JAPANESE TRADITIONAL PATTERNS AS AN INSPIRATION FOR BUILDING-INTEGRATED PHOTOVOLTAICS (BIPV)

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日本学生支援機構
Japan Student Services Organization

Photovoltaic → Solar Energy → Energy

Building → Integrated → Architecture

Sustainability → Design → Innovation

Patterns → Performance → Communication

Low-resolution → Pixels → Solar cells

Light → Shadow → Nuances of depth

Tradition → Locality → Culture

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Energy

Sustainability

A sustainable energy supply

"implies a local scale for energy sourcing".

(Acres, 2007, p.102)

→ **Locality**

Energy

"Energy is all.
We are still largely unconscious of it,
but our entire lives (both urban and rural)
are driven by our access to energy
(how we use it, why we use it,
what sort of energy we use)."

(Webb, 2005, p.75)

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→ **Culture**

Energy

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*"[O]ur culture needs to internalise
a new valuation of energy."*

(Webb, 2005, p75)

→ **Culture**

Energy

"The essence of culture is in locality.
There's any such thing as a global culture."

(Sen, Caltroni & Hara, 2009, p.94)

→ **Locality** → **Culture**

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Sustainability

"[...] the meaning of sustainability depends on the context, in which it is applied."

(Kajikawa et al., 2007, p.222)

"Four Layers of Architecture"

(Namba, 2006)

Architecture

Sustainability

Layer	**Mode** (Standpoint)	**Program** (Design requirements)	**Technology** (Means of solutions)	**Theme of sustainability design** (Program of contemporary architecture)
1st layer	physical thing	material parts structure construction	production assembly	reuse and recycling long-lasting lightweight
2nd layer	energy-controlling device	environmental energy	electric machinery climate control	energy conservation high performance
3rd layer	social function	purpose building type	planning organization	family community lifestyle urbanity
4th layer	symbol meaning	form space	representation criticism	virtual reality ephemeralization

"However, properly speaking, sustainable design should involve all four layers."

(Namba, 2006)

Architecture

Sustainability

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traditional Oriental mashrabiya

