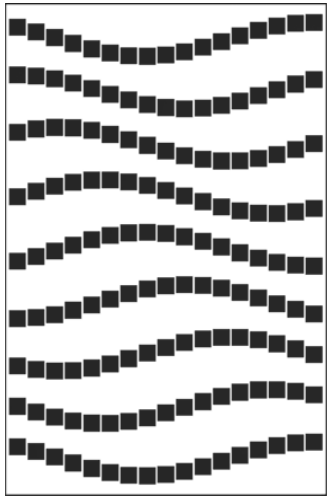


Fig.35 © Robert Baum

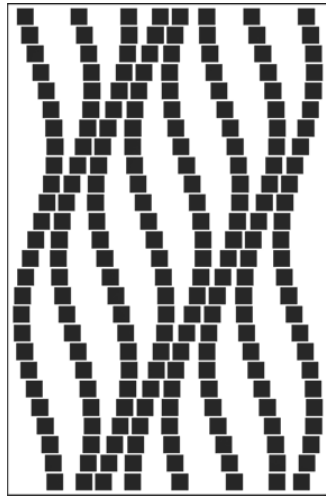
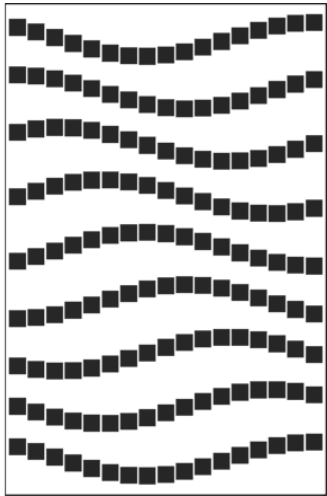


Fig.36 © Robert Baum

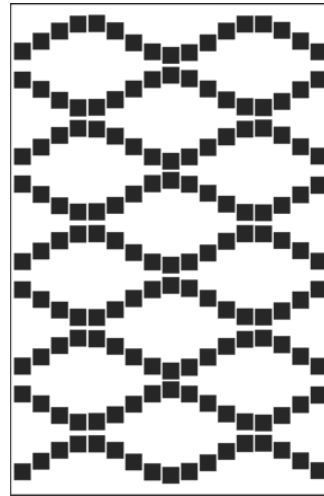
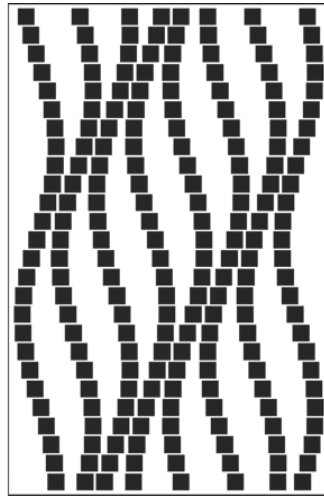
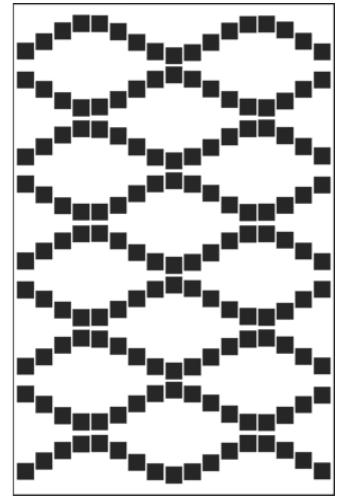


