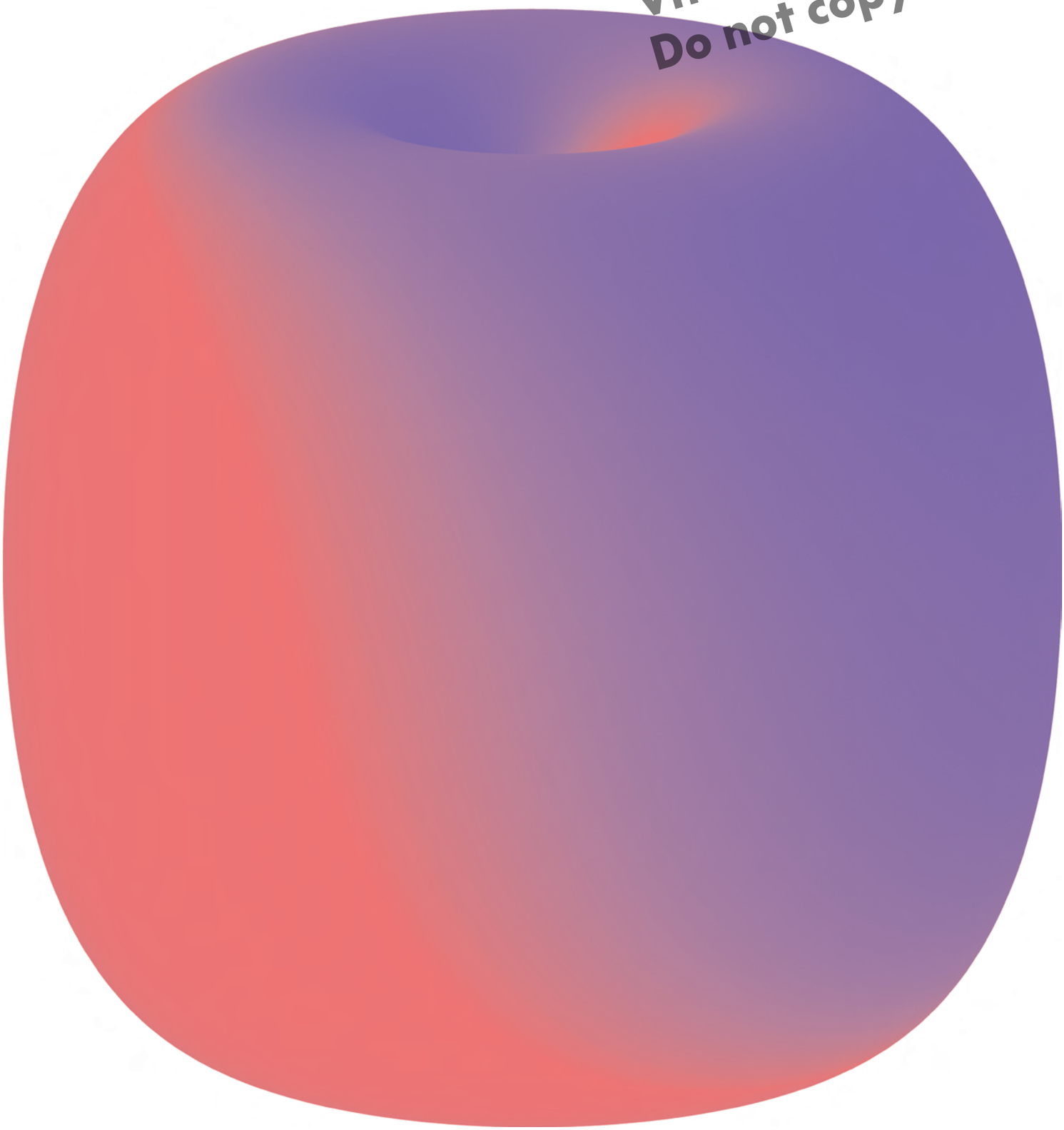


Energy is the main driving force of our society; energy is political; energy is invisible. In previous centuries, energy appeared to be an inexhaustible resource. Today, we know that using it sustainably and efficiently is crucial for our future on planet Earth. Design plays a central role in the necessary transition because all the buildings and products for the generation, distribution, and use of energy are designed.

The exhibition *Transform! Designing the Future of Energy* examines the role of design in the current energy transition – from energy-efficient everyday products to the design of solar houses and wind power plants, from intelligent mobility concepts to future visions of energy-autonomous cities. Some of the projects and designs shown solve concrete problems; others use design to raise questions or inspire us to think about energy as such. Examples from design history show that we can learn from the experiences of the past and that some of the ideas discussed today are not that new, whether they be off-grid products or the generation of wind and solar electricity. However, the focus is on current projects and future visions that demonstrate how design can help shape the current energy transition. The precondition for this is a rethink, not only on the part of designers but also users, industry, and politicians.

For their generous support of the exhibition, we would like to thank the Deutscher Sparkassen- und Giroverband and the IKEA Foundation. I would also like to thank the exhibition's curator, Jochen Eisenbrand, who has developed a fascinating exhibition and book on a highly complex and relevant theme. Incidentally, the design for this book is inspired by manuals from the 1960s and '70s, when the devastating ecological consequences of consumer society were first realized and such manuals presented proposals for building sustainability into everyday life. Something of this era's pioneering spirit and joy in experimentation would be of great help in the, at times, quite bleak atmosphere of our present age. And the title of the exhibition should be taken as an encouragement – so let's design the future of energy!

Mateo Kries
Director
Vitra Design Museum

DIRECTORY

ADAPTIVE SOLAR FAÇADE

In order for the European goal of climate neutrality to be reached by 2050, the construction industry must also reinvent itself, as the building sector is responsible for more than one-third of global CO_2 emissions. One solution is to utilize building façades to generate solar energy and to optimize this use. The Adaptive Solar Façade (ASF), developed by the A/S Research Group at ETH Zürich, consists of a lightweight grid construction composed of metal tubes with movable solar modules mounted at their intersections. The solar modules consist of 42 × 42-centimetre aluminium panels that are laminated with photovoltaic cells. The vertical and horizontal

1 The Adaptive Solar Façade installed on the NEST, a modular research and innovation building in Dübendorf, Switzerland, 2022.

orientation of these solar modules can be controlled pneumatically by means of “soft robotics”. This enables the light incidence and the shadows cast by the modules to be regulated, along with the amount of solar energy they can use. The solar modules are also equipped with sensors so that its position in space can be precisely determined. The structure can be mounted on the outside of windows and glass façades of both new and existing buildings. According to the developers, ASF should not be seen as an isolated element but rather as an integral component of a building system, since it augments the other technical components, such as lighting, heating, and ventilation. A first prototype of ASF has been installed at ETH Zürich’s House of Natural Resources, while a second module has been installed as part of the Hilo Unit at the NEST, a modularly constructed building in Dübendorf, Switzerland, where innovations in the building sector are researched and tested. Development of the Adaptive Solar Façade as a product for the international market has been ongoing since 2022 under the name Solskin.

