TECHNOLOGIES & AESTHETICS

RESEARCH P1

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Technologies & Aesthetics | graduation studio
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- E N E R G Y -

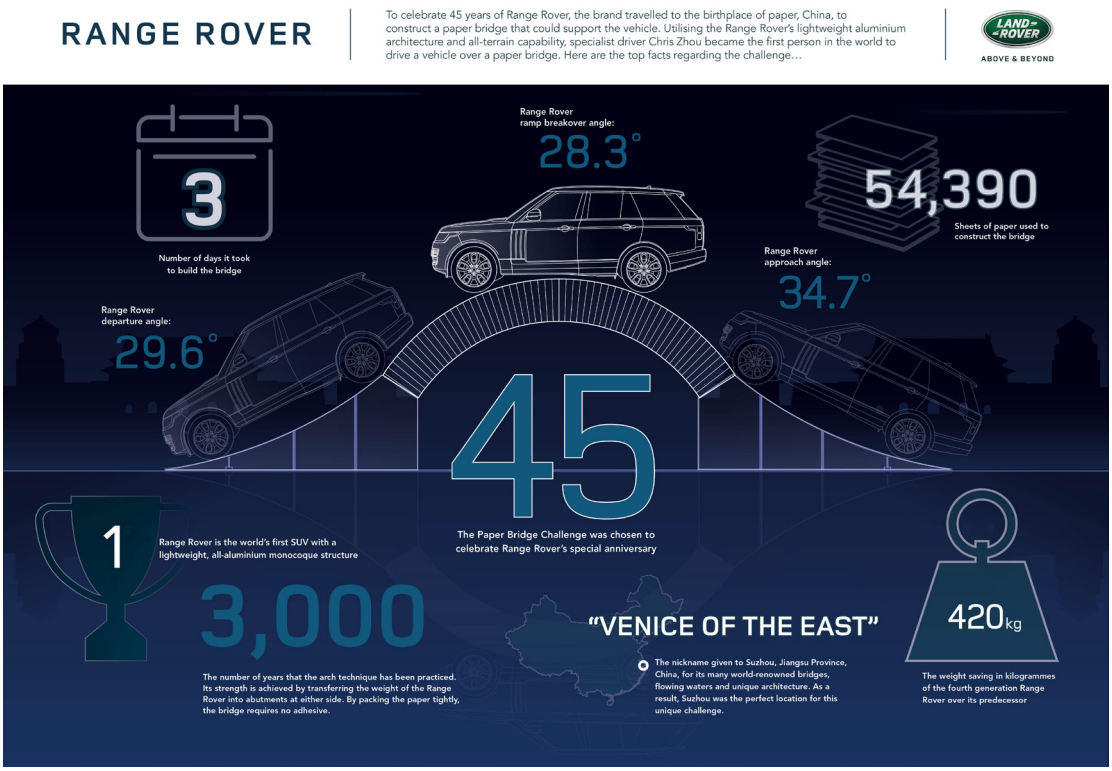
/ˈɛnədʒi/

1. the strength and vitality required for sustained physical or mental activity.
2. power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines.
3. the property of matter and radiation which is manifest as a capacity to perform work (such as causing motion or the interaction of molecules).

- I N D E X -

- PRECEDENTS -

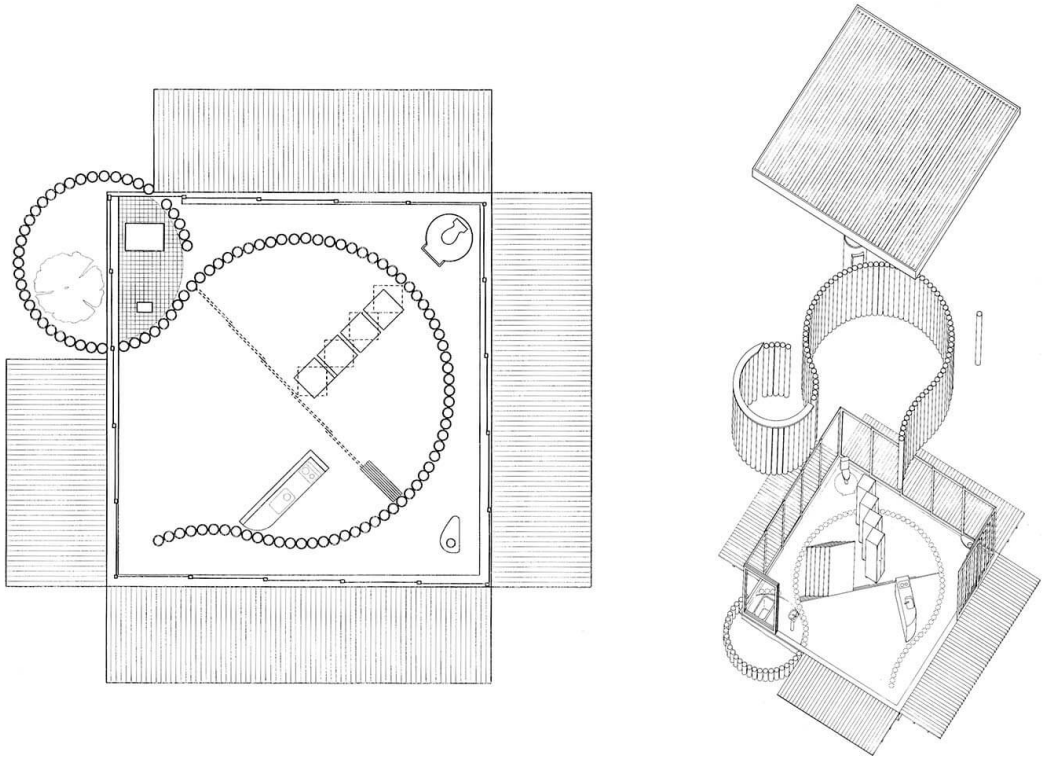
Land Rover Bridge - Steve Messam



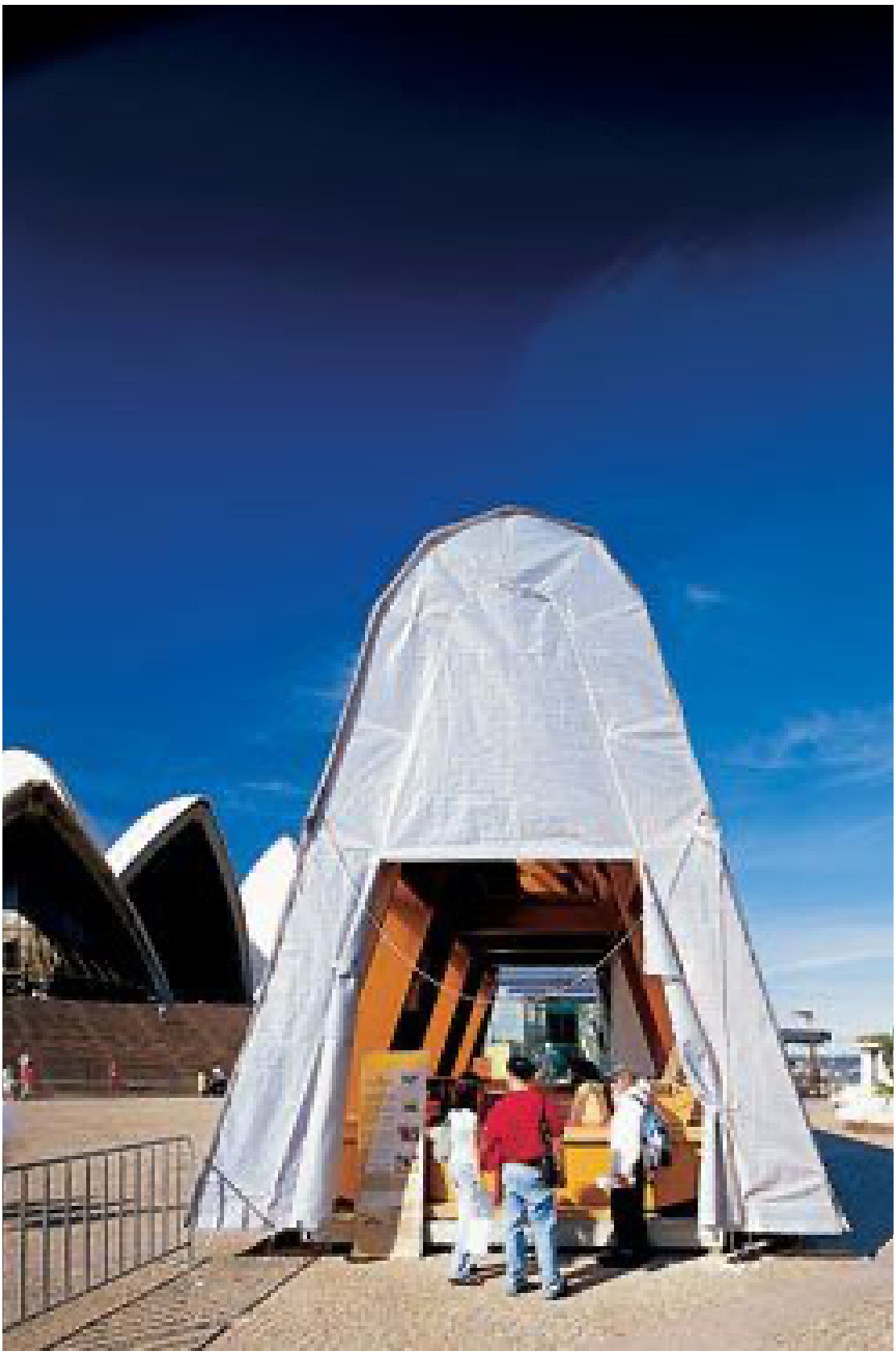
"Land Rover has driven its flagship Range Rover luxury SUV across a bridge made of paper. The freestanding structure in Suzhou, China, spanned five metres without glue or bolts to hold it in place.

Land Rover commissioned the unique bridge to mark the 45th anniversary of its Range Rover family and to highlight 45 years of Range Rover innovation ahead of the Guangzhou Motor Show in China." (Land Rover Media Newsroom, 2019)

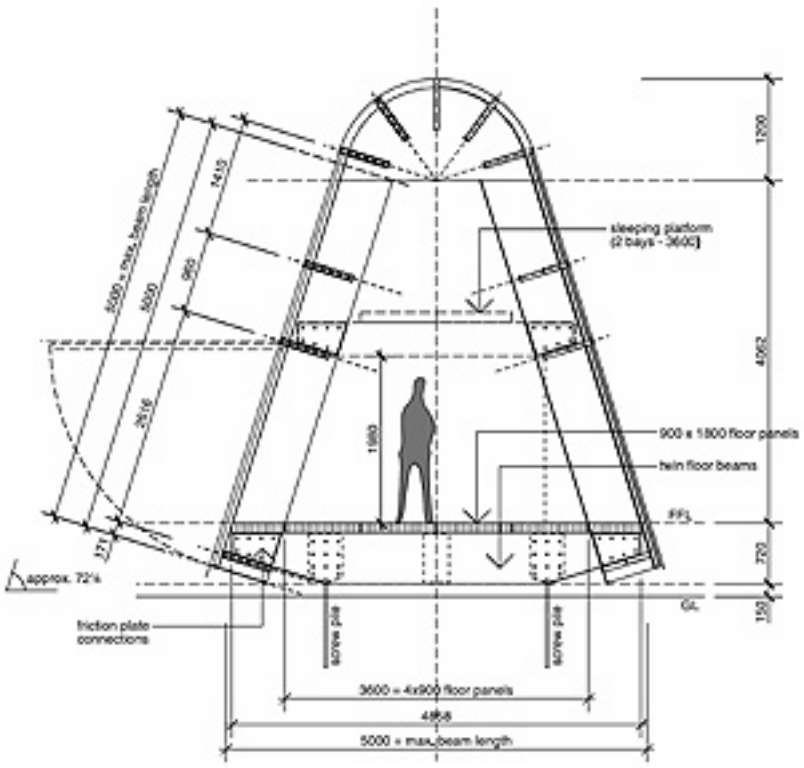
Paper House - Shigeru Ban



“An S-shape configuration comprised of 110 paper tubes (2.7m high, 275mm in diameter and 148mm thick) defines the interior and exterior areas of the paper house. This was the first project in which paper tubes were authorized for use as a structural basis in a permanent building. Ten paper tubes support the vertical load and the eighty interior tubes bear the lateral forces. The cruciform wooden joints in the bases of the columns are anchored to the foundation by lug screws and cantilevered from the floor. The large circle formed by the interior tubes forms a big area. A freestanding paper tubes column with a 1.2m diameter in the surrounding gallery contains a toilet. The exterior paper tubes surrounding the courtyard stand apart from the structure and serve as a screen.” (Shigeru Ban Architects, z.d.)



Cardboard House - Peter Stutchbury & Richard Smith

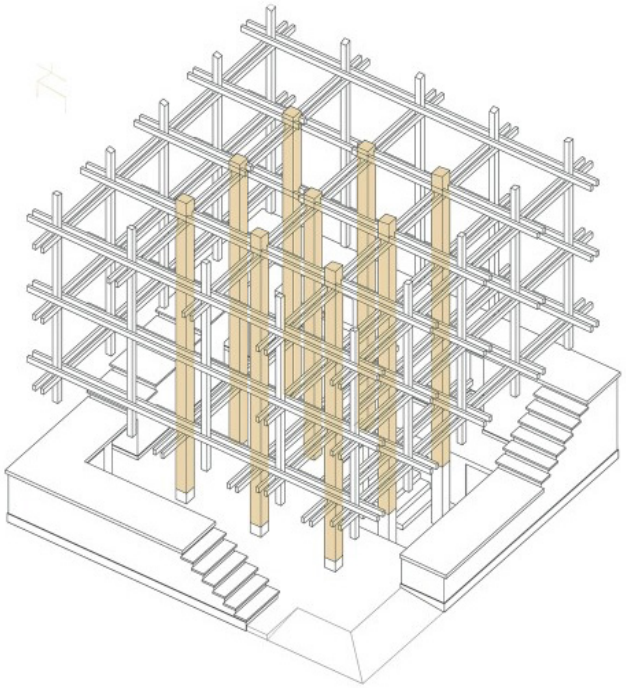


The cardboard building is completely covered with a high-density polythene textile to protect the construction against the weather. The cover can be taken of as well. The idea of the architect was to design a building that is cost-efficient, lightweight, easy to transport and assemble, and recyclable.