Architecture

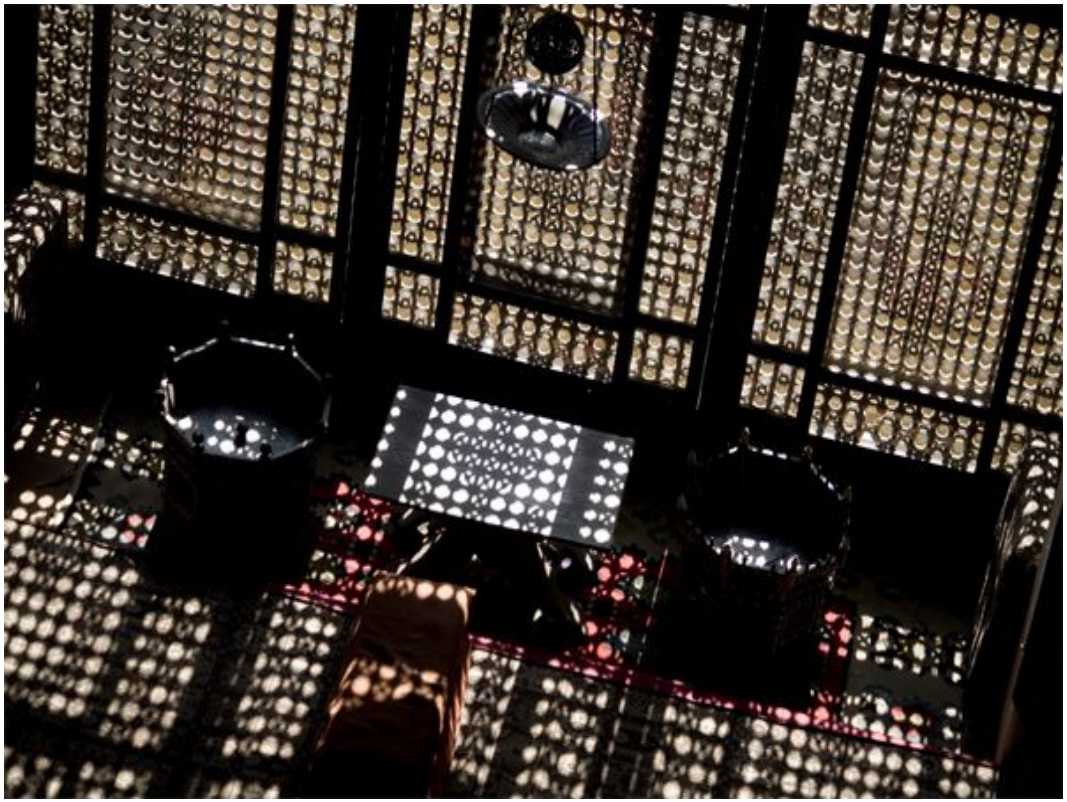


Fig. 1 © Cora Edmonds

Arab World Institute,
Paris, France
architect: Ateliers Jean Novel, 1987

Architecture

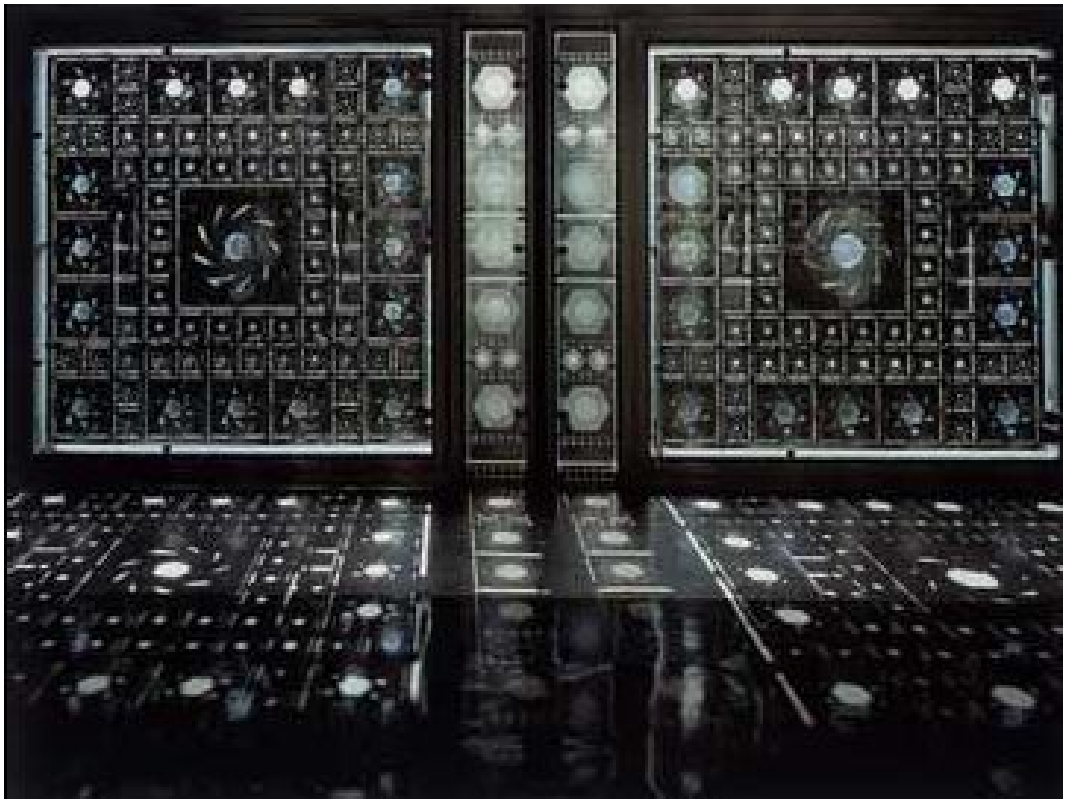


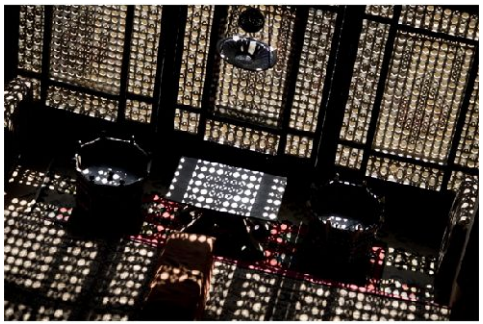
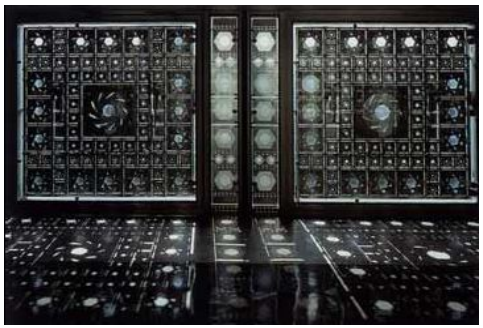
Fig. 2 © Ateliers Jean Novel