→ SOLGAMI
→ COPENHAGEN INTERNATIONAL SCHOOL

APTERA SOLAR VEHICLE

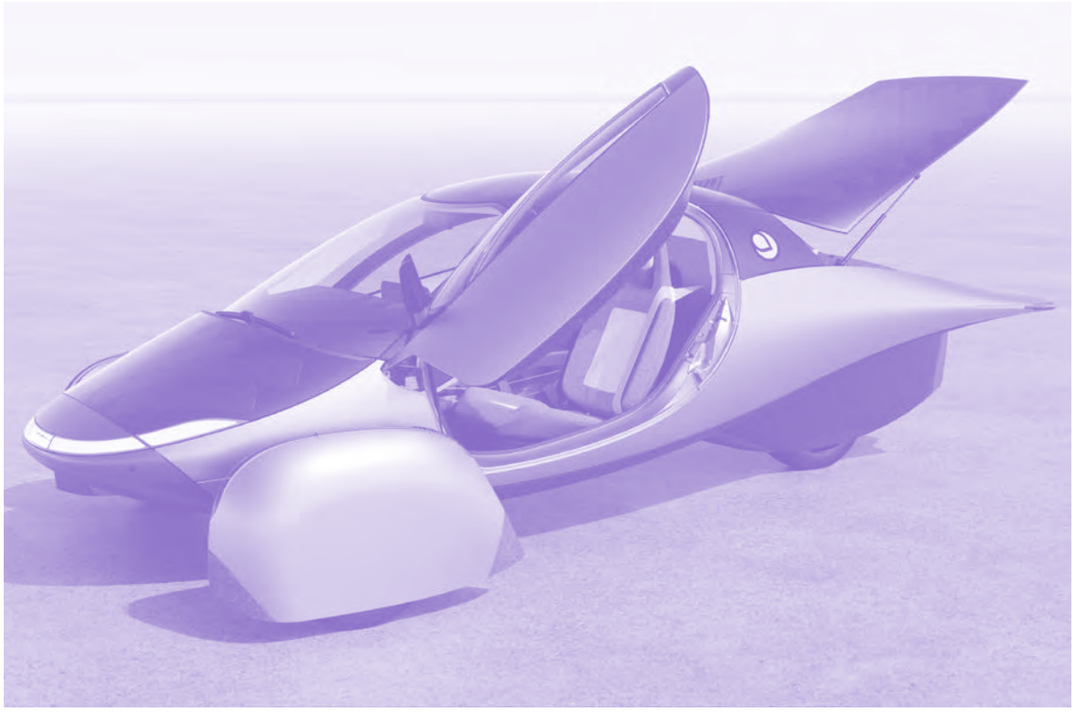
The bodywork of the Aptera solar electric vehicle is fitted with up to 189 thin and flexible solar cells, in the standard version on the roof and dashboard and in a special version with additional cells on the boot and bonnet. The solar cells deliver up to four kilowatt-hours (kWh) of electricity, which, according to the manufacturer, enables the vehicle to travel up to 40 kilometres daily. Here, the Aptera’s light weight, reduced roll resistance, and low air resistance, thanks to its aerodynamic design, prove advantageous. The three-wheel vehicle is not classified as a car but as a motorcycle. Inspiration for the Aptera solar vehicle’s bodywork came from the research of the Italian aerodynamic expert Alberto Morelli, who had a wind tunnel built for the Turin-based bodywork company Pininfarina at the beginning of the 1970s. For the serial production of its solar vehicle, Aptera had raised 80 million US dollars through crowdfunding by the summer of 2023, as well as receiving a state subsidy of 21 million US dollars from the California Energy Commission. However, to date, there is still a shortfall of 50 million dollars needed to start production, which is planned for the end of 2024. Among other clients, Aptera hopes to win companies that will use the solar vehicle for their corporate fleets.

→ FIG. 59
→ LIGHTYEAR
→ SION

3 Hermann Sörgel surrounded by Atlantropa maps in the offices of the *New York Times*, 1930s.

ATLANTROPA

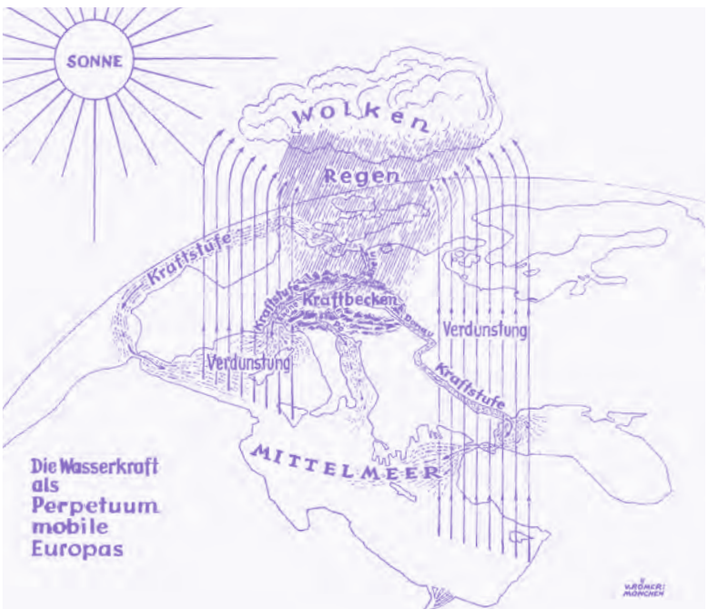
In the 1920s and 1930s, there was concern in Europe that global coal reserves could be exhausted someday given the world’s increasing energy demands. Even then, before oil had replaced coal as the most



2 The Aptera solar electric vehicle (2023) produces up to 4 kWh of solar power.

important energy source, industry and politics were considering renewable energies. Hope was centred on hydropower, which was named “white coal”. One of the biggest, albeit unrealized, projects for energy generation using hydropower was developed by the German architect Herman Sörgel starting in 1927. His vision, a project that involved the union of Europe and Africa as an economic unit and energy alliance, was called Atlantropa. Sörgel’s plan involved the construction of a gigantic dam and hydropower plant on the Strait of Gibraltar, which would supply electricity for the whole of Europe and North Africa; further hydropower plants were to be built at the mouths of the large rivers feeding into the Mediterranean, for example, the Nile, Rhone, and Ebro. Since this was to result in an inflow reduction that would lower the level of the Mediterranean Sea by 100 to 200 metres, Sörgel hoped to reclaim 3.5 million square metres of land for settlement. With the altered coastline and reduced sea level, Sörgel promoted the possibility of expansion to the Mediterranean port cities that would be landlocked as a result of these measures. Gaining the support of renowned architects such as Peter Behrens and Fritz Höger, Sörgel advertised his project and the associated architectonic and urban planning visions with exhibitions, newspaper articles, and his own publications, but also with numerous letters to politicians and specialists. For the African continent, Sörgel – who pursued his Atlantropa project until his accidental death in 1952 – envisioned a dam at the mouth of the Congo as it left the Congo Basin in order to create a huge inland sea (the “Congo Sea”). To the north, he planned to create a “Chad Sea” by means of another dam. According to Sörgel’s vision, these measures would create an area of two million square kilometres of fertile, irrigated land between the Atlantic Ocean and Egypt, including the Sahara. Undoubtedly, Sörgel’s ideas were still shaped by the imperialist spirit of colonialism. He saw the African continent primarily as a supplier of energy and raw materials. However, at the same time, Sörgel was a pacifist; he saw a unified “Large Power Network”, connecting Europe and crossing national boundaries, as a major project that would guarantee peace. Although Sörgel did also consider the climactic effects of Atlantropa and the changes in the salinity of the seas, the actual consequences of the huge interventions in nature he planned could not have been foreseeable at this scale.

→ ENEROPA
→ HONNEF WIND POWER PLANTS
→ WORLD GAME



4 Atlantropa diagram by Hermann Sörgel with a dam and hydroelectric power station on the Strait of Gibraltar, 1932.

5 The water cycle as a source of energy. Illustration by Botho and Hans Römer, Munich, for Atlantropa, 1930s

6 “Instead of dividing walls, binding lines”. Drawings from Hermann Sörgel, *Die drei großen ‘A’. America Atlantropa Asia* (“The three big ‘A’s’. America Atlantropa Asia”), 1938

ATOMKRAFT? NEJ TACK

The Smiling Sun logo in red, framed by the words “Nuclear Power? No Thanks”, is the international symbol for the anti-nuclear power movement known worldwide. The Danish activist Anne Lund first sketched the sun in April 1975 in a letter to her friend Siegfried Christiansen. The Organisationen til Oplysyning om Atomkraft (OOA, Organization for Information about Nuclear Power), of which Lund was also a member, had been founded by Christiansen a year earlier. On 1 May 1975, Labour Day, the first stickers and badges bearing the sun symbol were distributed in Aarhaus in Denmark. Assisted by the commercial designer Lene Hvidfeldt Larsen, Lund reworked the sun again a little in 1976, resulting in the final version of the symbol with the slightly extended ray towards the bottom left, which also

7 Logo of the anti-nuclear power movement. Design by Anne Lund, 1975

allowed it to be interpreted as a speech bubble. In the same year, German, Swedish, French, Dutch and American versions followed, and today there are more than 40 different language variants. Although the trademark rights on the sun have been owned by the OOA since 1977 (since 2000 by the OOA Fonden), no action has been taken against copies. The struggle against nuclear power was successful in Denmark; in accordance with a resolution that was passed by the Danish parliament in 1985, no nuclear power plants have been built in the country to this day. Currently, half of Denmark's electricity production is based on wind energy, with a small percentage of nuclear power imported from other countries. Anne Lund's letter, with the first sketch of the sun, has been kept in the Danish National Museum collection in Copenhagen for the last 20 years.

→ FIG. 67

ATOMTELLER

Collectible porcelain plates with Delft-blue decoration are widely known. A popular motif is windmills – technical constructions that harnessed mechanical energy from a bygone era. With their series of porcelain plates designed in 2015, the author and director Mia Grau and the architect and designer Andree Weißert took another form of energy as their theme – one that Germany has also recently consigned to the past: atomic energy. The series, produced by the Royal Porcelain Factory (KPM) in Berlin and realized in cooperation with the porcelain painter Heike Tropisch, shows all 19 German nuclear power plants that have been decommissioned since 2023, embedded in picturesque-looking cultural landscapes. On the back of the plates are details about the respective power plant, such as its electrical output and the date it was decommissioned, but also the number of incidents – an indication that the idyll is deceptive. In contrast to the windmills, it is unlikely that future generations will look at the nuclear power plants depicted on the plates with unadulterated nostalgia. Even after the reactors have been decommissioned and then dismantled or converted, the dangers of radioactive waste will remain.