Clubhouse Ring Pass - Nils-Jan Eekhout & Octatube

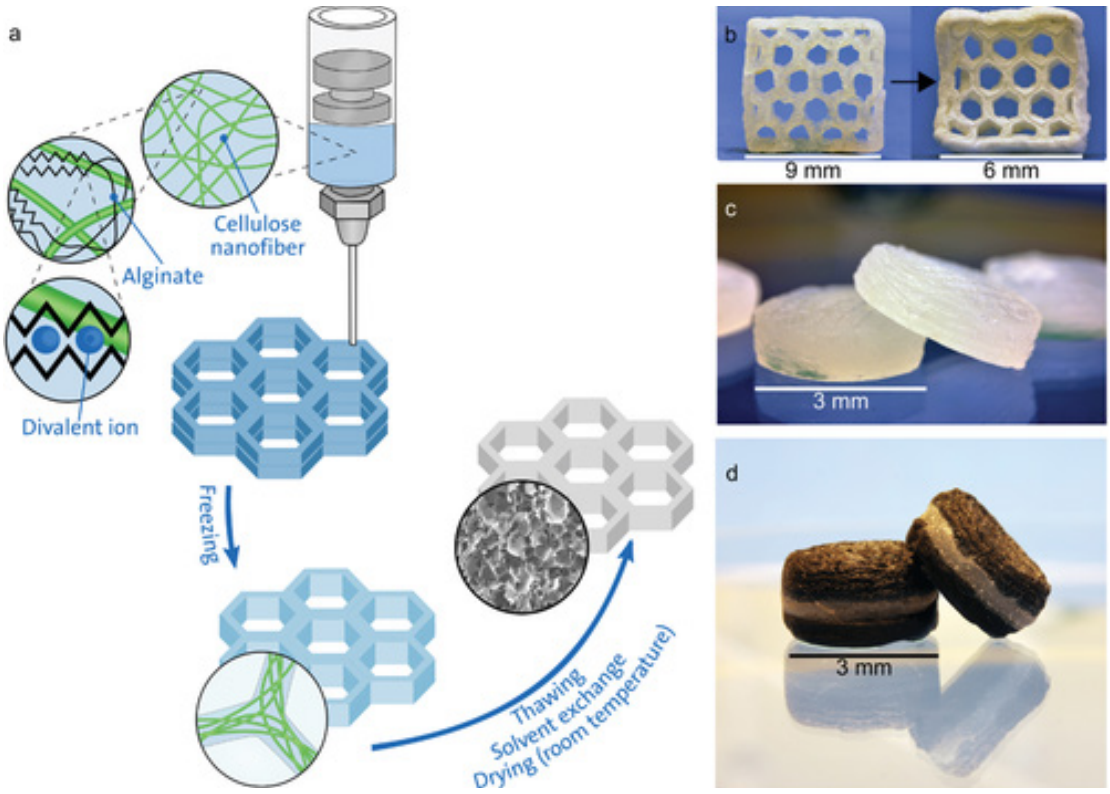
“The connection between a cardboard tube and a Tuball has been realized in a different manner than with steel spaceframes. At the ends of the cardboard tubes flange plates are placed, instead of welding a ‘clot’ with a threaded rod sticking out. A threaded rod does go through the tube and through the flange plate providing as a tension rod and guaranteeing that the cardboard tubes will only be exposed to pressure forces. This is because cardboard cannot deal with tensile forces and bending stresses.” (Ring pass, z.d.)

Nest We Grow - Kengo Kuma



Nest We Grow, designed by architect Kengo Kuma, is a remarkable community-centric space in Japan. This innovative structure serves as a communal dining hall and gathering place, promoting sustainable living and connection with nature. The building's exterior is adorned with a timber lattice framework, creating a sense of harmony with the surrounding landscape. Inside, the space features movable wooden furniture that encourages flexibility and interaction among its users. The building's sustainable design includes a greenhouse and rainwater collection system, emphasizing self-sufficiency and ecological responsibility. Nest We Grow embodies Kengo Kuma's philosophy of integrating architecture with the natural environment, fostering a harmonious relationship between people and nature. Besides using Nest We Grow as a construction precedent, the concept of this agriculture centre is very inspiring for my own design.

3D printing paper

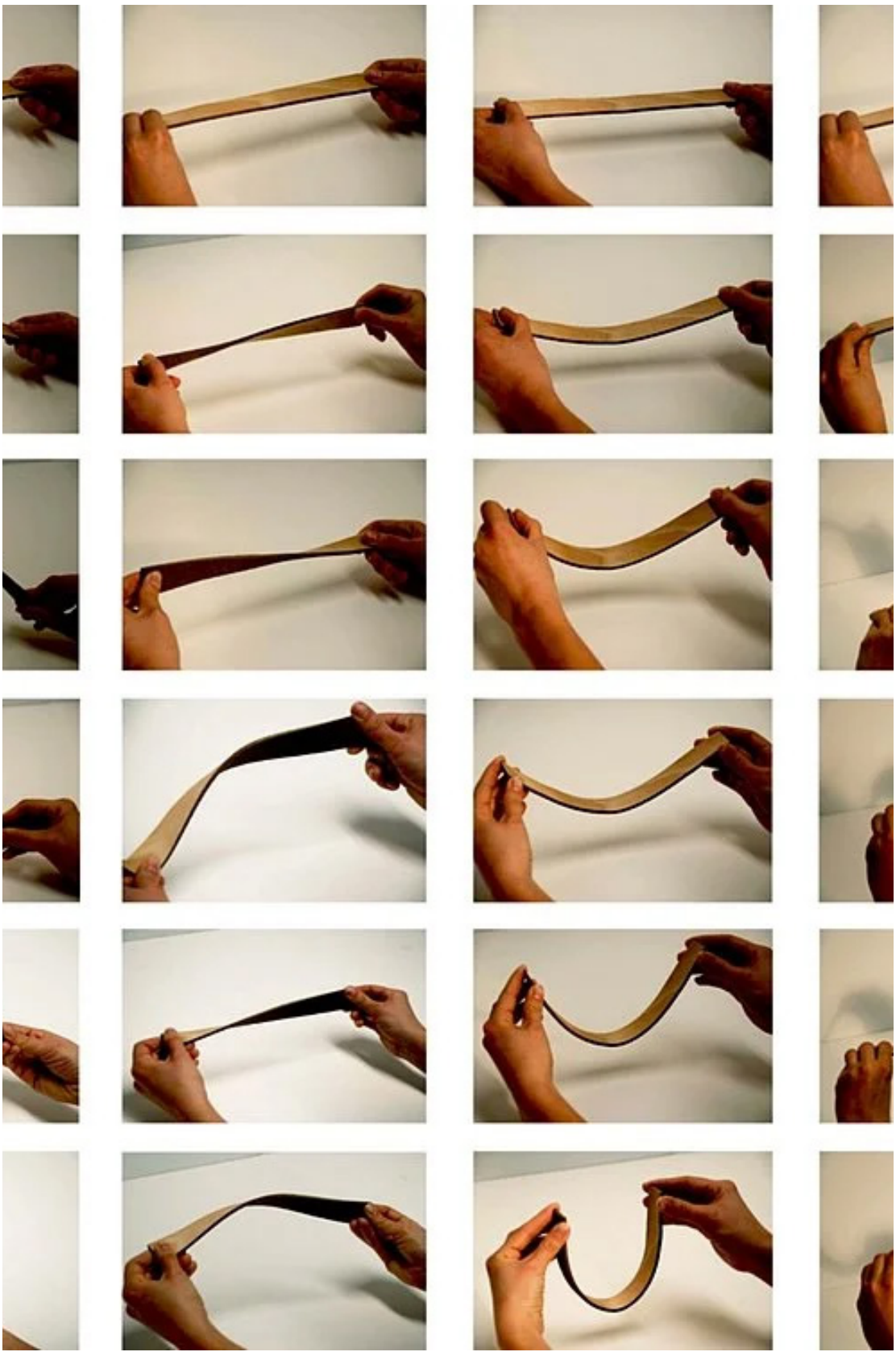


“TU Delft researchers have demonstrated 3D printing with waste cellulose and lignin materials. Cellulose and lignin are made by trees, and the two organic polymers make up the majority of mass of tree structures.

Lignin in particular is the stronger of the two, providing tree cells with stiffness necessary to grow to tall heights against the pull of gravity.

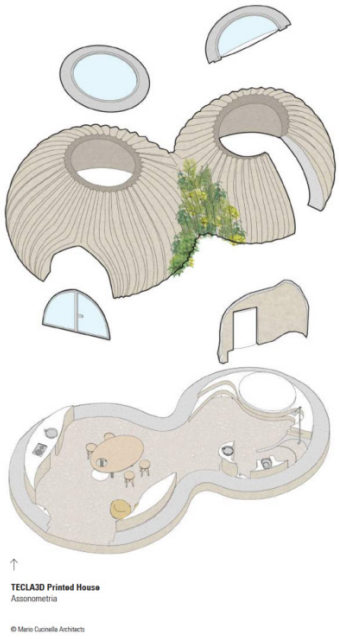
For millennia trees grew and fell, without the lignin decomposing — and that’s where coal comes from. In fact, this era of around 300 million years ago is known as the “Carboniferous Period”. Eventually bacteria evolved to eat the lignin, and that period concluded.

Today lignin is still produced by trees, and is often a waste product from pulp and paper processing. The researchers believed it might be possible to make use of this otherwise waste material by converting it into a usable 3D print material.” (Stevenson, 2022)



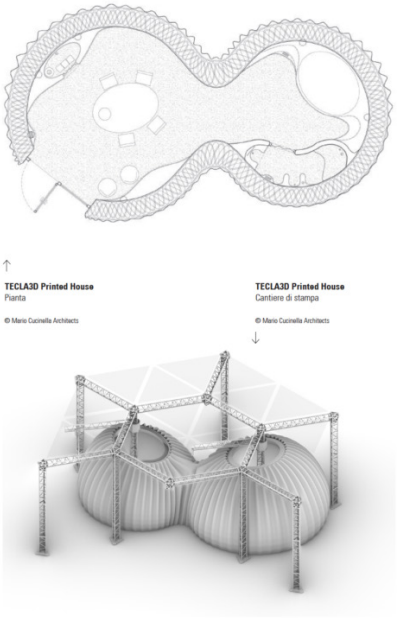
“The HDF board developed by Prof. Hanaa Dahy contains 80 to 90 percent annually renewable raw materials such as straw. This natural fiber is available worldwide as a residual material and therefore costs little. Moreover, straw does not compete with food production. The fiberboards can be made of wheat, maize, rice, oat, barley or rye straw fibers. Fiberboards made of rice straw have even an added benefit, i.e. their silicate concentration reach up to 20 % of the dry fiber weight. Since silicate is a natural fire-retardant material, the DIN 4102-B1 material classification “hardly inflammable” is thus already fulfilled by the addition of purely mineral additives.” (“BioFlexi” is an extremely flexible high-density fiberboard made of renewable raw materials., 2019)