Menara airport,
Marrakech, Morocco
architect: E2A architecture, 2008

Architecture

Fig. 3 © Brigit Varenkamp

Architecture

	traditional Oriental mashrabiya local craftsmen	Arab World Institute, Paris, France arch: Ateliers Jean Novel, 1987	Menara airport, Marrakech, Morocco arch: E2A architecture, 2008
	 Fig.1 © Cora Edmonds	 Fig.2 © Jean Novel	 Fig.3 © Brigit Varenkamp
1st layer	Wooden latticework	Mechanical devices glass panes	Photovoltaic glass laminate
2nd layer	Daylight transmission, shading, cooling, air conditioning	Daylight transmission, shading, transparency	Daylight transmission, shading, energy generation
3rd layer	Privacy and views in residential houses	Representative street façade of the Arab World Institute	Skylight at an international airport
4th layer	Geometrically crafted patterns in accordance with Islamic laws	High-tech image, modern interpretation of the traditional mashrabiya	Green energy, modern interpretation of the traditional mashrabiya

"At its highest level of significance, architecture is the fusion of culture and the need for enclosure made material in physical form; it is the meeting point of the need to build and the innate urge to communicate."

(Wigginton, 1996, p.10)

Architecture

→ **Communication**

→ **Culture**

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(Wigginton, 1996, p.10)

Building →

"In the thousands of years since he learnt to build, man has had to try to meet two particular, and often conflicting needs: on the one hand, the need to create enclosure for shelter, protection and privacy;

Light

on the other, the need to transmit light to provide illumination and view."

Building →

"And so it has come to be that the beauty of a Japanese room depends on a variation of shadows, heavy shadows against light shadows - it has nothing else."

(Jun'ichiro Tanizaki, 1933, p.18)