→ FIG. 134
→ FAZIT

AVAILABLE NETWORKS

The starting point of the speculative design project of the French designer Pablo Bras was a YouTube tutorial on how to build a simple generator – from a toothpick, magnets, and copper wire. Commencing with this simple device which generates a weak electric current, Bras began his practical research in the field of energy. His premise was not to proceed from our current actual energy need and then attempt to produce this energy, but to examine how much energy is actually available to us if we were only to use the materials and phenomena in our immediate surroundings. In the next step, Bras developed a repertoire of technical aids for this scenario in order to channel the natural forces of water, wind, and sun, channelling them to an electricity generator and thus utilizing the micro-energies that surround us daily. This resulted in various typologies, including aqueducts, windmills, solar concentrators, and electricity pylons. These vary both in their degree of technical development – from primitive gadgets through to high-tech – and in their efficiency. Bras subsequently developed a several of these elements into products. A film he produced in 2019 documents the use of his designs in a suburban context.

→ IS THIS YOUR FUTURE?
→ GRAVITY BATTERY

8 Collectable nuclear power plants. Gundremmingen power station from the Atomteller series of collectable porcelain plates 2015

9 Rainwater downpipe with built-in turbine. Pablo Bras, Available Networks, 2019

10 Wind turbine for the chimney. Pablo Bras, Available Networks, 2019

(B)PACK

The (B)pack is a rucksack from the company (B)energy that can be used to save and store biogas. On the African continent in particular, where over 600 million people still cook using wood and charcoal, it provides access to clean, smoke-free cooking gas. The cushion-shaped (B)pack only weighs four kilogrammes when full, has a storage capacity of 1,000 litres of raw biogas, sufficient for two to four hours of cooking, and, thanks to two belts, can be worn as a rucksack. Thus, biogas becomes both saleable and a potential

15 Waste incineration plant and amusement park: CopenHill by BIG, 2019

Danish company SolarLab, which has developed façade elements where the photovoltaic technology is hidden behind coloured glass without effecting their efficiency. Depending on the orientation of the panels and the light intensity, the panels glow from sea-green to dark blue. Furthermore, the building's solar energy is an integral component of the school's curriculum, as the students monitor the energy capture and examine the data obtained in physics and mathematics lessons.

→ ADAPTIVE SOLAR FAÇADE
→ POWERHOUSE BRATTØRKAIA

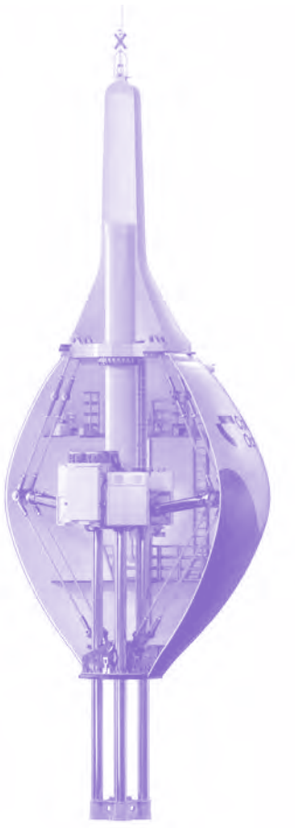
COPENHILL

With their design for the Amager Resource Center, also known as CopenHill, the Bjarke Ingels Group (BIG) architects have combined two seemingly irreconcilable activities: waste incineration and leisure activities. The building of the waste incineration facility in an industrial park close to the centre of Copenhagen, designed by BIG and completed in 2019, has been fashioned as an artificial mountainside that completely conceals the plant. On the facility's planted roof, called the "hillside", BIG has created a hiking trail and a 500-metre-long ski slope made from green mats with different levels of difficulty. An 85-metre-high climbing wall has been integrated into the highest steep face of the complex. Visitors are not only rewarded with a view over Copenhagen, but on the way, they also receive insights into the waste incineration plant's technical processes. On the one hand, BIG has succeeded in transforming what is effectively a site with negative associations into a positive experience: CopenHill has long since become a recreational destination for locals and a tourist attraction, while the green roof is a site of biodiversity. On the other hand, waste incineration is not inherently sustainable, even if the 440,000 tons of rubbish burned in the plant every year is converted into energy, supplying electricity and heat to 150,000 households. To run the facility at full capacity, the plant needs to import waste from Germany, Italy, Great Britain, Ireland, and the Netherlands. The building has received numerous awards, including the Energy Globe National Award 2022.

→ FIG. 62
→ FAZIT
→ FILTRATION SKYSCRAPER
→ HOT HEART

CORPOWER OCEAN

The Swedish company CorPower Ocean, founded in 2012, has developed a fibreglass buoy that captures wave energy and converts it into electricity. The buoy, which is around 18 metres tall with a diameter of nine metres, weighs 17 tons and is anchored to the seabed via a rod attached to a plate. When the buoy moves up and down during a sea swell, this sets the two interconnected pistons that are located inside in motion. Their movement is transmitted to gears, which in turn drive two generators. By this means, each buoy can generate up to 300 kilowatt-hours of electrical power. The buoy is equipped with two modes that enable optimal adjustment to the weather conditions: a tuned mode in which the buoy is completely attuned to the wave movements, and a detuned mode, which is activated when the waves are very high in order to protect the buoy. Similar to



16 CorPower Ocean's CorPack buoy is 18 metres tall.

offshore wind power plants, the buoys are designed to be deployed in groups.

→ MEYGEN TIDAL POWER
→ ORBITAL O2 2MW

COVESTRO SONNENWAGEN

Since 1987, every two years, Australia has hosted a World Solar Challenge in which teams from universities and companies compete in a race against each other in custom-made solar cars. A similar European Solar Challenge has been held in Belgium since 2010. In 2015, students from the technical universities of RWTH and FH Aachen founded the Team Sonnenwagen Aachen, which has since built four solar cars and successfully competed in races in Australia and Belgium. The essential parameters in the development of solar cars are aerodynamics, weight, and the efficiency of the solar cells employed. Built in 2019, the Covestro Sonnenwagen only weighs 164 kilograms. Its four wheels can be steered individually so that it can be optimally aligned, depending on the wind direction. Photovoltaic cells are arranged around the passenger cabin across an area of 2.64 square metres. These are composed of gallium arsenide and are especially efficient; however, they are also expensive and present various problems in manufacture due to the volatile arsenic, which is why, until now, they have been used primarily only in space technology, for example, satellites. The Covestro Sonnenwagen, which is also equipped with a lithium-ion battery as an energy storage source, has a top recorded speed of 144 kilometres per hour (km/h) and, with an average speed of 90 km/h, has a range of around 500 km. At the European Solar Challenge in 2021 and 2022, the Covestro Sonnenwagen took second place on both occasions. The research findings on the experimental solar vehicles will also flow into the domestic car industry in the future.

→ FIG. 66
→ APTERA
→ LIGHTYEAR

EAZ WIND

In the nineteenth century, windmills were a common feature of farms and homesteads in countries such as the USA, Greece, and Spain. At the time, they were used primarily to operate water pumps in rural areas. To provide today's farmers with an alternative form of sustainable energy generation, the Dutch company EAZ Wind has developed a windmill that can be installed on farms in a simple procedure. The company takes on the entire installation process, from the building permit and survey reports to connection to the grid. At 15 metres high, the windmills are relatively small, but – depending on the location and wind speed – they can deliver an output of 25,000–50,000 kilowatt-hours of power. Almost all the materials used originate from Europe. The rotor blades – which for conventional wind turbines are manufactured from composite materials and therefore cannot be recycled – are even made from wood from Dutch forests.