TECLA Technology and Clay 3D Printed House - Mario Cucinella Architects



TECLA3D Printed House
Assonometria

© Mario Cucinella Architects



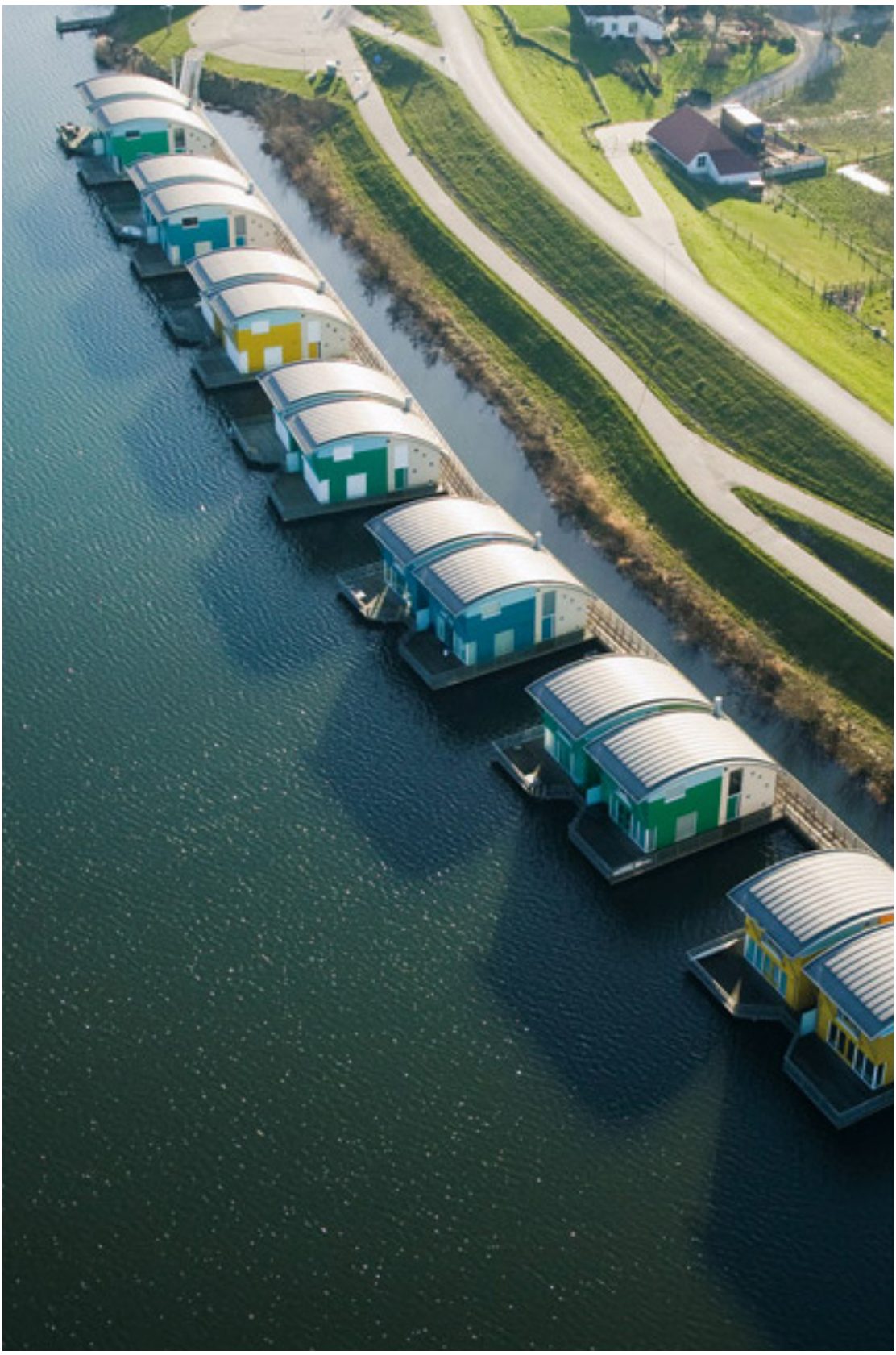
TECLA3D Printed House
Pianta

© Mario Cucinella Architects

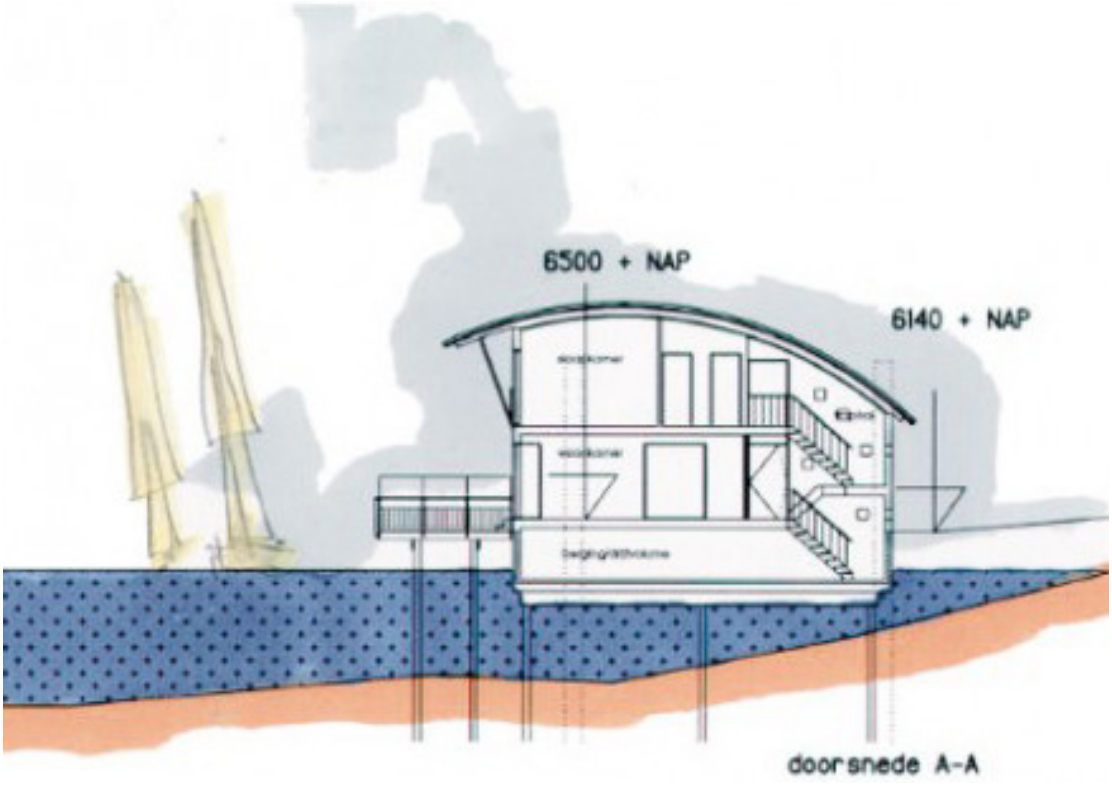
TECLA3D Printed House
Cantiere di stampa

© Mario Cucinella Architects

"The first eco-sustainable housing model 3D printed entirely from local raw earth. This genuinely innovative and pioneering approach was conceived from the start as a joint project between the two firms, who worked closely throughout the project's design and construction. Metaphorically inspired by one of Italo Calvino's 'invisible cities' - the city in continuous construction - the name TECLA evokes the strong link between past and future by combining the matter and spirit of timeless ancient homes with the world of 21st-century technological production. The atypical shape, from the geometry to the external ridges, has enabled the structural balance of the construction - both during the 3D printing phase of the envelope and once the covering is completed - giving life to an organic and visually coherent design.
With an area of about 60 square meters, it comprises a living zone with a kitchen and a night zone which includes services. The furnishings - partly printed in local earth and integrated into the raw-earth structure, and partly designed to be recycled or reused - reflect the philosophy of a circular house model." (Pintos, 2021)

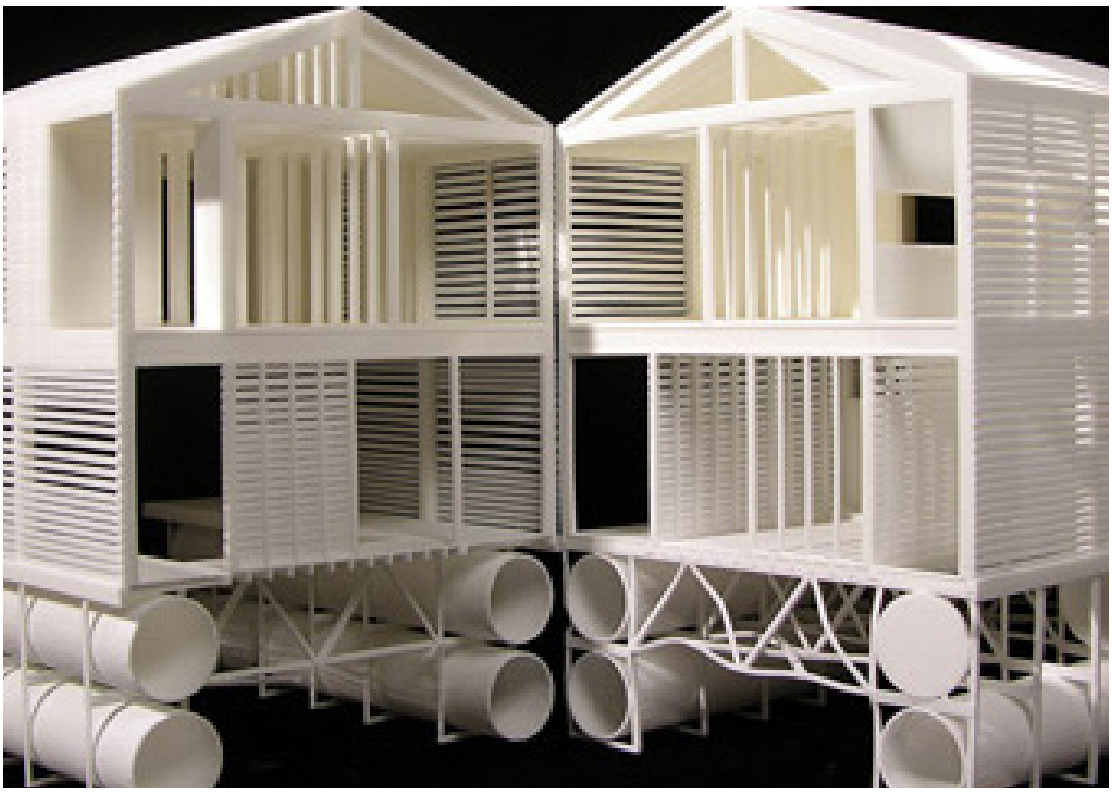


Floating Housing



“This project is an attempt to test and demonstrate a transformative approach to adaptation in the case of flood resilient architecture. Designed by Factor Architecten bv, the floating houses at Maasbommel are fastened to flexible mooring posts and rest on concrete foundations. The house units are all similar and made using a concrete barge with lightweight timber construction atop. These posts limit the motion caused by the water while allowing the houses to move upwards and float when the level of the river rises.” (Srishti, 2020)

Floating House - MOS Architects



A structure of steel pontoons allows this wooden cabin by New York studio MOS Architects to float on the surface of Lake Huron.
Named Floating House, the two-storey building provides a summer residence on the Canadian side of Lake Huron – one of North America's Great Lakes – for a Cincinnati-based couple.
Thanks to its pontoon base, the house adapts to the changing water levels of the lake, which rise and fall throughout the year.

"Annual cyclical change causes Lake Huron's water levels to fluctuate drastically month to month, year to year," explained MOS Architects. (Frearson, 2015)

CASE STUDY - SAN GIOBBE +160 PROJECT, VENICE

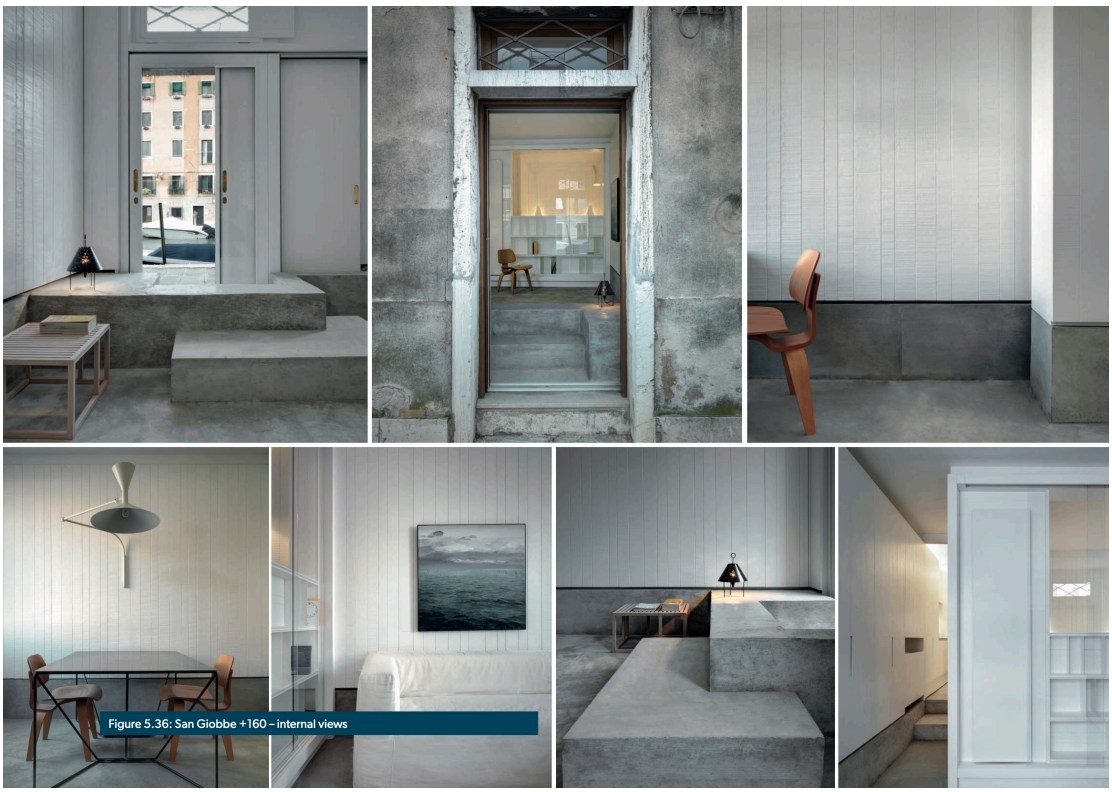
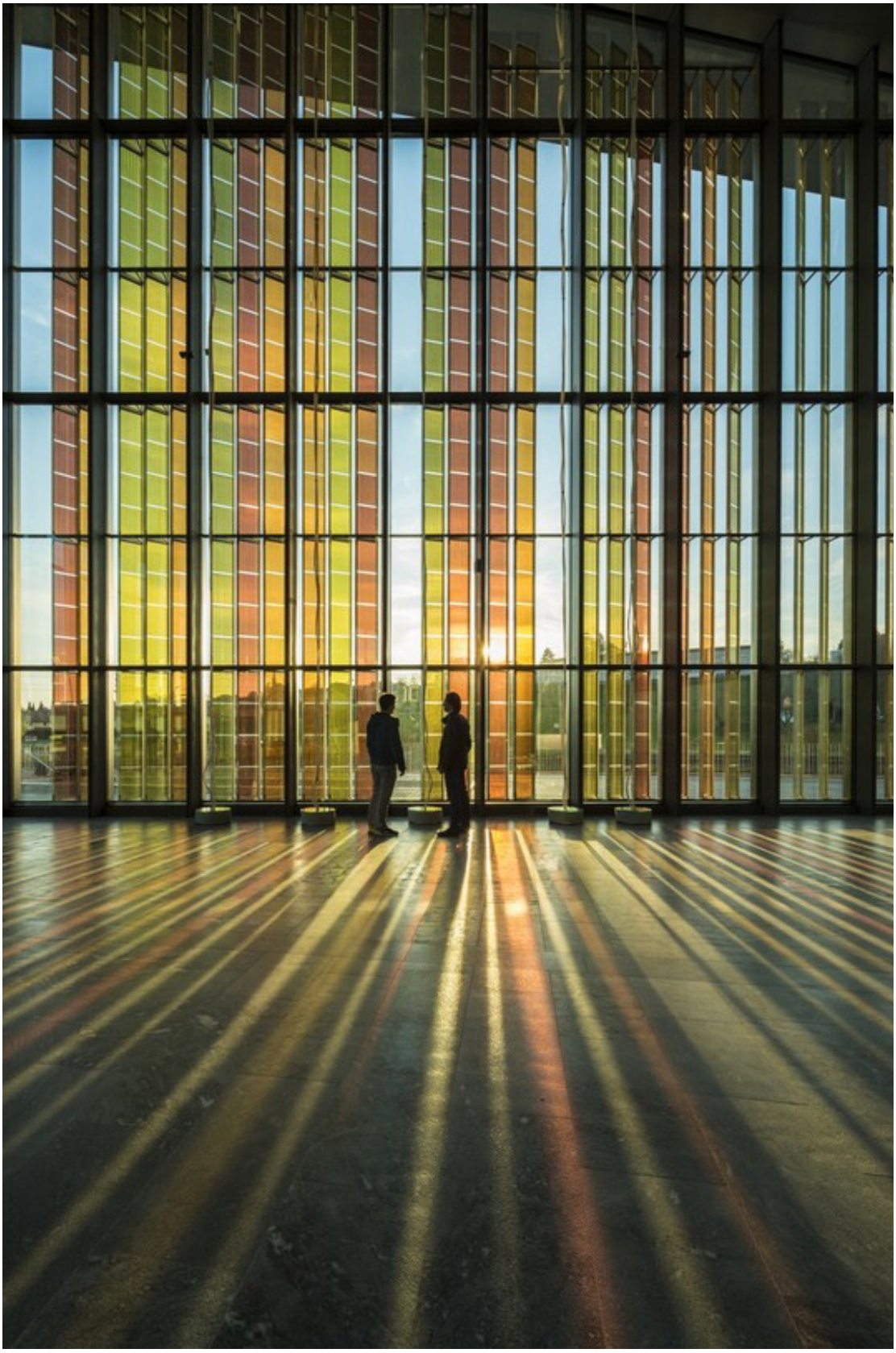
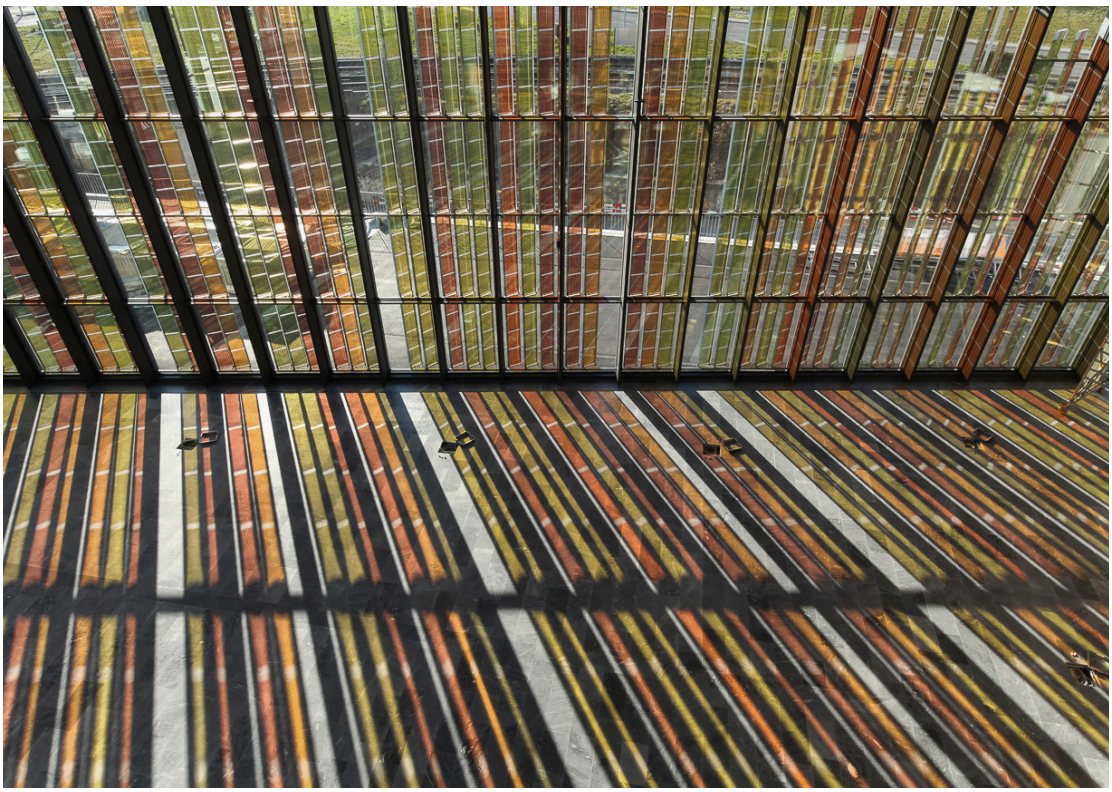