Shadow

→ Culture

Building

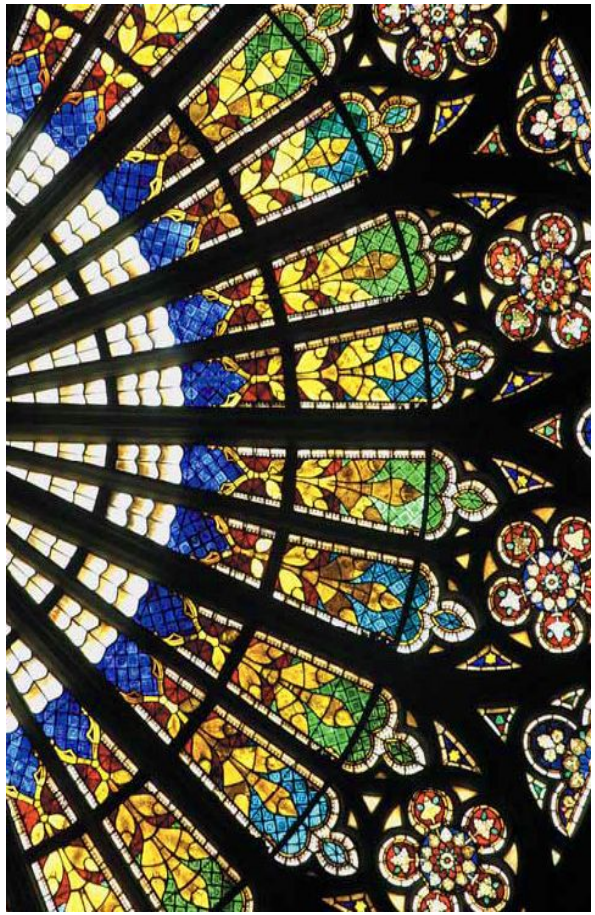

Fig. 4 © Henri Parent

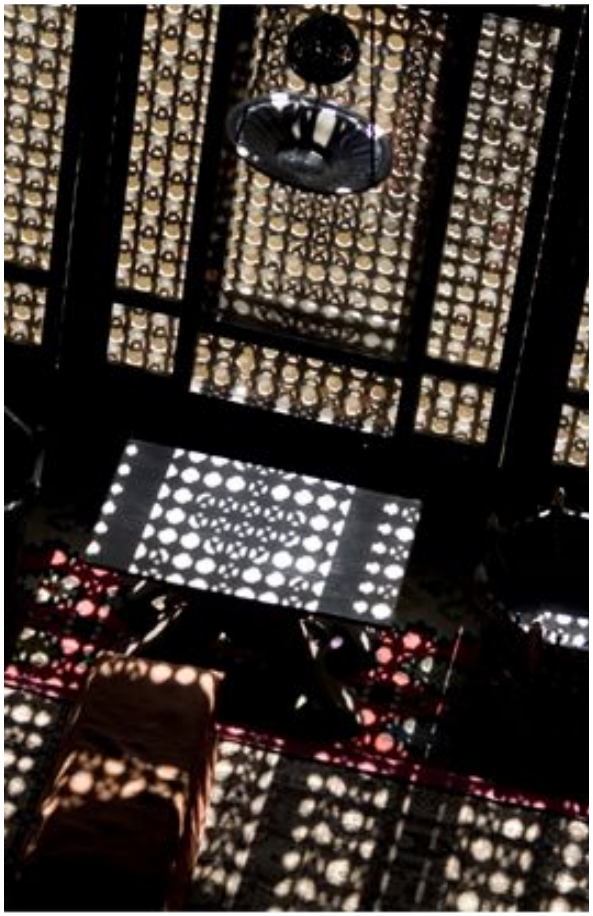

Fig. 1 © Cora Edmonds

Light → Shadow

→ Culture

Building

"The theme of light […], the blurring of contours, the superimpositions, in reverberations and reflections and shadows."

(Jean Novel, about the Arab World Institute)

Light → Shadow

→ Culture

Building

"The theme of light […], the blurring of contours, the superimpositions, in reverberations and reflections and shadows."

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Architecture

Patterns → Performance → Communication

"Patterns provide architects with a device to connect apparently incongruent categories and synthesize a multitude of performances, project requirements and informational types in a perception-based medium."

(Anderson and Salomon, 2010, p.14)

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"[L]ow-res tactics in order to achieve appropriate, affordable, as well as poetic and more subliminal, effects, harnessing emotion rather than technology. At the same time, these tactics are programmed to be adjustable."

(Bullivant, 2005a, p.6)

Low-resolution

Torre Agbar,
Barcelona, Spain
architects: Ateliers Jean Novel, 2005

Fig. 5 © Agbar Tower Corporate Marketing Department

→ **Architecture**

"The surface of the building evokes water:
smooth and continuous,
shimmering and transparent,
its materials reveal themselves
in nuanced shades
of color and light."

(Jean Novel)

GreenPix - Zero Energy Media Wall, Beijing, China
Architects: Simone Giostra & Partners, 2008

Fig. 6 © Simone Giostra & Partners

→ **Architecture**

"seascapes as an example of an ever-changing visual experience"

(Eakin, 2007, p.48)

Santa Caterina Market renovation,
Barcelona, Spain
architects: Miralles - Tagliabue | EMBT, 1997

Fig. 7 © Miralles - Tagliabue | EMBT

→ **Architecture**

"reflect the polychrome art nouveau façades of the merchants' mansions and the public buildings those merchants sponsored"

(Riley, 2006, p.25)

Technorama, The Swiss Science Center,
Winterthur, Switzerland
architects: Ned Kahn, Durig and Rami, 2002