→ ICEWIND
→ O-WIND TURBINE

17 Team Sonnenwagen, Covestro Sonnenwagen, Australia, 2019

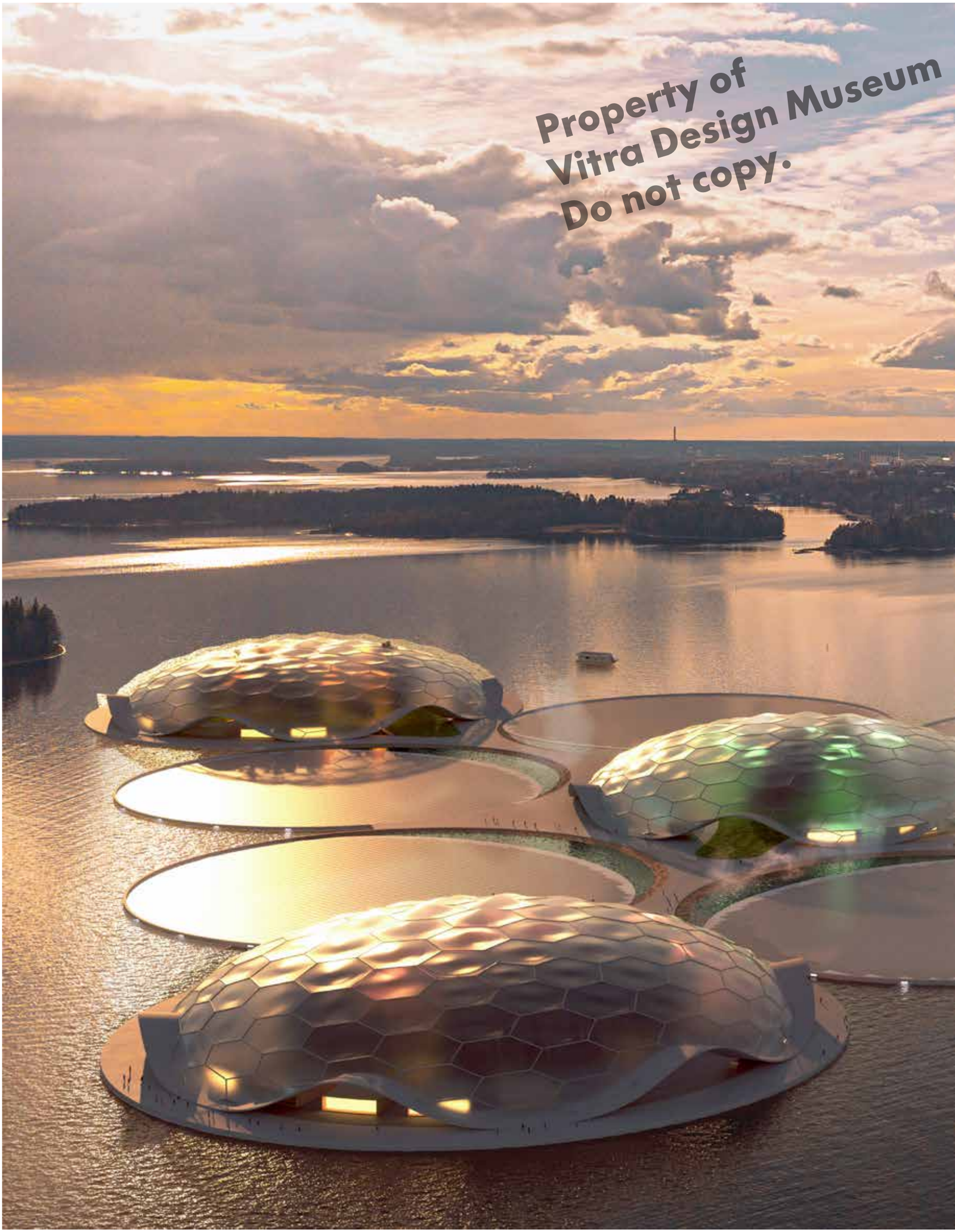
18 Sailing cargo ship EcoClipper500, 2015