Figure 5.36: San Giobbe +160 – internal views

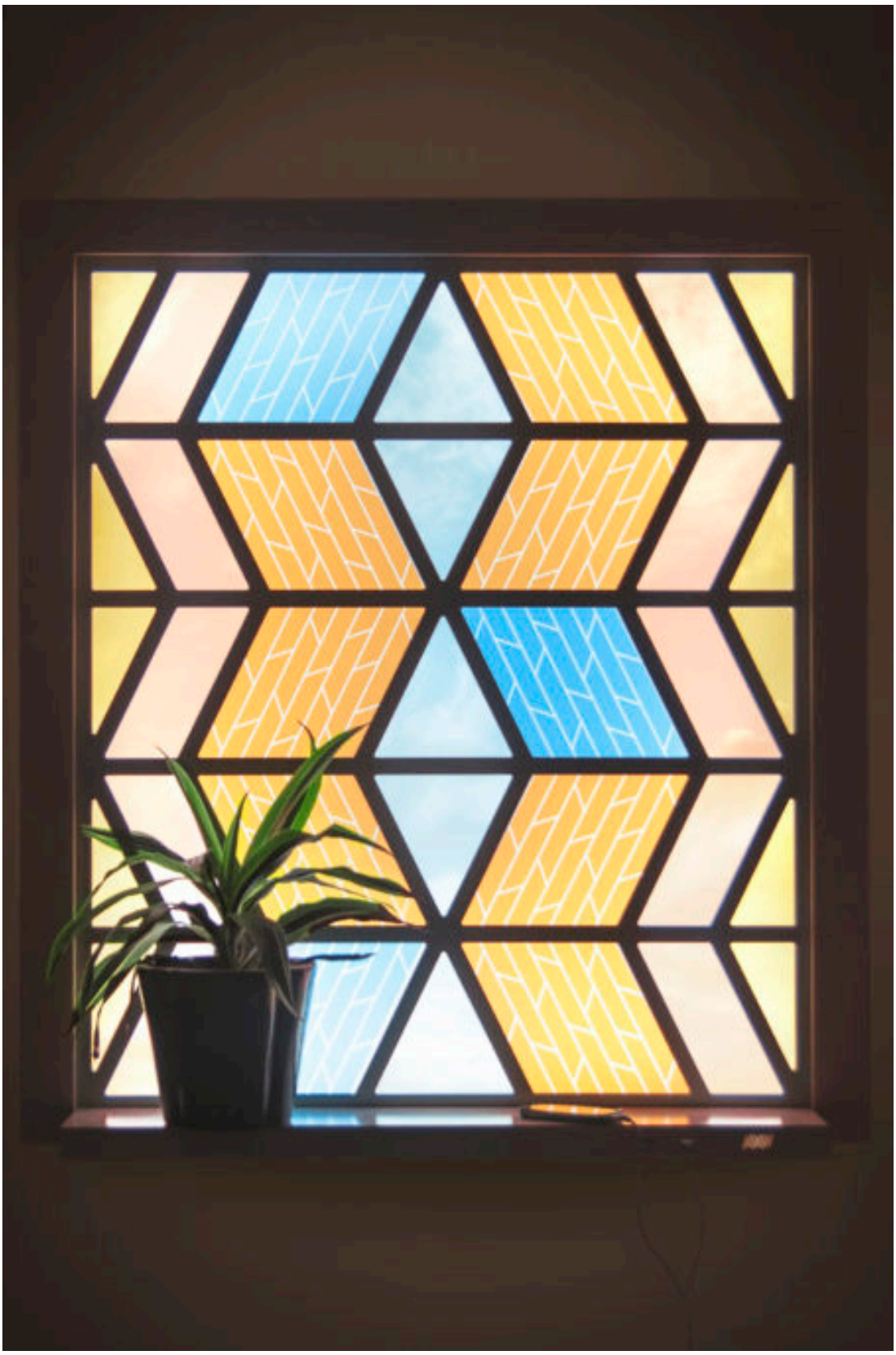
“The architects wanted to develop a strategy for the restoration that would eliminate water penetration and dampness as well as provide protection against periodic acqua alta (high tides). Research on the historic and future maximum tide levels revealed that the building would need to be protected (made flood resistant) to a height of 160 cm from the external ground levels. This datum became one of the key features that drove the design concept and reorganisation of the internal layout. Rather than using deployable flood-resistance measures (e.g. removable flood boards), a waterproof reinforced concrete tank was designed with concrete walls along the perimeter of the space that adhered to the underlying slab and is sealed with waterproof joints. The tank containment rim has been customised and configured to function as a step, shelf, furniture support and floor for the kitchen/bathroom (which are lined with handmade black sepia ceramic tiles). Above the 160 cm datum, walls are lined in wooden panelling (with humidity protection insulation behind) and the bedroom is built on wooden planks that sit atop the tank rim.” (Edward Barsley, 2020)



SwissTech Convention Centre - Richter Dahl Rocha & Associés



1400 25-by-50 centimeter solar cells. First BIPV project using dye-sensitised solar cells by Solaronix. 300 square meters generate 8000 kW hours per year.

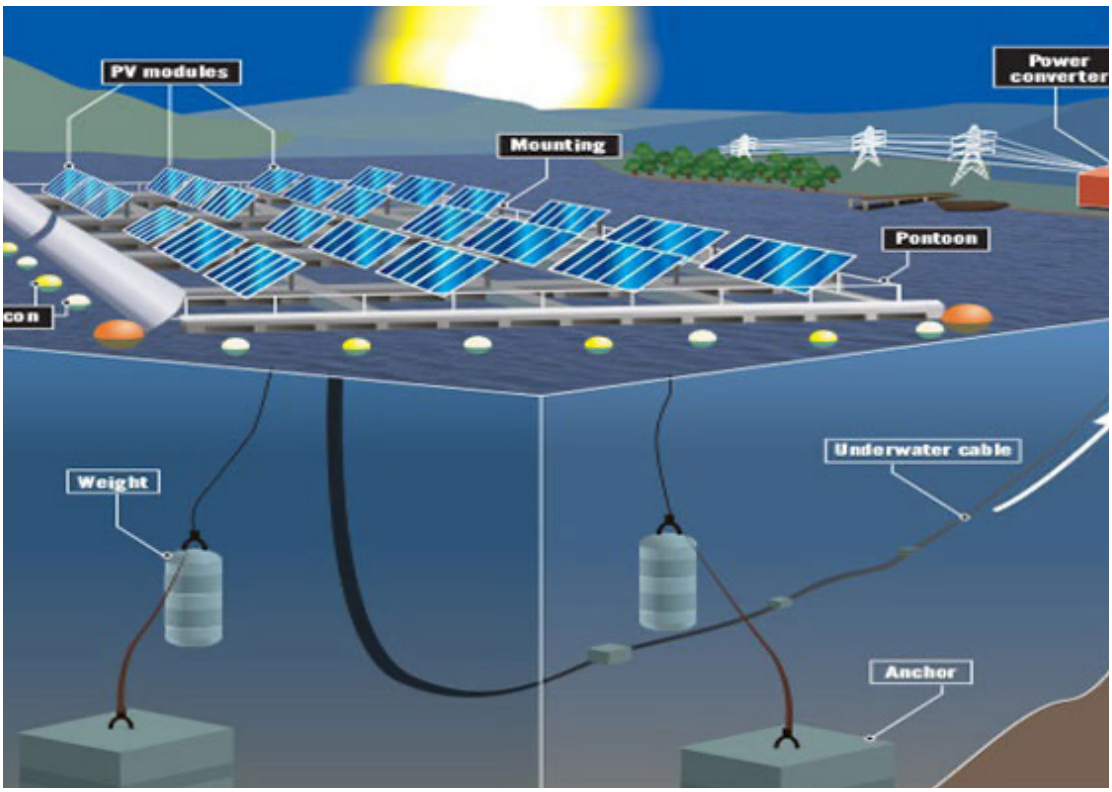


Current Window - Marjan van Aubel Studio

“Current window is a modern take of stained glass. Whilst the coloured panels of glass perform their traditional role, they also generate electricity from daylight which can then be used to power appliances indoors.

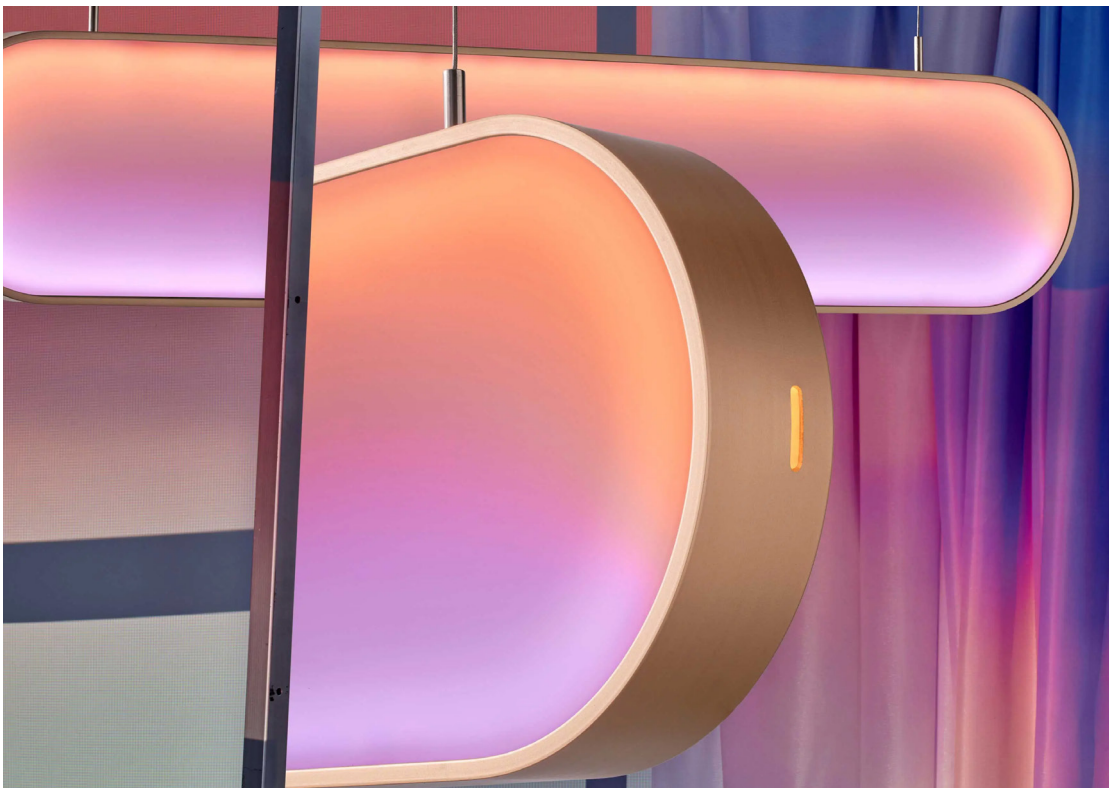
The glass panels are made from dye-sensitised solar cells (DSSC) which use the properties of colour to create an electrical current – a technique based on the process of photosynthesis in plants. Plug in your devices to charge using USB ports integrated into the window ledge; The larger the surface area, the more efficient this window will be as a power source.” (Current window, z.d.)