→ **Architecture**

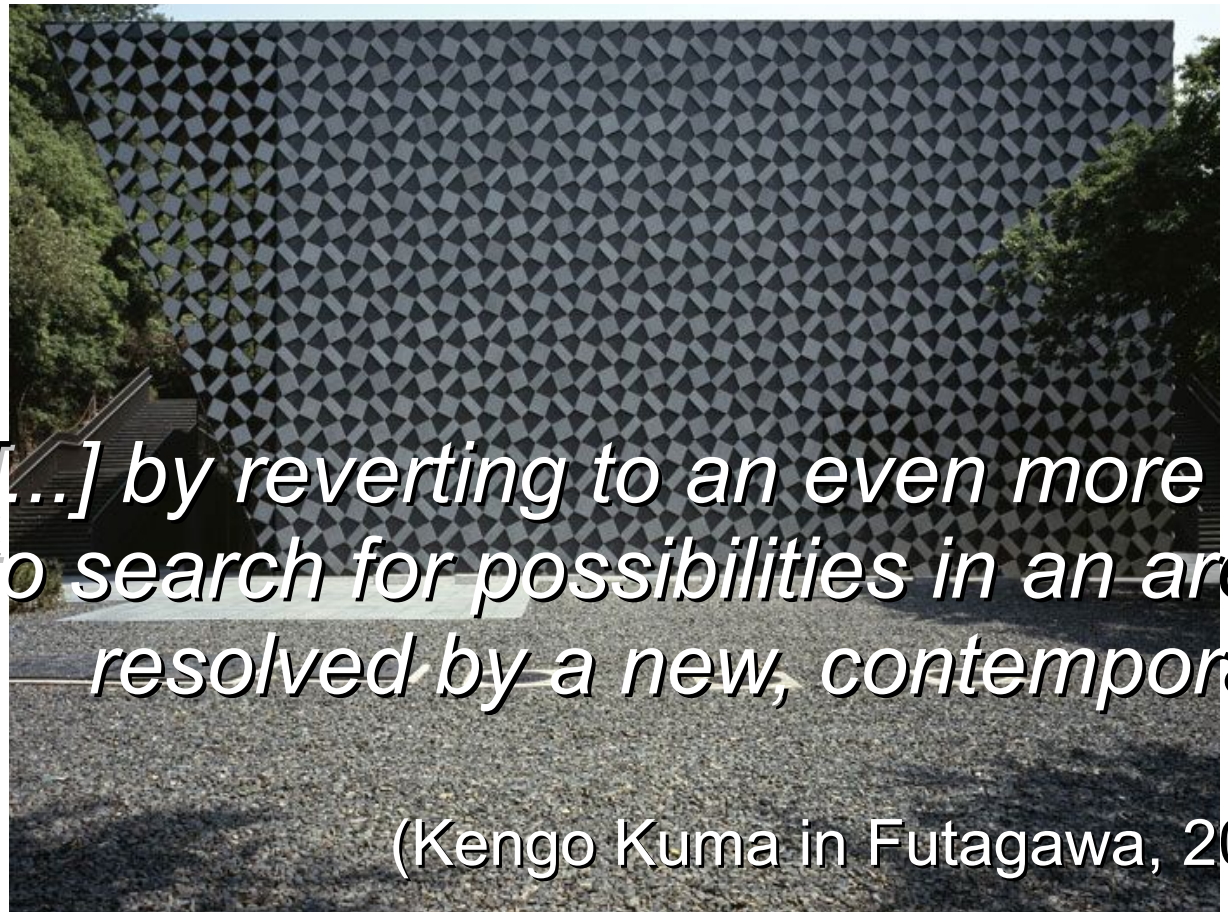
Fig. 8 © Ned Kahn

"reveal the complex patterns of turbulence in the wind"

(Kahn, undated)

Museum of Kanayama Castle Ruin, Kanayama Community Center,
Ota city, Gunma, Japan
architects: Kengo Kuma & Associates, 2009

→ **Architecture**



"[…] by reverting to an even more primitive condition, to search for possibilities in an area that can only be resolved by a new, contemporary technology."

(Kengo Kuma in Futagawa, 2009, p.116)

Fig. 9 © Takashi Yamagishi

Hotel Industrial,
Paris, France
architects: Emmanuel Saadi, Jean-Louis Rey, François da Silva, 2008

→ **Architecture**

Solar cells

Fig. 10 © Nicolas Borel

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This paper reports the results
of an investigation into applying
the inventory of local cultural heritage,
here Japanese traditional family crests,
as **an inspiration for technological innovation**,
here alternative patterns
for solar photovoltaic (PV) panels.

Aim

To improve the versatility of
light-transmissive PV panels
used for architectural integration
into building skins (BIPV).

two major groups of PV technologies

crystalline silicon

Fig. 11 © Emmanuel Saadi

thin-film

Fig. 12 © HBS Wolfhagen

Study Background

With the kind of PV panels called **'light-through'**,
translucency is achieved by
spacing the opaque crystalline solar cells,
so that
light can penetrate through the resulting gaps.