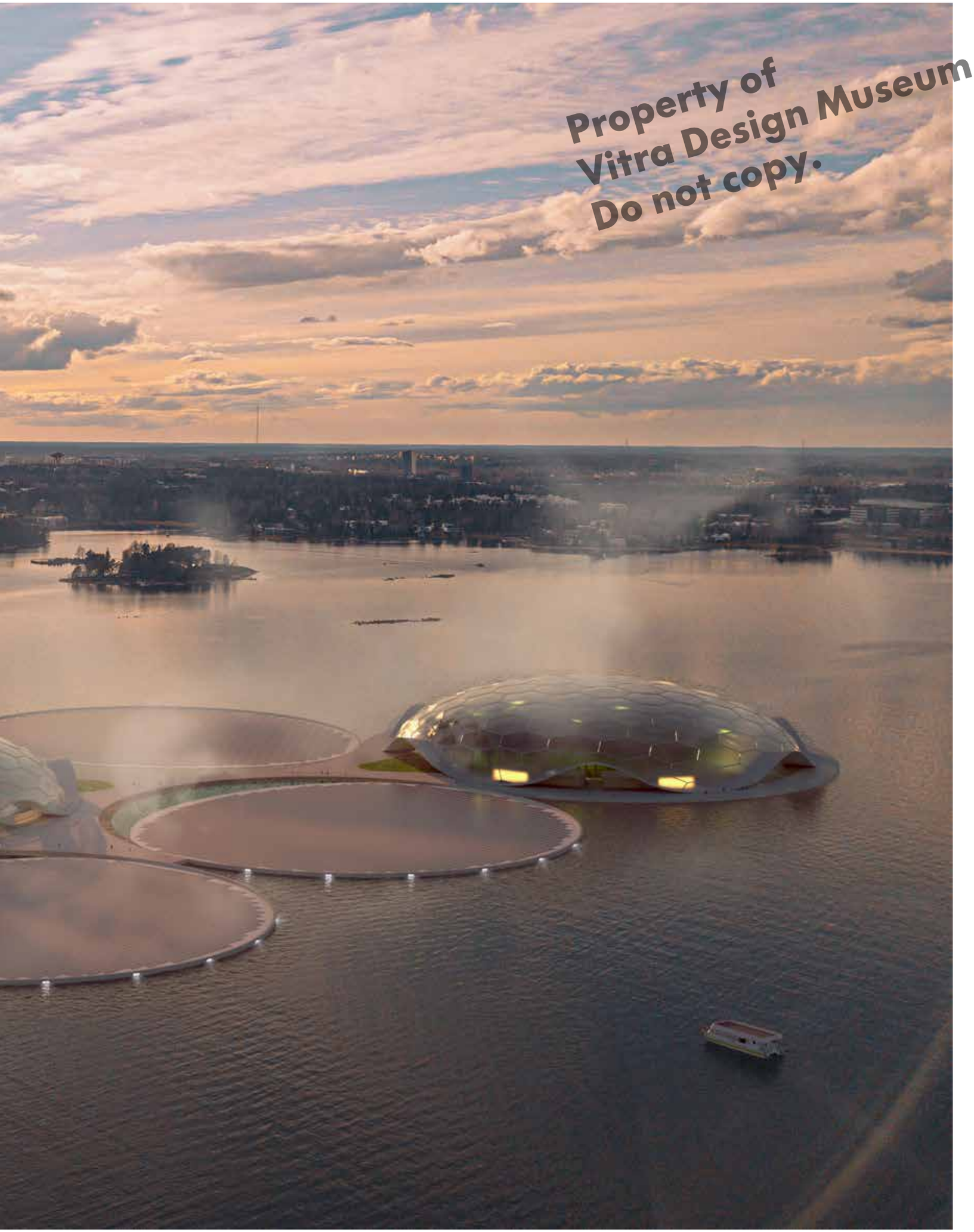
ECOCLIPPER500

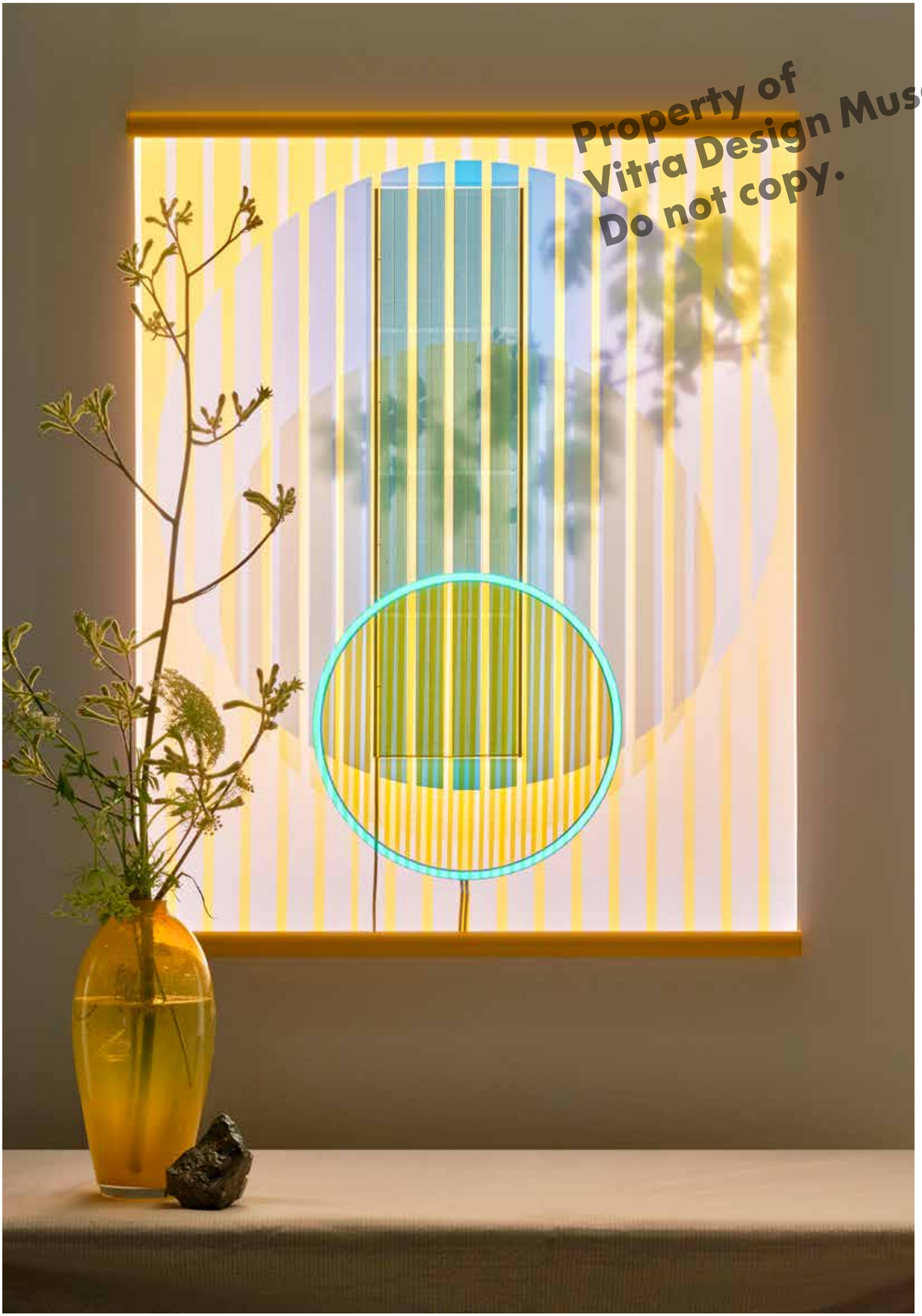
For thousands of years, sea routes have been used to transport goods. During the nineteenth and twentieth centuries, sailing ships were gradually replaced by coal- or steam-powered ships and then increasingly by ever larger freight and container ships with diesel engines. Today, 90 per cent of global trade is carried by sea; accordingly, shipping transport accounted for around 2.6 per cent of global climate-damaging CO_2 emissions in 2021. EcoClipper, a Netherlands-based initiative, was founded in 2018 to counter this development, with the aim of building a fleet of sailing freighters. The reintroduction of wind power for shipping would reduce the consumption of diesel fuel and the associated CO_2 emissions. Furthermore, the engineless, thus silent ships, do not put a strain on underwater ecosystems. EcoClipper plans to both convert existing sea freight transport as well as develop a new cargo sailing model. One such retrofitted ship is the *De Tukker*, which carried almost 50 tons of freight on its maiden voyage in 2023 and, en route from the Netherlands to Portugal, visited various other European ports. The team is currently working on financing the design for a new ship prototype, the *EcoClipper500*. This vessel will be fitted with a modern steel hull and the latest navigation equipment, have a payload of up to 500 tons, and even operate the Pacific and Atlantic ocean routes. The company is financed through crowdfunding and, as a cooperative, receives investments from its members. It is still uncertain whether the funds raised will be enough to support production of the new *EcoClipper500*.

→ TOWT


covestro
FH AACHEN
77







MOBILITY DESIGN GUIDE

In Germany in 2020, traffic was responsible for over 20 per cent of total energy consumption. On its own, switching from the internal combustion engine to the electric motor for privately owned vehicles will not adequately reduce the energy consumption and CO_2 emissions created by individual mobility to the necessary extent. Mobility design can contribute to increased public acceptance of walking, cycling, the use of public transport, and sharing offers, as well as the combined use of all these options. The digital Mobility Design Guide therefore aims to make public analogue and digital mobility services more visible and better connected, improve waiting situations for passengers, and increase their subjective and objective safety.

70 With the digital Mobility Design Guide (2023), mobility strategies and solutions can be explored at different "flight altitudes".

71 Acopian Solar Radio (1957) from the collection of the Museum of Solar Energy

The Mobility Design Guide presents numerous examples of opportunities to influence the experience of mobility, ranging from process to spatial design to analogue or digital information products. The digital guide has been developed as an updatable, interactively usable manual. It has a systematic approach and shows examples of various mobility focal points and different mobility hubs. Responsible parties in politics, urban planning, and transport planning, as well as architects and designers working in the field of mobility, are the intended audience. The Mobility Design Guide emerged from a LOEWE research project on the theme "Infrastructure – Design – Society" in an alliance between the University of Art and Design Offenbach, the Frankfurt University of Applied Sciences, the Technical University Darmstadt, and the Goethe University Frankfurt. The Hessen Ministry of Science and the Arts financed the project from 2018 to 2022.

→ ENERGY SHAPES THE CITY
→ ESSAY: STEFAN RAMMLER, PP. 128-34

MUSEUM OF SOLAR ENERGY

The Museum of Solar Energy (MOSE) is in the city of Duluth, Minnesota, USA. The museum's founder, Karl Wagner, is fascinated by the elegance of photovoltaic technology and has been collecting solar objects for 20 years. He began by collecting surplus solar cells and using them to build various solar-powered gadgets, forms of illumination, and models. Over time, he has amassed an extensive collection of various solar objects, dating from 1900 to the present. A visit to the exhibition *Mark Dion: Misadventures of a 21st-Century Naturalist* in 2017 at the Institute of Contemporary Art in Boston, Massachusetts, inspired Karl Wagner to found the Museum of Solar Energy and to use his collection to tell stories. In keeping with Charles Eames' motto, "We want to make the best for the most for the least", the museum is designed as a digital platform, enabling worldwide access to the collection. Since the website went online in 2019, 250 solar-powered objects have been inventoried, and hundreds of additional objects are in the process of being catalogued. The collection includes, among other things, the first modern solar cell, which was invented by Bell Laboratories in 1954; numerous solar radio models such as the Acopian Solar Radio (1957); toys; and educational construction kits such as the Bell Solar Energy Experiment (1962). With this construction kit, school

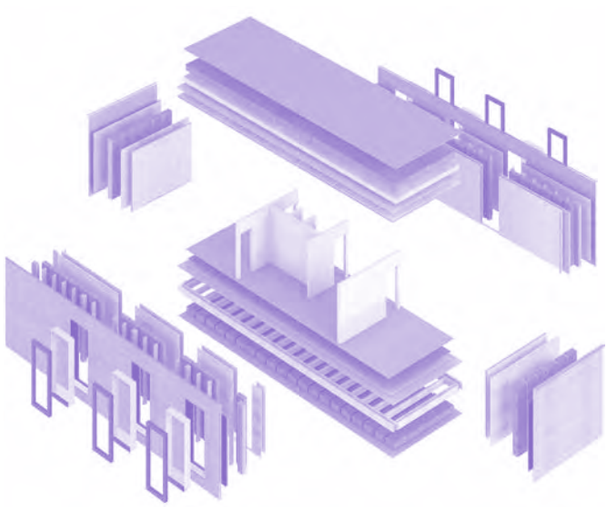
80 Plus Minus 25 °C, curtain printed with phase-change material (PCM), by Anna Koppmann and Esmée Willemsen, 2020

and releases heat. This is comparable to the way a conventional hand warmer or cold pack works, except that in this case, the change in the curtain's aggregate state is caused primarily by the intensity of the sunlight entering the window and the alternation of day and night. To achieve the temperature-regulating effect of the fabric, the students use a PCM powder mixed with dye and the silk-screen printing process on each side of the fabric. Since Koppmann and Willemsen's prototype curtain was very well received, the developers are now looking for opportunities to bring the product onto the market.

→ HARVEST/ENERGY

PLUSENERGIE-QUARTIER P18

The engineering and architecture firm, founded in Stuttgart in 1992 by Werner Sobek and now operating worldwide, has dedicated itself to sustainable building practices. A reduction in energy consumption, emissions, and waste is one of the company's stated goals. The Plusenergie-Quartier P18 in the district of Bad Cannstatt in Stuttgart, planned by Werner Sobek together with the company Aktiv-Haus, exemplifies this approach. It is the largest sustainable housing project realized in Germany using modular wooden construction. Built for employees of Klinikum Stuttgart (Clinical Centre Stuttgart), it consists of 330 apartments distributed between six buildings of four or five storeys. Thanks to the innovative and light timber frame construction, the buildings have 75 per cent less building mass compared to conventionally constructed buildings. The prefabricated wooden modules are serially produced in the factory and put together on site. This reduces the consumption of materials and the generation of waste during production and enables continuous quality control. The modules are prefabricated, complete with kitchens, lighting fixtures, electricity sockets, and so on, and, following delivery to the construction site via a heavy goods vehicle, are installed within 30 minutes. This enables the completion of one storey per day and one building per



81 Plusenergiequartier P18 district by Werner Sobek and Aktivhaus. Façade with balconies, 2021

82 View of Plusenergiequartier P18

83 Exploded view of a prefabricated residential unit in the Plusenergiequartier P18 district

week. During the first building phase, the quarter was built in the record time of just six months and handed over to the owner-builder, the Stuttgarter Wohnungs- und Städtebaugesellschaft (Stuttgart Housing and Urban Development Association, SWSG). In the event of demolition, the wooden modules can be completely dismantled and sorted according to the individual material types; 98 per cent of the materials can be recycled, and 82 per cent of them can be reused without additional processing. On average, the car-free Plusenergie-Quartier produces more energy from sustainable, regenerative sources than it consumes per year. This has been achieved through an efficient heating system based on brine water heat pumps, photovoltaic modules, and solar hybrid collectors. Additional heat pumps on the roofs of all the buildings provide heat recovery from the exhaust air and ensure minimal energy loss. All the roofs are fitted with PVT collectors to make use of solar energy in the form of both electricity and heat. Also, the south façades of most of the buildings are equipped with integrated PV modules to maximize energy capture per house. Battery storage units increase the quarter's self-sufficiency. In the end, it was even possible to dispense with connection to the clinic's existing district heat system, which was originally planned to cover peak loads in winter.