Giant Floating Solar Flowers - Nils-Jan Eekhout & Octatube



“The floating PV plant is a combination of onshore solar technology and floating structure technology. This style of PV plant is growing in popularity in mountainous and densely populated regions because it covers only the water’s surface, which is an idle space, and has the advantage of up to 10% higher power generation compared to onshore PV power plant thanks to less shadowing influence and the cooling effect of the water.” (Besty, 2020)

Sunne - Marjan van Aubel Studio

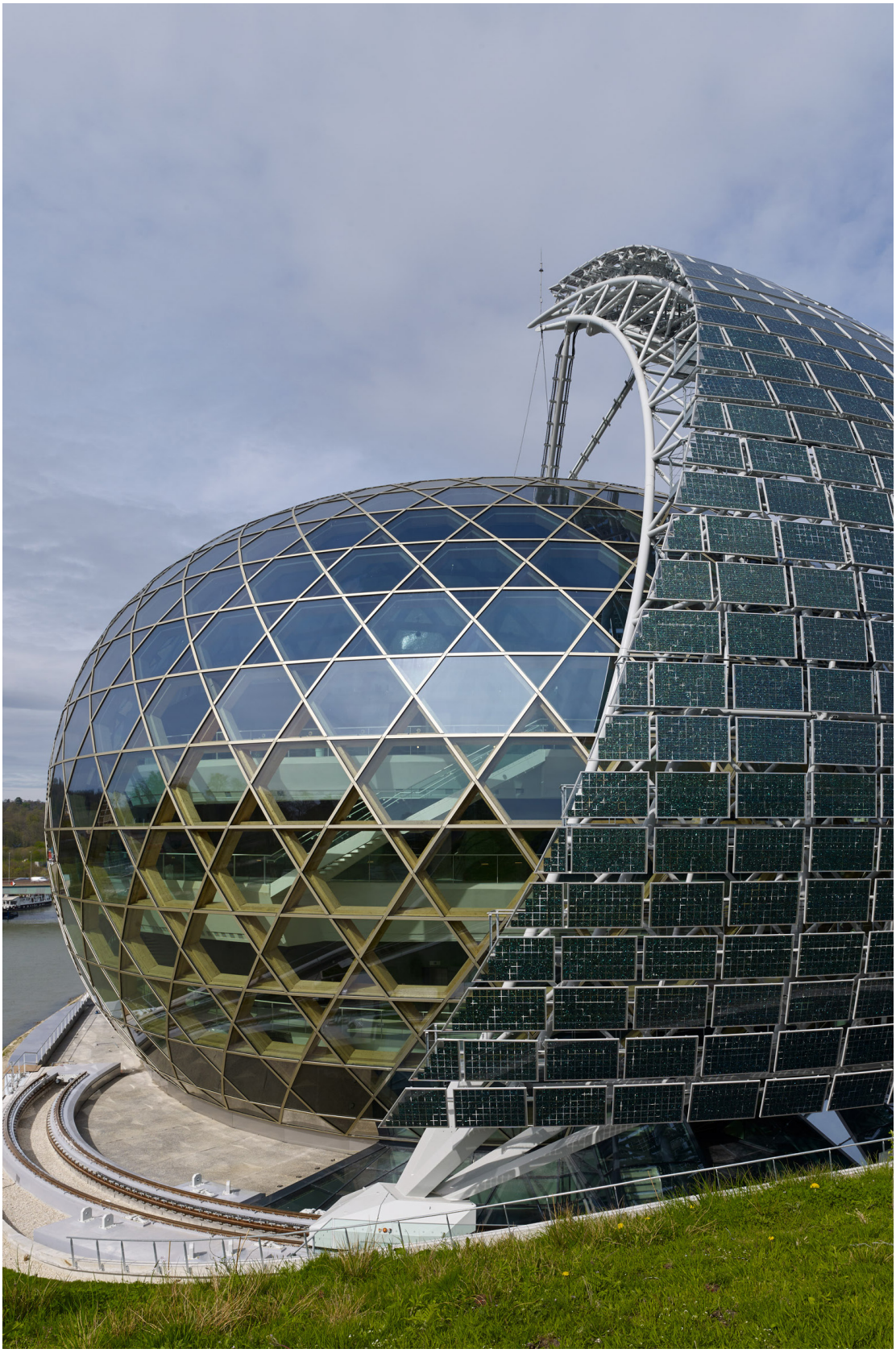


“Dutch designer Marjan van Aubel has developed a solar lamp that is designed to be hung in front of windows so it can generate its own energy.

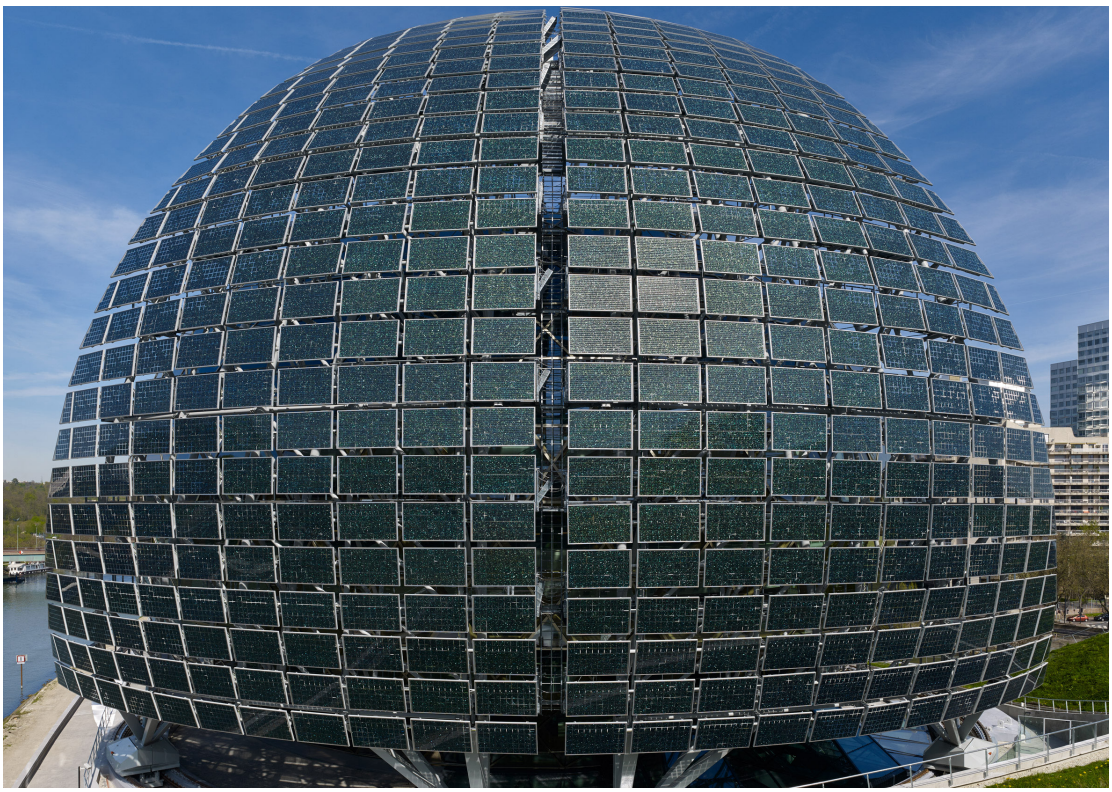
Called Sunne, the light is equipped with photovoltaic cells and an integrated battery, allowing it to harvest and store enough energy throughout the day to light up a room at night.” (Hahn & Hahn, 2021)

Organic solar PV cells on paper substrate

“Researchers at the Indian Institute of Technology Kanpur have developed 12×12 cm2 sub-modules from organic solar PV cells on a paper substrate that could be used to power flexible electronic devices under an indoor lighting environment. Paper substrates are low cost and more environment friendly. The modules are said to deliver a power density of up to 12 μW/cm2 under illumination from a 1000-lux cool-white LED.
Under “standard illumination” (1 sun intensity and AM1.5G spectrum), the researchers demonstrated active-area power conversion efficiencies of up to 4.23% with PTB7:PCBM blend and 2.38% with P3HT:PCBM blend photoactive layers. They claim the results to be among the highest reported efficiencies for sub-modules of organic solar cells built on paper substrates to date.” (Gupta, 2020)



La Seine Musicale - Shigeru Ban



“Pritzker Prize-winning architect Shigeru Ban has completed a music complex near Paris, featuring an egg-shaped auditorium and a wall of solar panels that move to follow the path of the sun. The Japanese architect’s Paris-based office won an international competition held in 2013 to design La Seine Musicale – a musical facility comprising a large multipurpose venue and a smaller auditorium. The triangular sail is mounted on rails that allow it to follow the path of the sun, therefore increasing its efficiency and ensuring the lobby behind is shaded throughout the day. “The form of the solar panel is inspired by a sail, so we can compare La Seine Musicale to a sailing ship,” said the firm in a statement. “This environmentally friendly ‘ship’ will ultimately make a new symbol for the west gate of Paris.” (Griffiths, 2017)

Powerhouse Brattørkaia office - Snøhetta

“Snøhetta has completed the sustainable Powerhouse Brattørkaia office in Trondheim, Norway, which produces more than double the amount of electricity it consumes daily.

The building’s upper facade and pentagonal-shaped roof are clad with a total of 3,000 square-metres of solar panels.

To ensure these harvest as much solar energy as possible, the form of the building was created by Snøhetta to ensure there is maximum exposure to the sun. This was a challenge for the architects, given the limited daylight hours in its northern location.” (Crook, 2019)

Google’s Bay View campus - BIG and Heatherwick Studio

“Search engine company Google has opened its BIG and Heatherwick Studio-designed Bay View campus in California’s Silicon Valley, which features sweeping, scale-like panels across its roof.

Each structure is covered in a tent-like roof made up of a system of inward curving panels which were fitted with a combined total of 50,000 silver solar panels that can generate almost 7 megawatts of energy.” (Parkes, 2022)

- AESTHETIC TECHNOLOGIES IN SOLAR ENERGY -

Aesthetic Technologies in Solar Energy

Introduction

Solar energy has emerged as a sustainable and renewable energy source, offering a promising solution to our growing energy needs. However, despite its environmental benefits, widespread adoption of solar panels has faced challenges related to aesthetics and desirability. According to solar design company Kameleon Solar, technology will become desirable when it becomes beautiful. “We believe that if we can adapt solar technology to suit the desires of an artist, an architect, a product designer, or a building owner, then mankind will embrace solar energy on a wider scale than ever before.”

This research looks into the design possibilities when considering solar panels from an aesthetic perspective. The five, in my opinion, most intreseting technologies have been selected and will be explained. All five technologies can be implemented in architectural design, some easier than others. Both the technological side and the aesthetics of the technique will be discussed and also one or more precendents will be added as an example to help getting a better understanding of the implementation.

Solar Windows

Technology
These transparent panels look just like regular windows, but they are a bit more special. They are transparent solar cells (TSCs) and they combine the benefits of converting light to electricity and being fully transparent. They are composed of organic salts that are designed to absorb specific invisible UV and infrared light wavelengths, which then glow as another invisible wavelength. This new wavelength is guided to the edge of the window, where thin PV solar cell strips convert it into electricity. (Mag, 2021)

There are many different types of these TSCs. All of them have a different level of transperency and efficiency rate. In general, the more transparent the glass is, the less effiecient the panel is in generating electricity. Researchers say that when mass production starts, the fully transparent panels can reach a efficiency of 10%. (Mag, 2021)

Aesthetics
The aesthetics of this technology are not very special. It looks very similar to a normal piece of glass or window. Therefore, aesthetic wise, it could be easily substituted for a regular window.

Precedent

"In a recently built office building in Boulder, Colorado, there are solar panels on the roof. But the building also has one of the world's first installations of solar-window technology—transparent panels that look like ordinary windows, but also invisibly generate energy.

Because typical solar panels absorb the full spectrum—making them appear black—the solar windows capture about a third less energy. But since they can be used in areas where regular solar panels can't, they can help add to the supply of renewable energy.

The windows, with two panes of glass that are sealed together, have wires that can be connected either directly to something next to the window—such as a light or electronic blinds—or connected to a battery in the building or back into the electric grid." (Peters, 2022)

Solar Visuals

Technology
This technique can be used in many different ways but has a quite simple system. The technology involves applying a full-color graphic over the photovoltaic layer from the solar panel. This allows for the realisation of nearly any color, pattern, or image, and is even possible to mimic real materials such as brick or wood.