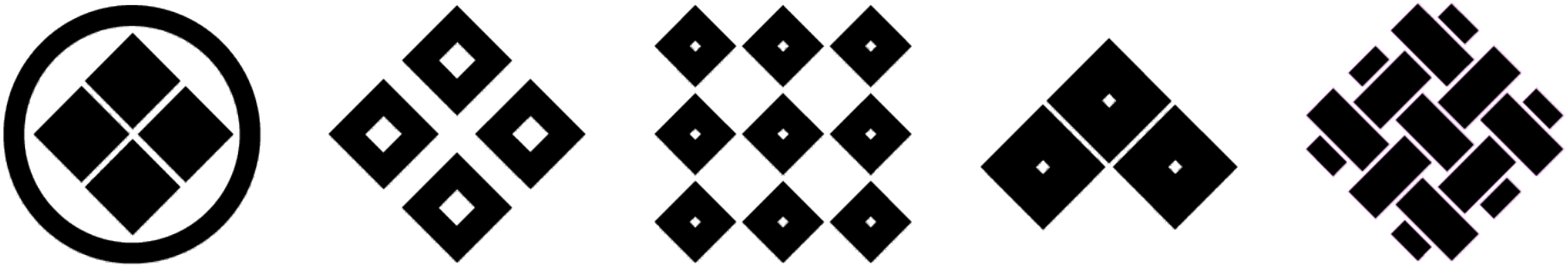
The usual design alternatives
offered by the PV industry
are mostly restricted to an equal spacing of
the cells throughout the grid pattern.

Methodology

Cultural individuality,
essential for local and global sustainability,
provided the basis for inspiration.

The inherent geometric **qualities of traditional** Japanese family crests are analysed and applied to generate alternative light-transmitting PV patterns.

Kamon – Japanese family crests



Layering of photovoltaic laminate

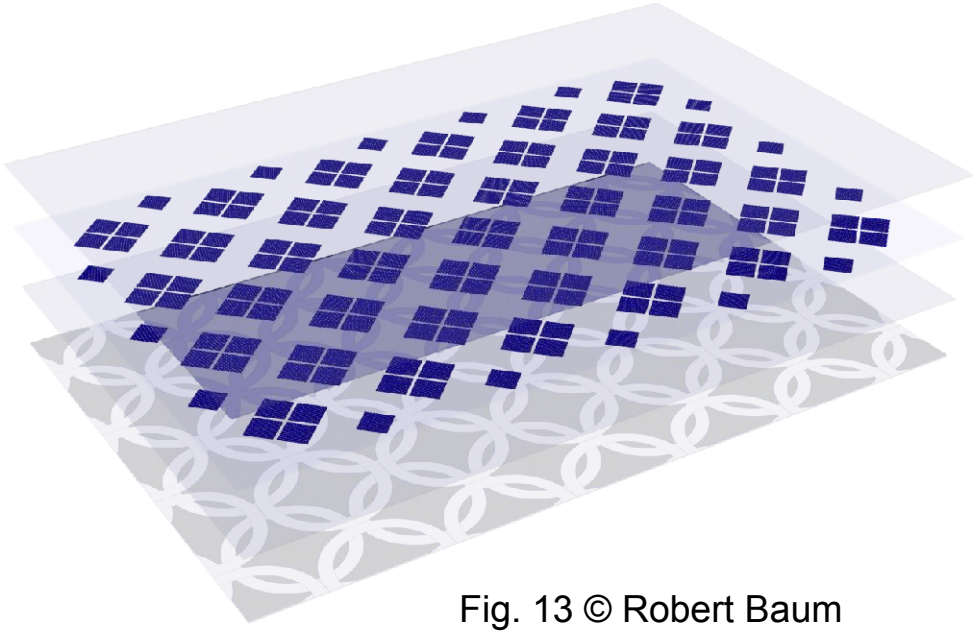
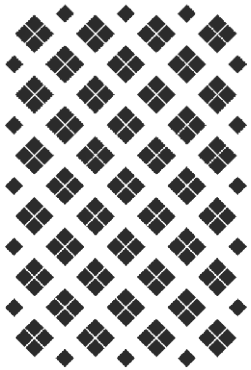