→ FIG. 145
→ POWERHOUSE BRATTØRKAIA

POWER SUITS

Power Suits is a collection of wearable energy generators designed by the British creative studio Isabel + Helen. With a total of seven both playful and poetic-looking models, the collection illustrates the energy made by the human body in motion. Light is generated by moving air. Founded in 2012, the London-based studio of Isabel Gibson and Helen Chesner creates elaborate, experimental installations and kinetic sculptures at the interface between art and design. The Power Suits were presented in September 2023 at the London Design Festival fashion show in the Exhibition Road Quarter courtyard of the Victoria and Albert Museum in London.

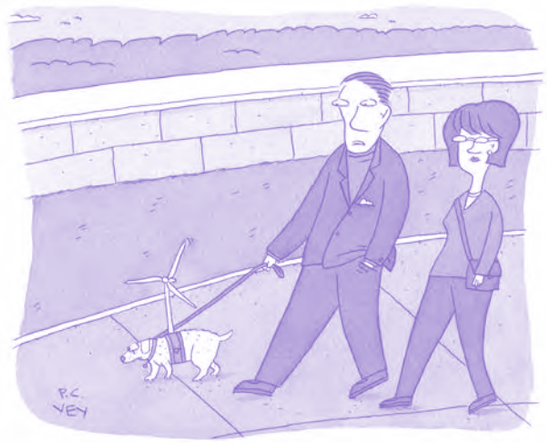
→ FIG. 132
→ HUMAN POWER PLANT
→ SOLAR DO-NOTHING MACHINE

POWERHOUSE BRATTØRKAIA

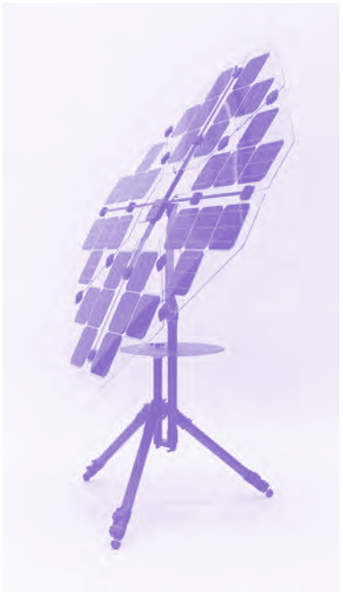
Over recent years, the Norwegian-American architectural firm Snøhetta has focused specifically on optimizing the energy balance of buildings in a series of construction projects. These "Powerhouses" include two office buildings – the Powerhouse Kjørbo (2012–14), developed from an existing building through energy optimization, and the newly built Powerhouse Telemark (2015–20) – along with a Montessori school, the Powerhouse Drøbak (2015–18). Completed in 2019, Powerhouse Brattørkaia at the port of Trondheim, Norway, is the world's northernmost energy-positive building. The office building generates more energy than will be consumed during its lifetime, including building, demolition, and the energy contained in the materials used. It has a total floor area of 18,200 square metres distributed across eight storeys, a mezzanine floor, and an underground carpark. The sloping, pentagonal roof and the upper part of the façade are fitted with around 2,870 square metres of solar cells, which, over the course of the year, generate around 460,000 kilowatt-hours of energy. The building produces twice as much energy on a daily average than

84 Power Suit by Isabel + Helen, 2023

85 Power Suit collection by Isabel + Helen, 2023



"Technically, he's supposed to generate more energy than he uses."



96 Solar Parasol by Ville Kokkonen, 2018

The electrification of rural regions also generally improves participation in education and opens up new economic opportunities for the local population. Thus, with their activities, Solar Mamas contribute to the development and sustainability of their communities. At the same time, the programme is designed to help participants achieve greater economic independence. In this way, it also teaches a diversity of soft skills such as bookkeeping and budget planning and uses teaching materials, such as colour coding, to enable illiterate participants to learn. According to Barefoot College, around 3,500 participants from 93 countries have completed the course so far and have introduced an electricity supply to an estimated 2.5 million people.

SOLAR PARASOL

The Solar Parasol was designed in 2018 as a mobile power supply for use in remote locations – as a charger for low-energy devices such as laptops or cameras, for example. The parasol is equipped with specially designed photovoltaic cells, held together with silicone and sandwiched between two 0.5-millimetre-thick plates of Gorilla Glass. The eight glass elements, each with four solar panels, are arranged so that the parasol can be compactly folded. In terms of its form and aesthetics, the parasol is based on technical equipment well known in the film and photographic industries. The power supply unit, with batteries, charge controller, and invertor, has an energy capacity of 12 volts × 40 amp-hours, which can be removed and used as a charging platform. The concept for the product was developed by the designer Ville Kokkonen and Exel Composites, a company specializing in fibre-reinforced composites. So far, the parasol only exists as a prototype.

→ AUREA

SOLAR PROTOCOL

Depending on the study, the Internet is responsible for between 1 and 5 per cent of global electricity consumption. Servers consume electricity and also need to be cooled 24 hours a day, 365 days a year. Against this background, the New York-based artists, designers, and researchers, Tega Brain, Alex Nathanson, and Benedetta Piantella, created the Solar Protocol in 2021: an artwork in the form of a network of servers powered by solar energy that hosts a website, which in turn is a platform for further artistic projects. The solar-powered servers, which are located in Dominica, Australia, Kenya, Canada, Chile, and India, are administered by volunteers. The website runs via whichever server is able to access the most solar energy at the time. This technology, instead of controlling nature, is a system that is controlled by nature; thus, in making us aware of our demand to be able to access the Internet at any time, anywhere, it highlights the consequences of this attitude. A further expansion of the server network is planned. The online exhibition *Sun Thinking* was launched on the Solar Protocol website in 2023.

→ LOW-TECH MAGAZINE

SOLAR SHIRT

In her designs, the Dutch fashion designer Pauline van Dongen thematizes the relationship between the human body and its surroundings, which is why she frequently integrates technology into her clothing. In 2015, van Dongen, in cooperation with the Holst Centre, a research and development centre in Eindhoven, designed the Solar Shirt – a garment fitted with 120 thin-film solar cells. The solar cells, arranged in a decorative