There are various ways to use these panels with a visual effect in a building. One of these options is to mount them on an existing facade or roof and attempt to blend them in. The visual design can then mimic the pattern of, for example, bricks or roof tiles, making it more camouflaged compared to a standard solar panel. (Kameleon Solar | Home, z.d.)
Another option is to use them as BIPV. In this manner, the panels are more integrated into the building and often serve a secondary purpose besides generating energy. Additionally, the solar panels will be less conspicuous within the building's facade because they become part of the facade itself rather than an additional layer.

Kameleon Solar suggests that the most ideal scenario would be for designers to integrate the solar panels into the design process from an earlier stage or even consider them as a starting point. Currently, the technology is often implemented towards the end of a project or used during renovations which leads to suboptimal results. When architects are already aware of the possibilities of these panels, the design could benefit significantly from their integration.

Aesthetics
The approach of mimicing materials is not yet optimal due to the difficulty in achieving a three-dimensional effect, given that solar panels are flat and lack texture. Therefore, when it is desired to blend in with an actual facade material, it is often more effective to create a pattern that complements with the material. What does work well is integrating solar panels with a finishing like facade panels, as these have a uniform color and are also flat which makes them easier to copy.

Precedent

“This colored solar façade in Helmond, the Netherlands, marks one of our projects where colored solar panels are integrated into the façade. Kameleon Solar’s ColorBlast® technology was used to create three shades of orange to complement the surrounding folded aluminum elements. These folded elements also act as a mounting system for the colored PV modules and have integrated LED lighting.” (Kameleon Solar | Kuijpers – Helmond, z.d.)

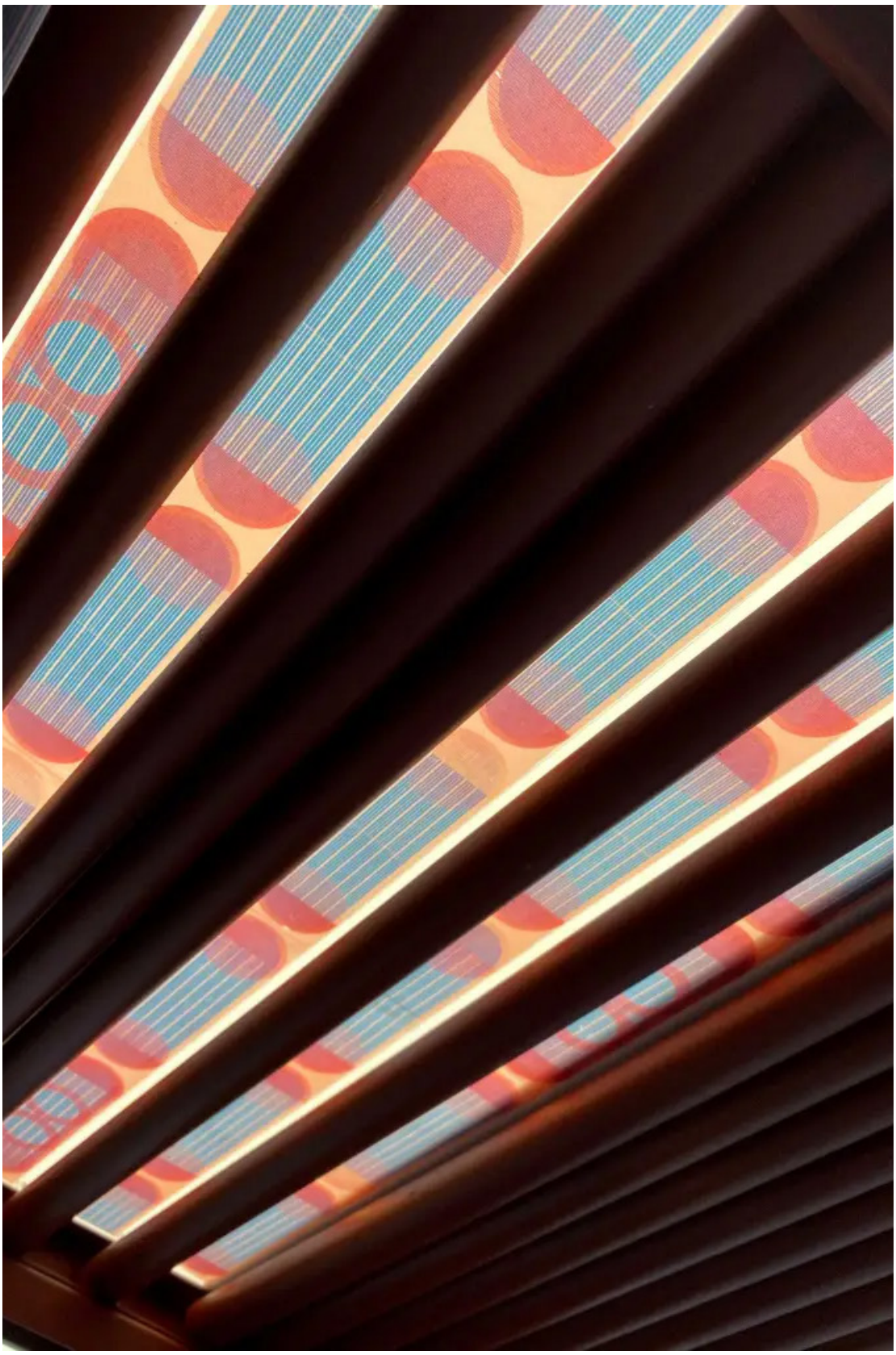
Printed Solar Cells

Technology
Printable solar cells are very lightweight, flexible and even low-cost. They can be printed on various materials like paper and foil. Because of it's flexibility, this technology can easily be implemented in buildings in many different ways.

One of the great benefits is that this technique works very well indoors and outdoors. It can be used on facades and windows, but also on indoor walls or in furniture. Also in shadowed places, with minimum lighting the cells still generate energy. Unfortunately, however, the technology of printed solar cells is not very efficient yet, in fact it's 10 times less efficient than most solar panels. (Saule Technologies, 2022)

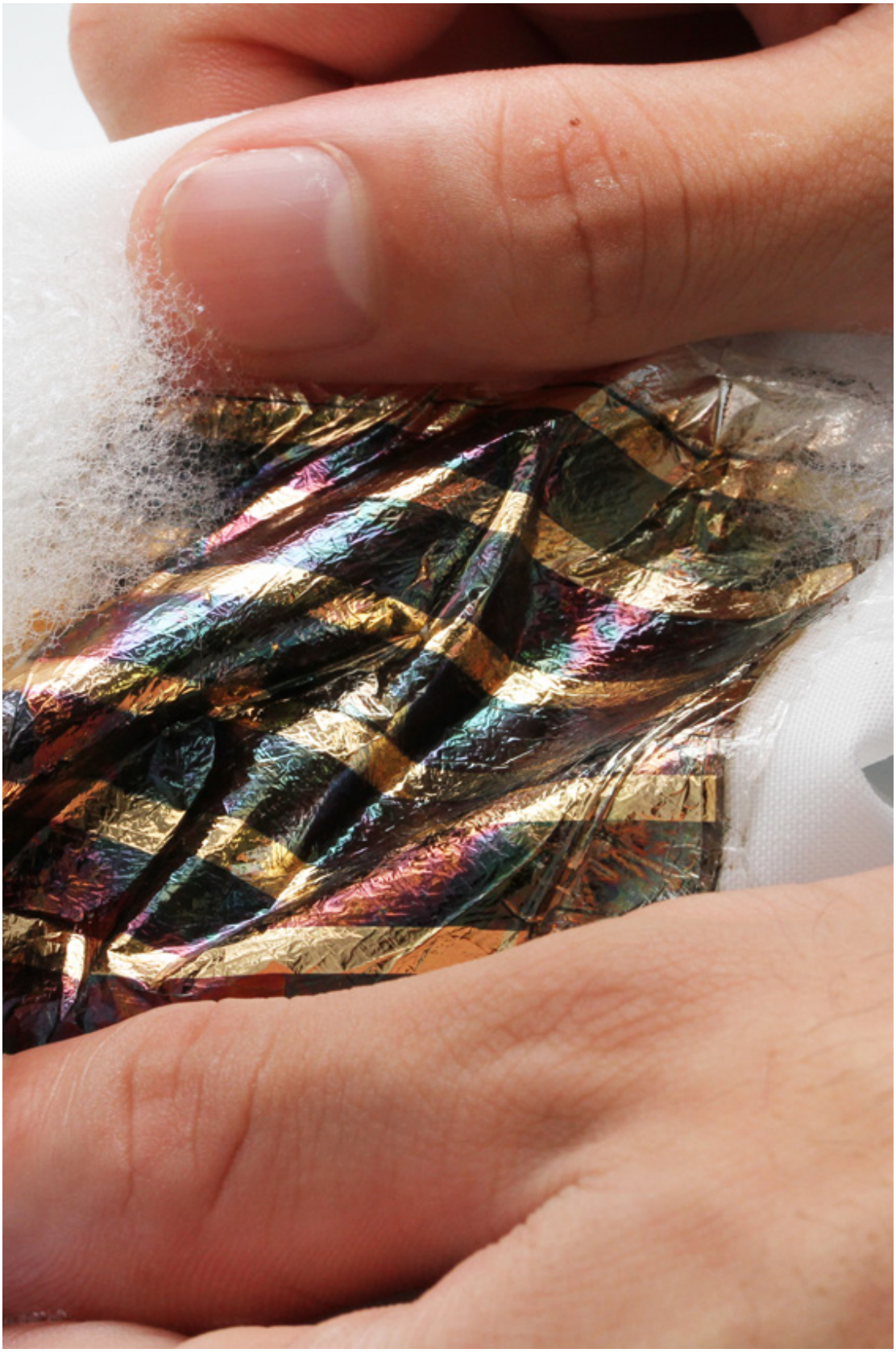
Aesthetics
The aesthetic possibilities of printed solar cells are quite broad. In theory almost any shape or pattern could be printed, one more efficient than the other.

The thinness of these solar cells can also be seen as aestheticly pleasing. Regular solar panels are much thicker of course and are more of a challenge to conceal in a design. Foils can be used on almost any surface and won't be as prominent.



Precedent

“Made out of lightweight, organic, transparent solar cells (OPV), Marjan van Aubel Studio’s colorful solar roof will span across the Netherlands Pavilion during the Expo 2020 in Dubai. The studio has marked their presence in the field with innovative solar energy based products before, and has once again combined technology with aesthetics for this futuristic design. The designer, van Aubel. demonstrates that solar panels can go beyond its functionality, of harvesting solar energy, and can be conceived as a form of art as well. The graphic design is made with a colored Moiré effect; the lines and patterns are interacting with each other creating beautiful light reflections in the pavilion. The colored ARMOR ASCA® OPV, a third-generation solar technology, is printed on PET foils and is produced in a sustainable manner. They are lightweight, making it easily transportable.” (Supreetha, 2022)



Solar Fabric

Technology
At the moment there are many different technologies for solar fabric, all with slightly different properties. Their purpose however is the same, a fabric that is able to generate energy. It can be used in clothing, tents, awnings and even buildings.

One example is from UCLA Samueli School of Engineering where bioengineers have developed and successfully demonstrated a wearable fabric that can harvest and store energy from the sun. (UCLA engineers develop fabric that harvests AND stores energy, z.d.)

Researchers from RIKEN and the University of Tokyo have developed a groundbreaking ultra-slim energy generating textile. It is shielded on both sides by flexible, waterproof layers and boasts the remarkable capability of sustaining solar power generation after immersion in water or exposure to stretching and compression. (A solar cell you can put in the wash | RIKEN, z.d.)

Aesthetics
The looks of solar fabric, besides that most of them look like textile, are still very diverse because there are many different technologies. It has not been used on a large scale in buildings yet. So far energy generating fabrics have been used in clothing and awnings as far as my knowledge goes. There are existing buildings where fabric is used as facades, so maybe in the near future, after further developments, solar fabric could be used in a similar way as has been done with for example Parque Científico Tecnológico “Magical”. (Molinare, 2023)

Precedent

“Dutch designer Pauline van Dongen has unveiled a vision to “reupholster our built environment” using a solar-energy-generating textile she is developing with manufacturer Tentech. Suntex is a durable and water-resistant solar textile that could be used to clad entire buildings, turning them into huge solar-energy generators. She sais that entire facades could be dressed in this fabric, which could create a completely new aesthetic for buildings.

The textile is created by weaving organic photovoltaic (OPV) solar cells, which are made from polymer, together with recycled polymer yarns.