Fig. 13 © Robert Baum

– outer transparent layer of glass or foil
– solar cell layer between films
– inner transparent layer of glass or foil
– semi-transparent print on either side of the inner layer

Family crest

Solar cells



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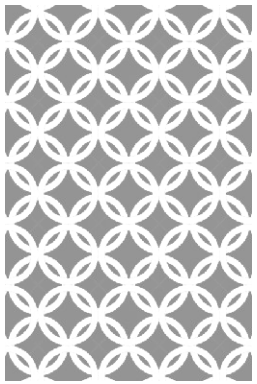
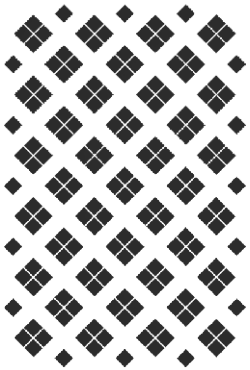


Case study A
Maru ni yottsu-wari-ishi

Family crest

Solar cells



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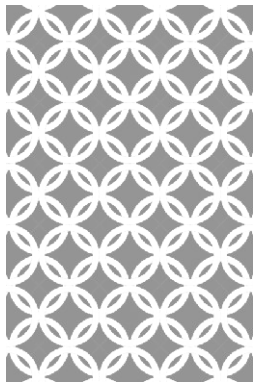
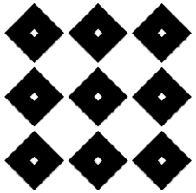


Fig. 14 © Robert Baum

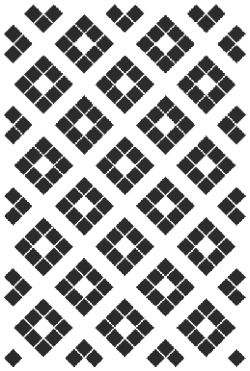
Case study B

Nanatsu-wari sumi-tate yottsu-me + Tsunagi kokonotsu-me

Family crest



Solar cells



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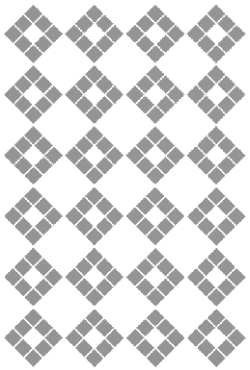
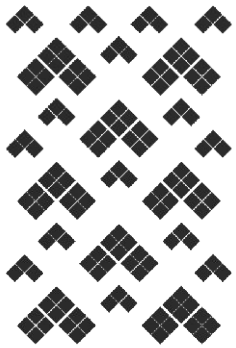


Fig. 15 © Robert Baum

Case study C
Mittsu-me

Family crest

Solar cells



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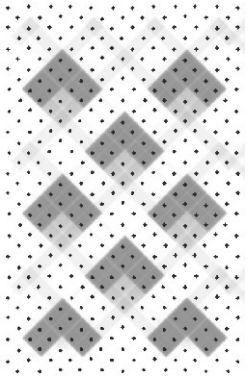
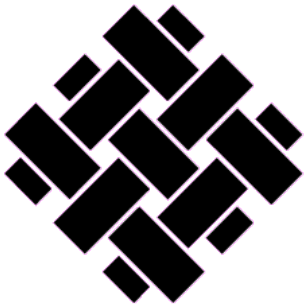


Fig. 16 © Robert Baum

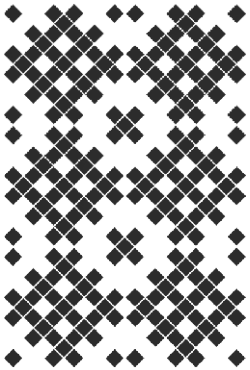
Case study D

Muttsu kumi sujichigai

Family crest



Solar cells



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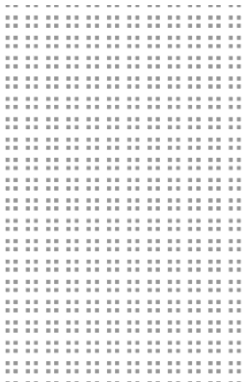