97 Solar Shirt by Pauline van Dongen, 2015

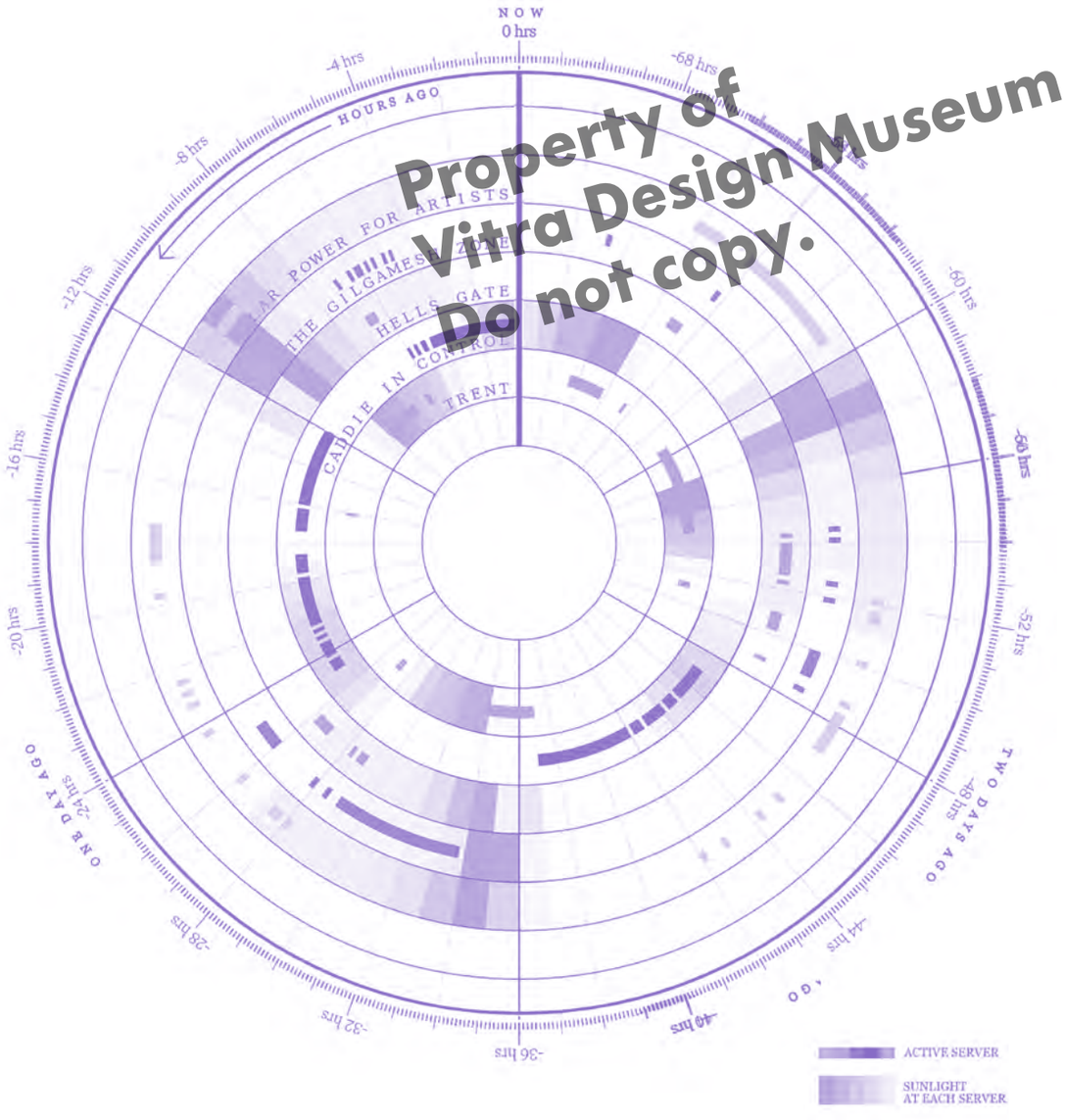
98 Solar Sinter, solar-powered 3D printer by Markus Kayser, 2011

graphic pattern, generate electricity as soon as the wearer moves into the sunlight. The power can then either be used directly to charge an electronic device, such as a smart phone, via a USB connection or it can be directed to a battery hidden in the pocket. In addition to these practical benefits, the Solar Shirt is also designed to make the user more aware of their surroundings, encouraging them to spend time outside, predominately in the sun.

→ FIG. 143
→ SUNTEX

SOLAR SINTER

With his 3D printer, Solar Sinter, developed in 2011, Markus Kayser has been investigating a production process that employs locally available and abundant resources. Kayser's printer, designed for use in the desert, takes advantage of the sun and sand. It works using a process much like laser sintering, where a laser melts a material in powder form – often plastic – from which a three-dimensional object is created, layer on layer, from bottom to top. The Solar Sinter process, however, involves using sand for printing by concentrating sunlight through a Fresnel lens to reach temperatures of between 1,400 and 1,600 degrees Celsius to melt the grains of sand. The shallow tray that holds the sand is kept moving during the printing process by a solar-powered electric motor. Each new layer of sand required in the process needs to be refilled manually, for which a sensor ensures that the whole construction automatically follows the course of the sun. Conceived initially as an experimental project, up until now Kayser has only deployed the printer in the Moroccan and Egyptian deserts to produce quite small glass objects, but ultimately, the aim is to provide impetus



99 Solar-powered server network: Solar Protocol by Tega Brain, Alex Nathanson, and Benedetta Piantella, 2021

to realize the project on a larger scale, for example, in small desert factories. In 2014, designers Qiu Song, Kang Pengfei, Bai Ying, Ren Nuoya, and Guo Shen presented their design for the so-called Sand Babel Skyscrapers, which they intend building from desert sand using Kayser's process.

→ THE IDEA OF A TREE

SOLAR TURTLE

In the rural regions and informal settlements of South Africa, electricity supply is often non-existent or, at best, unreliable. Consequently, the start-up Solar Turtle, founded in 2012, developed a franchise concept for mobile photovoltaic (PV) systems that can supply these locations with locally generated solar electricity. The main target group is women and young people, with the aim of providing them with the opportunity to use the systems to operate their own small businesses. Solar Turtle's central idea was a shipping container housing portable batteries, which can be charged by solar panels and then sold to end consumers. Initially, the concept envisaged storing the solar panels that would be charged during daylight hours in the container overnight to protect them from theft or damage. In addition, smaller mobile variants of the PV systems were designed and sold via sales carts that can be moved by hand or bicycle. The PV system produces electricity that can be used for cooking or cooling food, for example, and a mini system that fits in a rucksack enables smaller electronic devices to be charged and can be offered as a mobile service for a fee. The award-winning concept of the container has undergone a number of alterations over the years since it was founded, including the development of solar panels that are installed on the roof and retract automatically. However, in 2021, two of the CEOs, including one of the co-founders of Solar Turtle, withdrew from the start-up. The company, which has since been managed solely by the co-founder Lungelwa Tyali, still offers the container variant on its website but now appears to concentrate on the smaller mobile

Chiarito and Matteo Dal Lago involves the reuse of materials from an old fish-processing plant and thus establishes the historical connection to the cod fishery, an important source of income for this island community. Several proposals address the needs of the island's residents: "EVind" by Maxine Granzin and Paula Mühlena would serve as a charging station for electric vehicles; "Pneuma" by Jule Bols and Sophia Götz would supply heat and electricity all year round to a greenhouse set up at the base of the wind turbine; and "Windseed" by Yohanna Rieckhoff and Luis Rodriguez, envisages an algae processing factory that could be powered by wind energy. The eighth draft, Marcus Angerer and Sebastiano Gallizia's "Pyre", addresses the logistical challenges of remote locations: their 100-metre-high turbine could be built a long way away from roads and residential areas by producing the supporting structure on site using 3D printing.

→ FIG. 150
→ HONNEF WIND POWER PLANTS

ULTRA-THIN GLUCOSE FUEL CELLS

Up until now, medical implants, for example, pacemakers, have relied on batteries as a power source, which not only often make up 90 per cent of the total volume of the implant but also need replacing after a certain length of time. While searching for a smaller, alternative energy source, a research team from the Massachusetts Institute of Technology (MIT) and the Technische Universität München (TUM) came across glucose fuel cells. These consist of an anode and a cathode, as well as an electrolyte layer in between. The contact of the anode with the glucose initiates an electrochemical process that generates electricity. While glucose is available in the human body, these existing glucose fuel cells were not suitable for powering implants; for example, the plastic employed for the electrolyte layer would not have withstood the high temperature necessary for sterilization. The research team from MIT and TUM therefore used a ceramic electrolyte with the necessary characteristics. In 2022, the successful development of a glucose fuel cell that is only 400 nanometres thick and capable of producing 43 microwatts of electricity per square centimetre was announced. A single silicone chip can hold 150 of these cells. Work is currently underway to bring the mini fuel cell into widespread use for application in implants in the form of an ultra-thin film or coating.

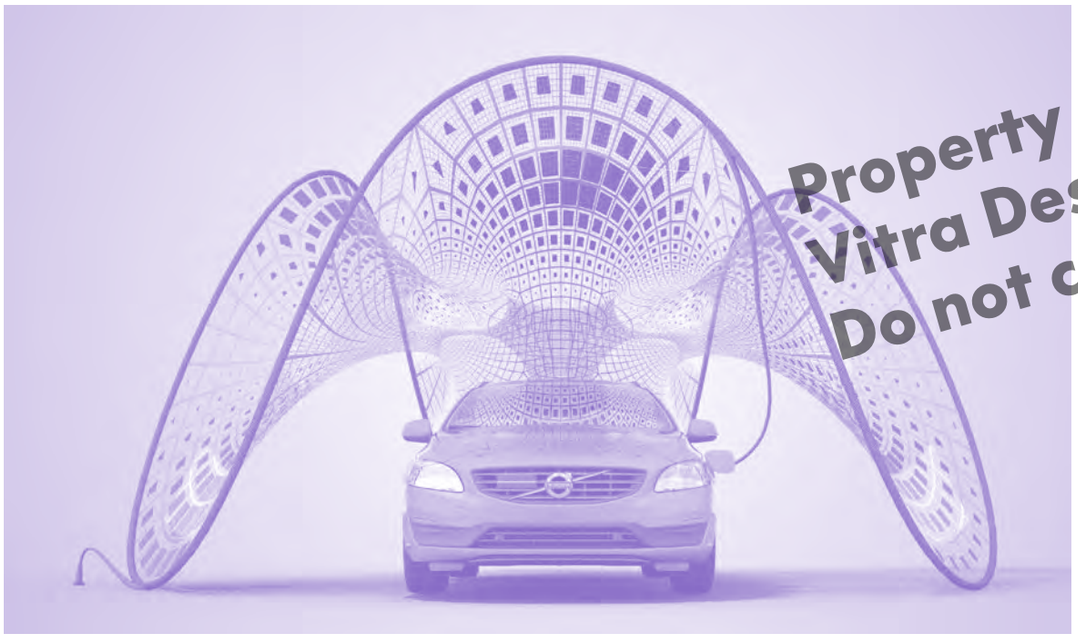
119 Ultra-thin glucose fuel cell developed by MIT, Cambridge, MA, and TU Munich, 2023