It is flexible and lightweight, so could be used as a cladding material for new and retrofitted buildings. It could also be applied across glazing to provide solar shading.” (Frearson, 2022)

AuREUS

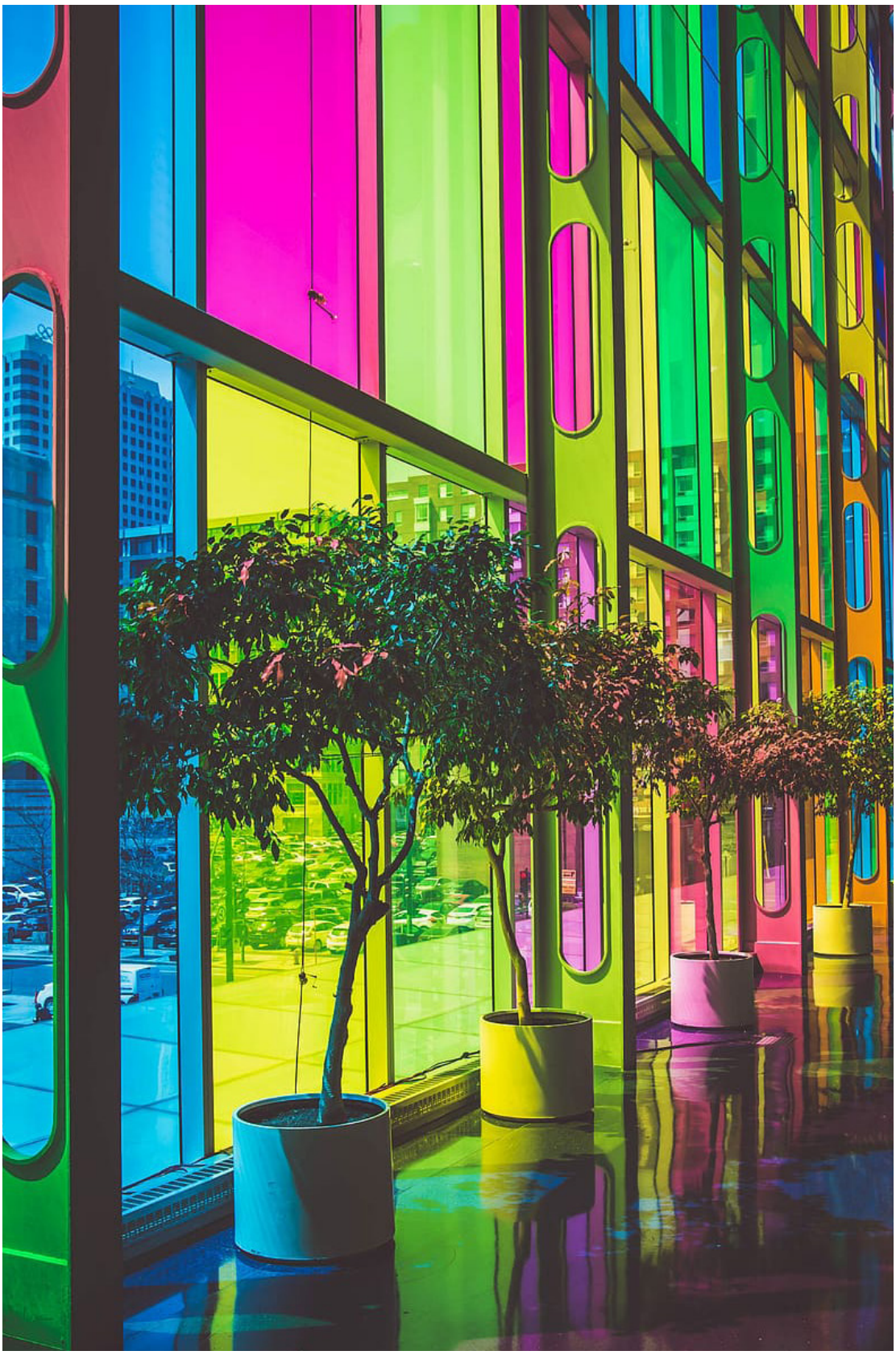
Technology
Filipino engineering student Carvey Ehren Maigue has developed an innovative material crafted from discarded fruits and vegetables. This unique substance has the capacity to capture ultraviolet rays from the sun and transform them into renewable energy. Maigue's creation, known as AuREUS, has earned him recognition and a sustainability award from the James Dyson Foundation.

AuREUS relies on naturally occurring luminescent particles found in the food waste, which capture ultraviolet rays and then convert this energy into visible light. When combined with photovoltaic (PV) cells, the material is capable of generating solar power, even when the weather is overcast.

One of the key features of AuREUS is its internal reflectance, allowing the material to emit visible light from its edges. This characteristic opens up the possibility of creating windows with built-in PV cells around the window frame to generate electricity.

In his innovative process, Maigue has employed nine different local crops. These crops are crushed to extract juice, from which the naturally luminescent particles are derived. Subsequently, these particles are mixed into a moldable resin to create the AuREUS material.

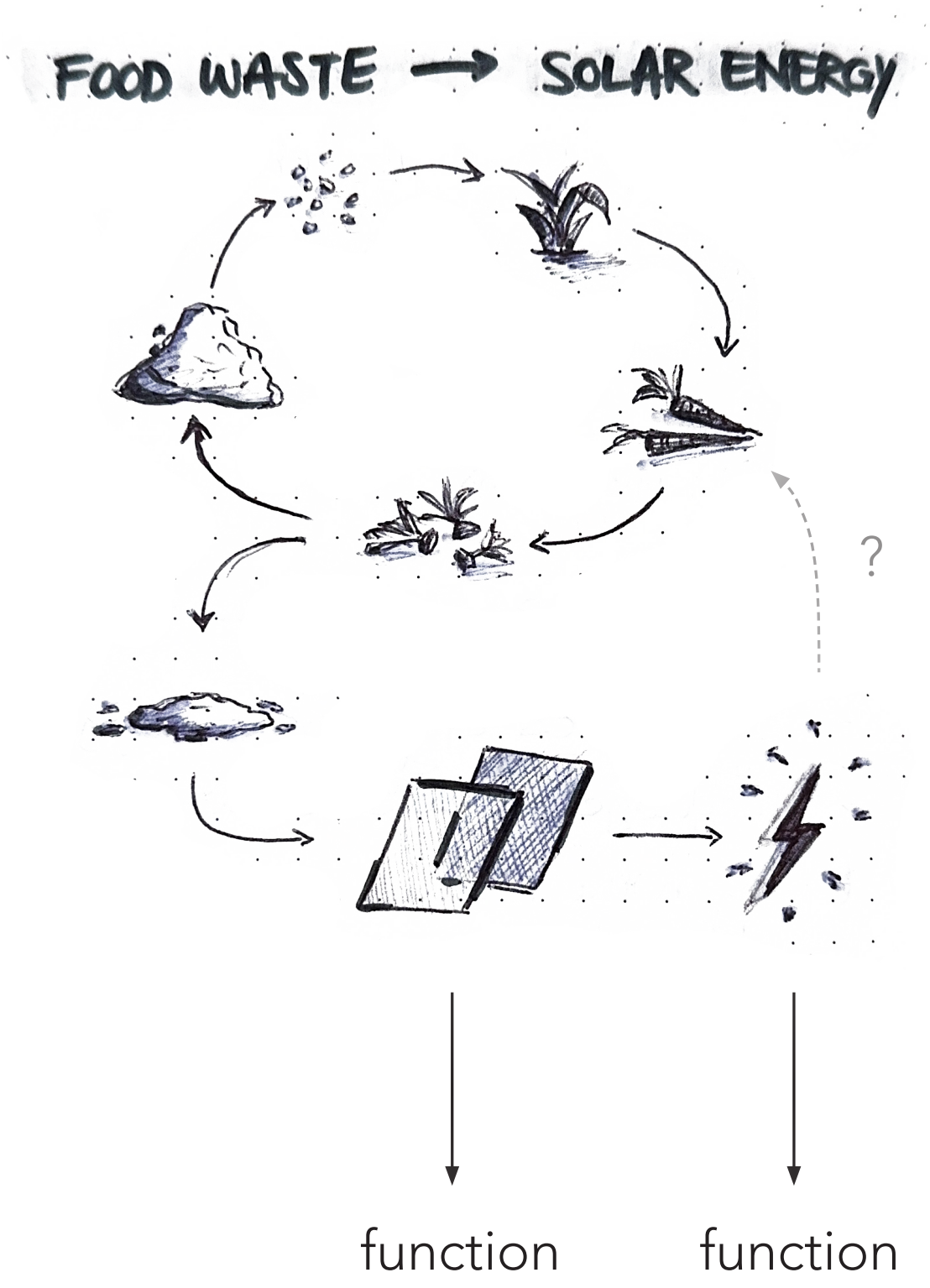
Aesthetics
So far AuREUS comes in five different colours; red, orange, yellow, green and blue. For all colours a natural dye is being used exept the blue one, a substitute for the chemical dye has yet to be found. The different colours of the panels could be used to play with the coloured incoming light in the building.



Precedent

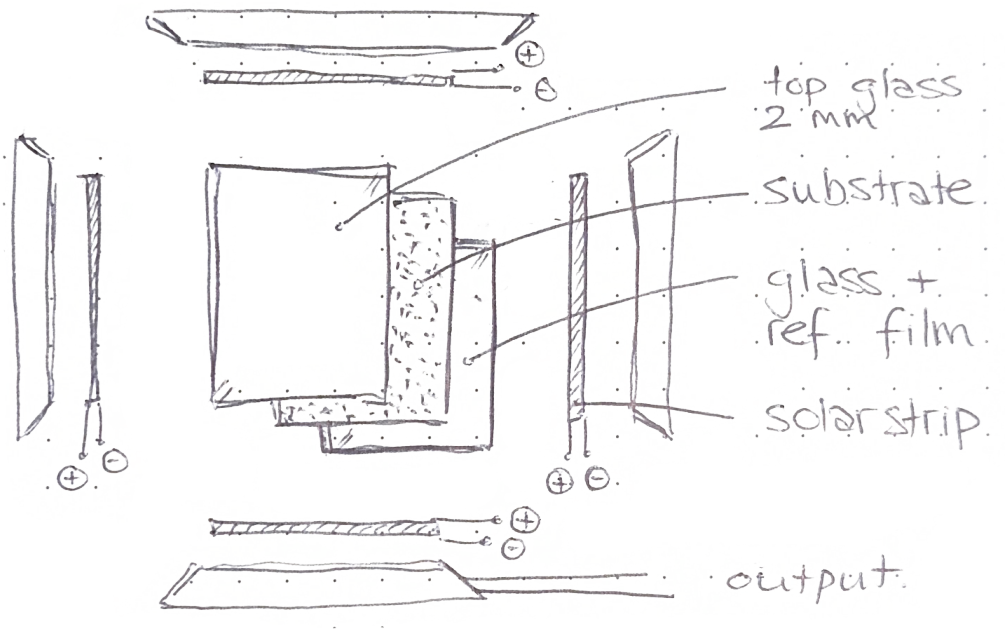
Right now this technology has not been used on a large scale yet. However, Maigue says the food waste solar panels could be used in entire buildings such as the Montreal Convention Centre." (Hahn, 2020)

- AUREUS P1 -



Food waste to solar energy, image by author

Charcoal workshop, image by author



AuREUS system, image by author

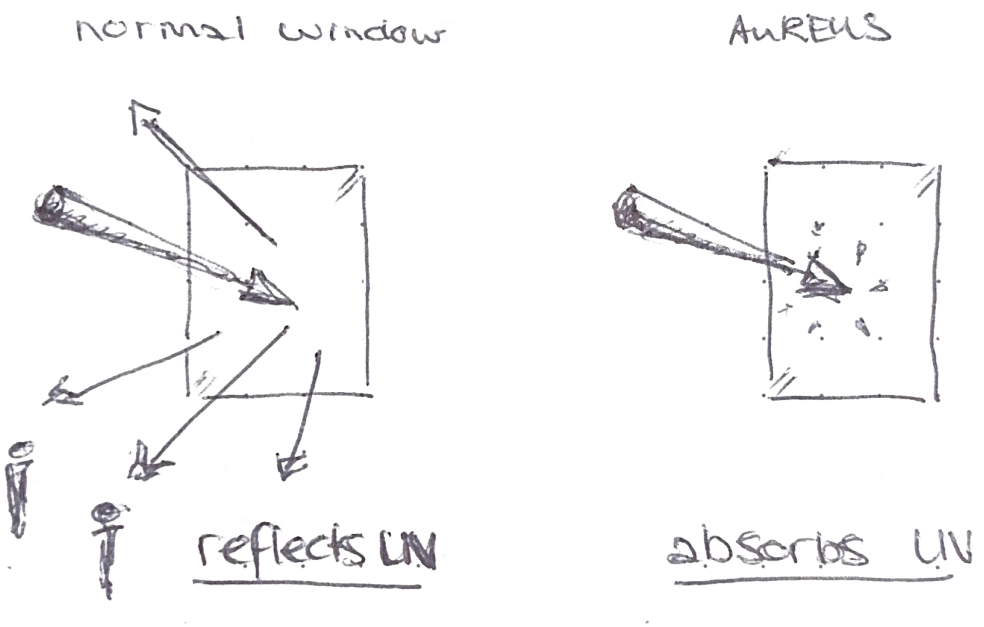
How it works

Both AuREUS devices, namely the Borealis Solar Window and the Astralis Solar Wall, employ a shared technology inspired by the phenomena governing the captivating Northern and Southern lights. Luminescent particles, derived from specific fruits and vegetables, are suspended in a resin substrate, constituting the fundamental technology in both devices. When exposed to UV light, these particles absorb and subsequently re-emit visible light along the edges through internal reflectance. Photovoltaic cells positioned along these edges capture the emitted visible light, converting it into DC electricity. The harnessed electricity undergoes processing through regulating circuits, enabling options such as battery charging, storage, or direct utilization. (AUREUS Aurora Renewable Energy UV Sequestration | James Dyson Award, n.d.-b)

UV absorption

[Regarding VS Quantum Dot Solar Windows:] AuREUS employs cost-effective materials and, since 2019, has been applied and tested for mechanical and acoustic properties in various building settings. In terms of application, AuREUS consistently takes the lead.

[Comparing with Solar Panels:] AuREUS demonstrates functionality even when not directly oriented towards the sun, utilizing UV scattering through clouds and the bouncing of UV light along surfaces such as walls and pavements. This capability facilitates the creation of a Vertical Solar Farm even on a limited lot area, particularly beneficial for skyscrapers in urban settings, providing access to clean and renewable electricity.