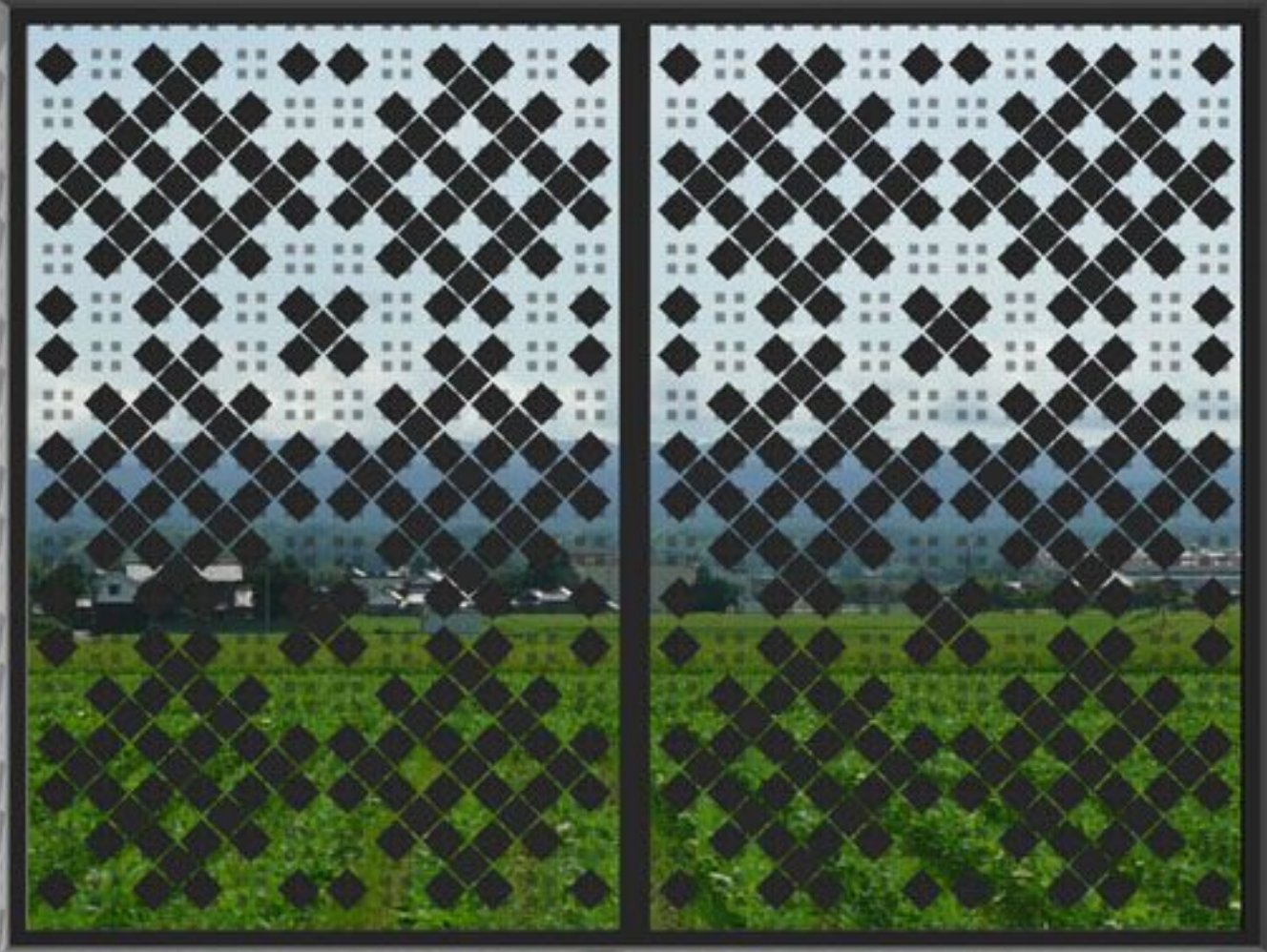

Fig. 17 © Robert Baum

"Japanese architecture
is a treasure trove of boundary techniques. […]
Diverse screens
(such as louvers and [curtains])
and intermediate domains
(such as verandas, corridors and eaves)
are gaining attention once more as devices
for connecting the environment to buildings."

(Kuma, 2010, p.15)

"This is not a dream, because technology plus poetry equals architecture […].

All architects […] have to do is make it happen."

(Wigginton, 1996, p.238)

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Figure list