Fig.37 © Robert Baum



Case study III

free-form pattern, rendering of a five-panel BIPV

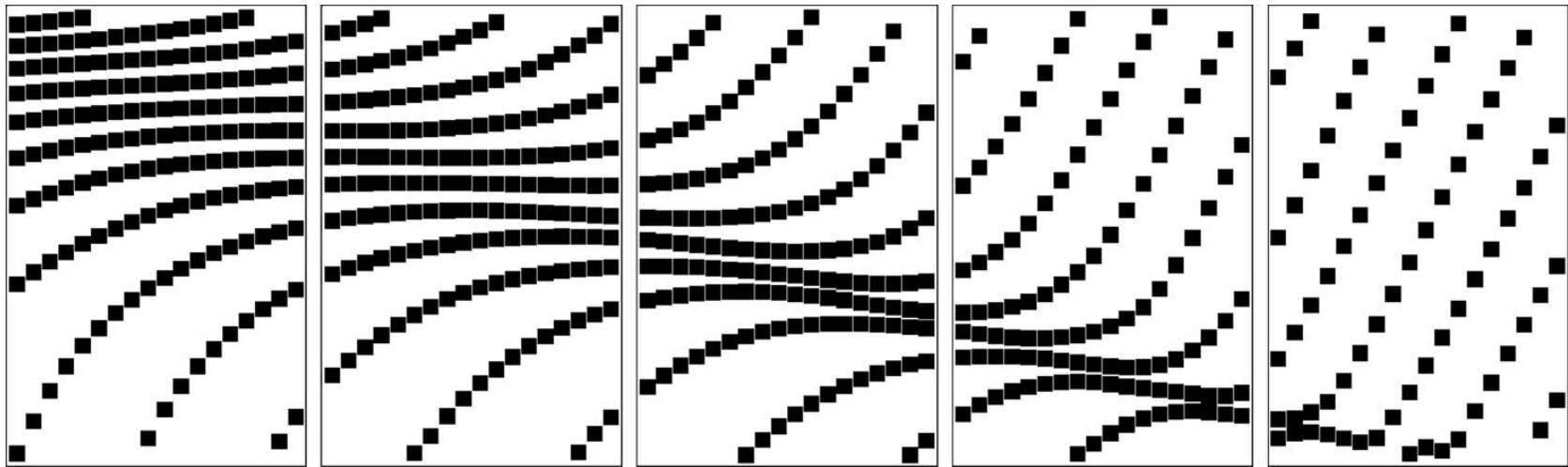


Fig.38 © Robert Baum

Case study IV

'W(e)AVE' pattern as transition between standard patterns

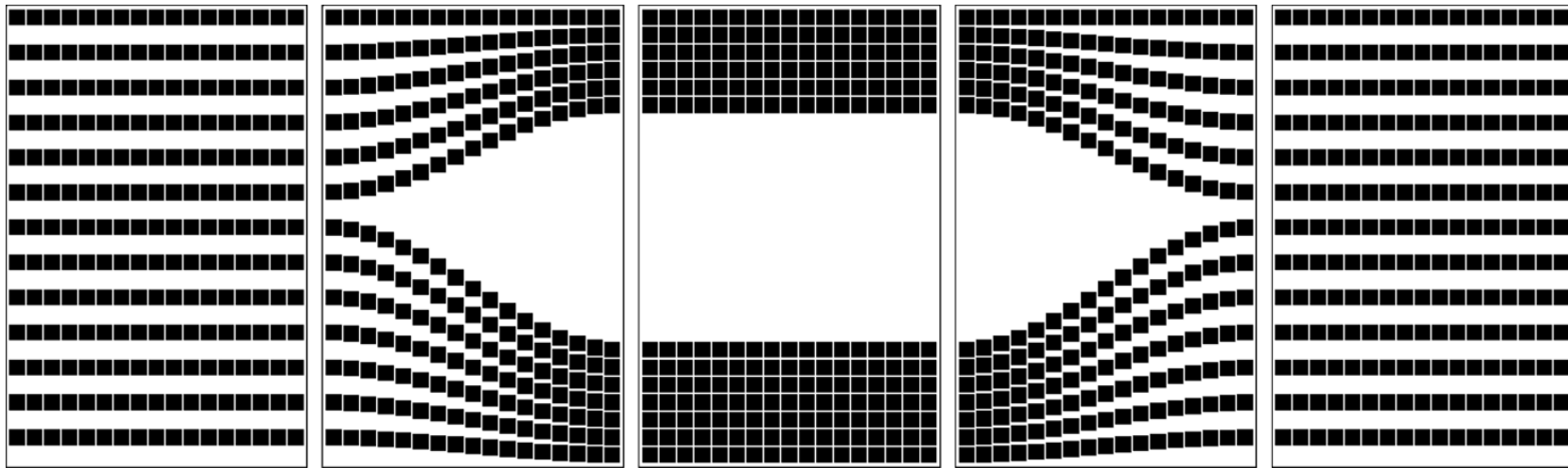


Fig.39 © Robert Baum

5. Conclusion

With the parametric approach 'W(e)AVE'
a wide range of solar cell pattern variations
akin to contemporary architectural design
become possible,
and enhance the options for individual designs
and architectural integration of PV
under the premise of “disguising” greatly.

A flexible change
in the level of transparency
enables the architect
to set the visible connection
between the interior space
and outside of a building
into a complex relation.

Thank you for your attention

Robert BAUM

Figure list

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