Absorption of UV-rays, image by author

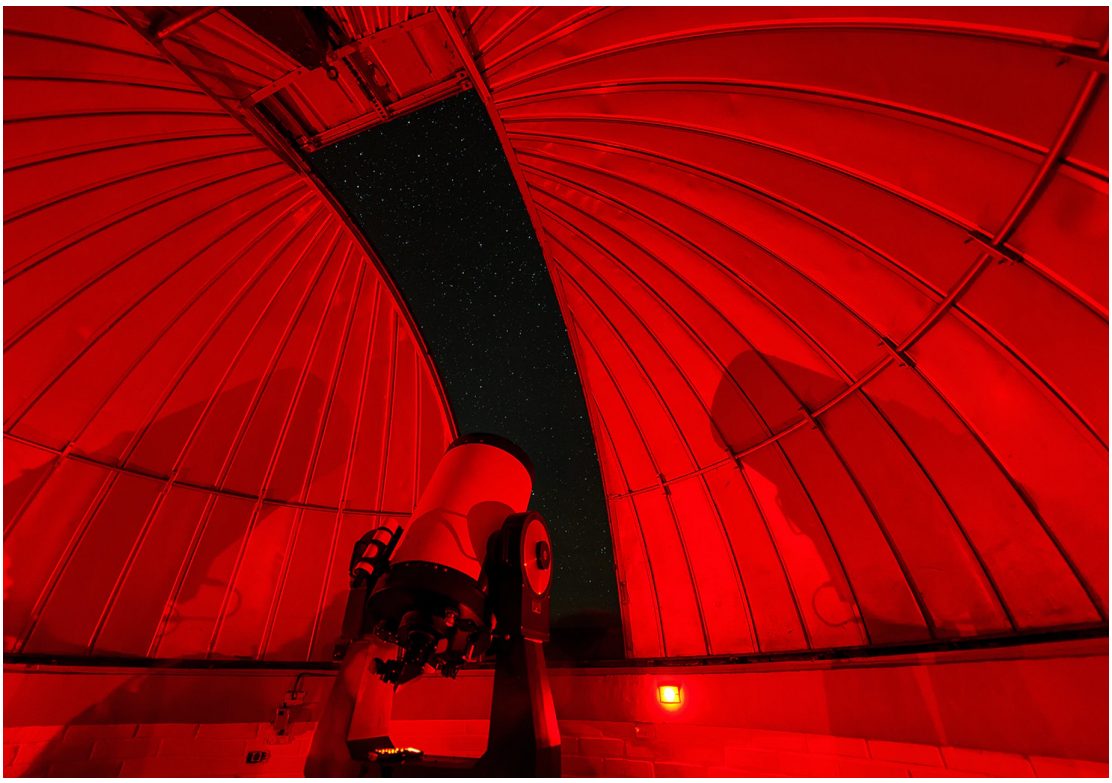
[Contrasting with Commercial Grade Windows:] Traditional glass cladding in buildings often incorporates films that reflect UV away, potentially exposing people outside to induced UV radiation. AuREUS, on the other hand, absorbs UV light, providing protection for individuals both indoors and outdoors.

[In Comparison with Crop Waste Disposal:] AuREUS engages in the upcycling of fruit and vegetable scraps, breathing new life into materials typically regarded as waste.
(AUREUS Aurora Renewable Energy UV Sequestration | James Dyson Award, n.d.-b)

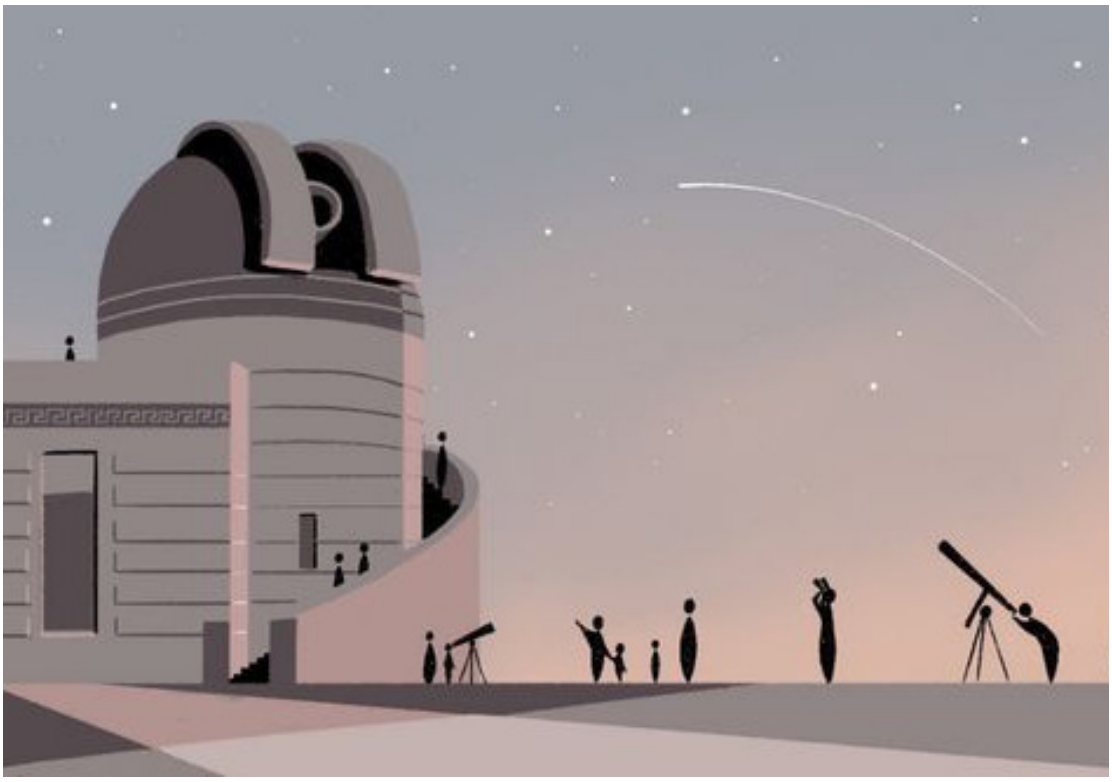
Efficiency

The average solar panel typically produces between 250 to 400 Watts of power. In contrast, the innovative AuREUS panel stands out by converting 1 kilogram of food waste into an impressive 108 Watts peak (Wp) of solar energy capture potential. While a conventional solar panel boasts an efficiency range of 15 to 22%, the AuREUS panel achieves a remarkable 50% efficiency, thanks to its ability to operate even on cloudy days.

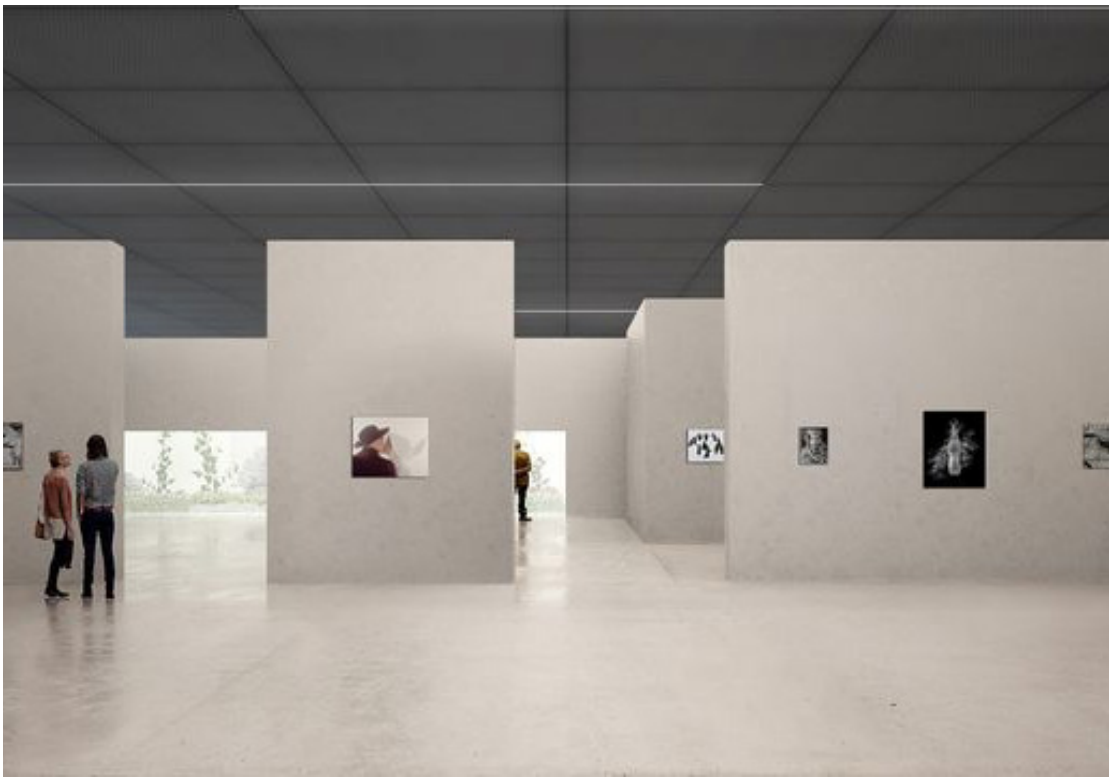
In terms of overall efficiency, a regular solar panel still outperforms the AuREUS panel. However, the AuREUS panel manages to generate 60% of the energy produced by a traditional panel. This highlights the promising potential of the AuREUS technology, especially considering its unique ability to utilize food waste and maintain functionality during less-than-ideal weather conditions.



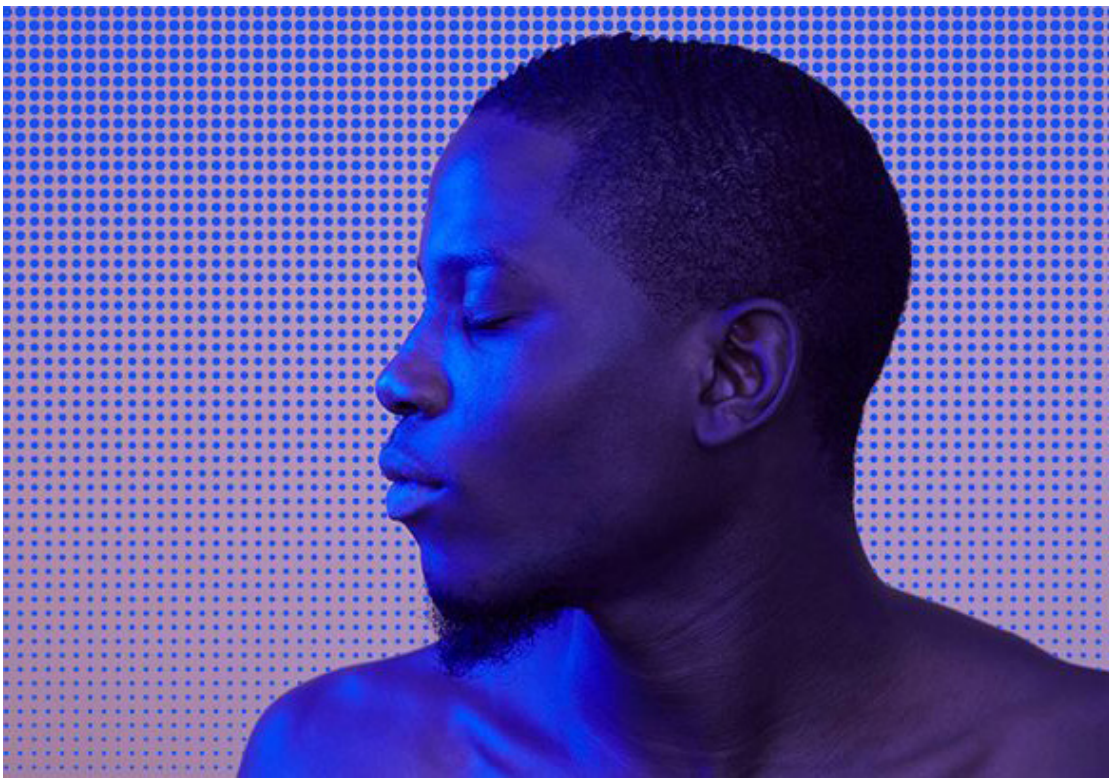
Red light to preserve night vision at an observatory

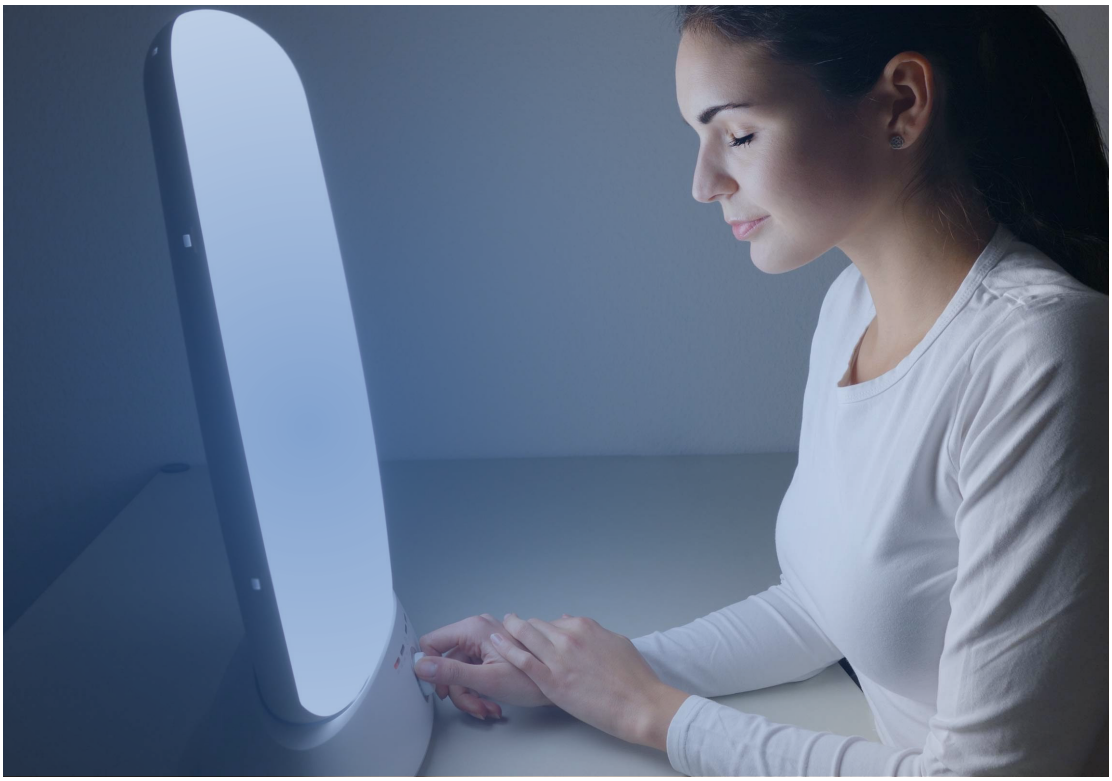


Red light for photo developing



Red and blue light to stimulate growth





Blue light to alleviate depression

FOLLOW-UP QUESTION

So, this is the technology and the possibilities, now I need to define aesthetics and find out how this technology can be aesthetically driven for widespread architectural implementation...