→ MICROBIAL ELECTRICITY-GENERATING BIOFILM

VOLVO PURE TENSION PAVILION

How could an electric car supply itself with energy, independent of any charging infrastructure and no matter

118 Wind turbine models by ECAL students for the community of Fogo Island, Canada, 2023



120 Pure Tension, mobile solar charging structure by Synthesis Design + Architecture for Volvo, 2013

where it was parked? With the Pure Tension design, architect Alvin Huang and his office Synthesis Design + Architecture provided a possible answer in 2013. The inspiration for the design came from a competition that the car manufacturer Volvo announced to mark the launch of its V60 model. Pure Tension is a mobile and dismountable pavilion that consists of a support structure made of CNC-bent aluminium tubes with plug-in connections into which a stretchable polyester mesh membrane is clamped. This membrane is equipped with 252 lightweight, flexible photovoltaic panels, which are arranged in such a way that they can capture solar radiation from different directions while also creating a dynamic graphic pattern. In line with state-of-the-art technology in 2013, the pavilion was able to recharge a completely discharged car in about 12 hours under optimal sunlight. It took two people another hour to set up and dismantle the pavilion. The pavilion weighs only 75 kilogrammes and, when disassembled, can be stored in two handy boxes that can be carried in the car.

→ APTERA
→ LEVANTE
→ LIGHTYEAR

WEAVING A HOME

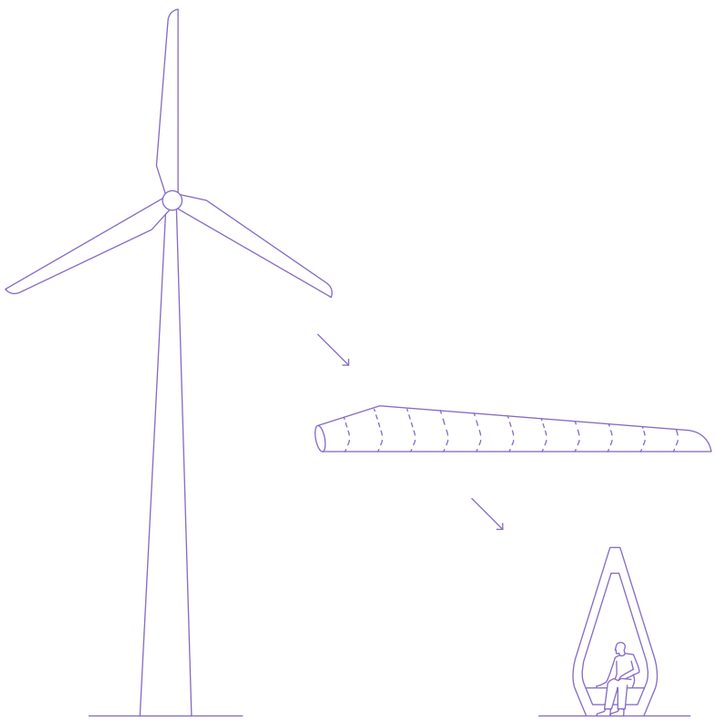
According to the UNHCR refugee agency, there were 108.4 million forcibly displaced people worldwide at the end of 2022. Along with their homes, the refugees not only lose protective accommodation but also the communities established in their native country. With her architectonic system Weaving a Home, which Abeer Seikaly began developing in 2013, the Jordanian-Palestinian architect and designer pursues the goal of providing shelter for refugees that, beyond fulfilling their basic needs of protection and retreat, can also become a new home. Seikaly's dome-shape tents consist of an outer and an inner shell, both of which are composed of a honeycomb framework of flexible tubes and a solar fabric. Thanks to the two-layered construction, openings for ventilation can be integrated into the shells. Seikaly took inspiration from the traditional tents used by Arabic-speaking nomadic peoples for the tent's honeycomb shape, which makes it simple to fold flat while dismantling. The shells of Weaving a Home are designed so that rainwater drains off, thus reducing the risk of water penetrating the tent's interior. On the inside of the tent, the honeycombs form pockets in which the inhabitants can store their belongings. The electricity generated by the solar fabric is fed to a battery so that the electricity supply is guaranteed around the clock. Solar energy also heats water that can be fed into the framework tubing. The warm water is then collected in a tank in the ceiling of the tent and is available for personal hygiene. Abeer Seikaly, who has now received a patent for Weaving a Home in Great Britain, is currently planning to produce full-scale prototypes of her system.

121 Rendering of a Weaving a Home tent by Abeer Seikaly at the Dead Sea, Jordan, 2020

→ FIG. 130
→ SOLAR E-TEXTILE
→ SUNTEX

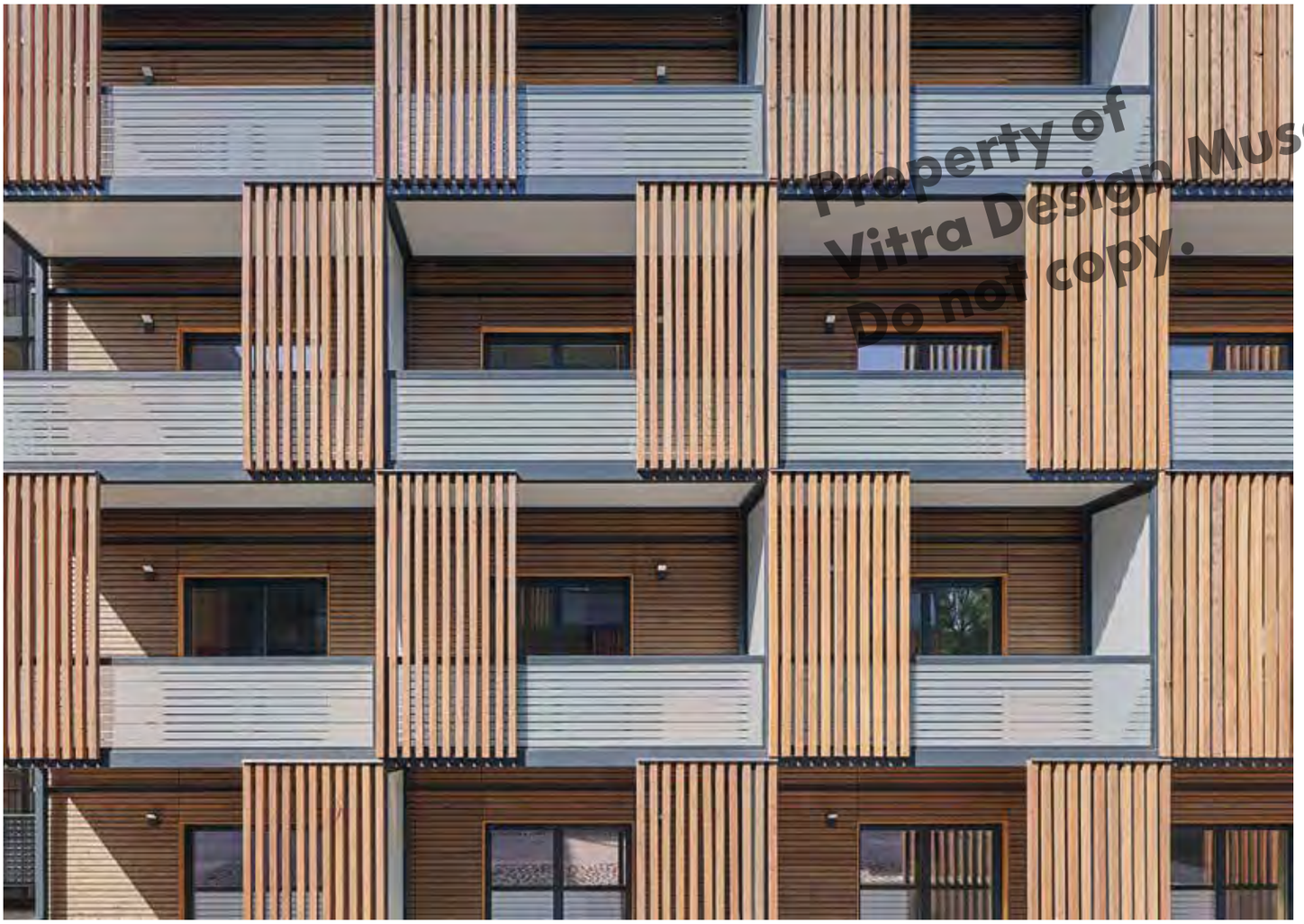
WINGS FOR LIVING

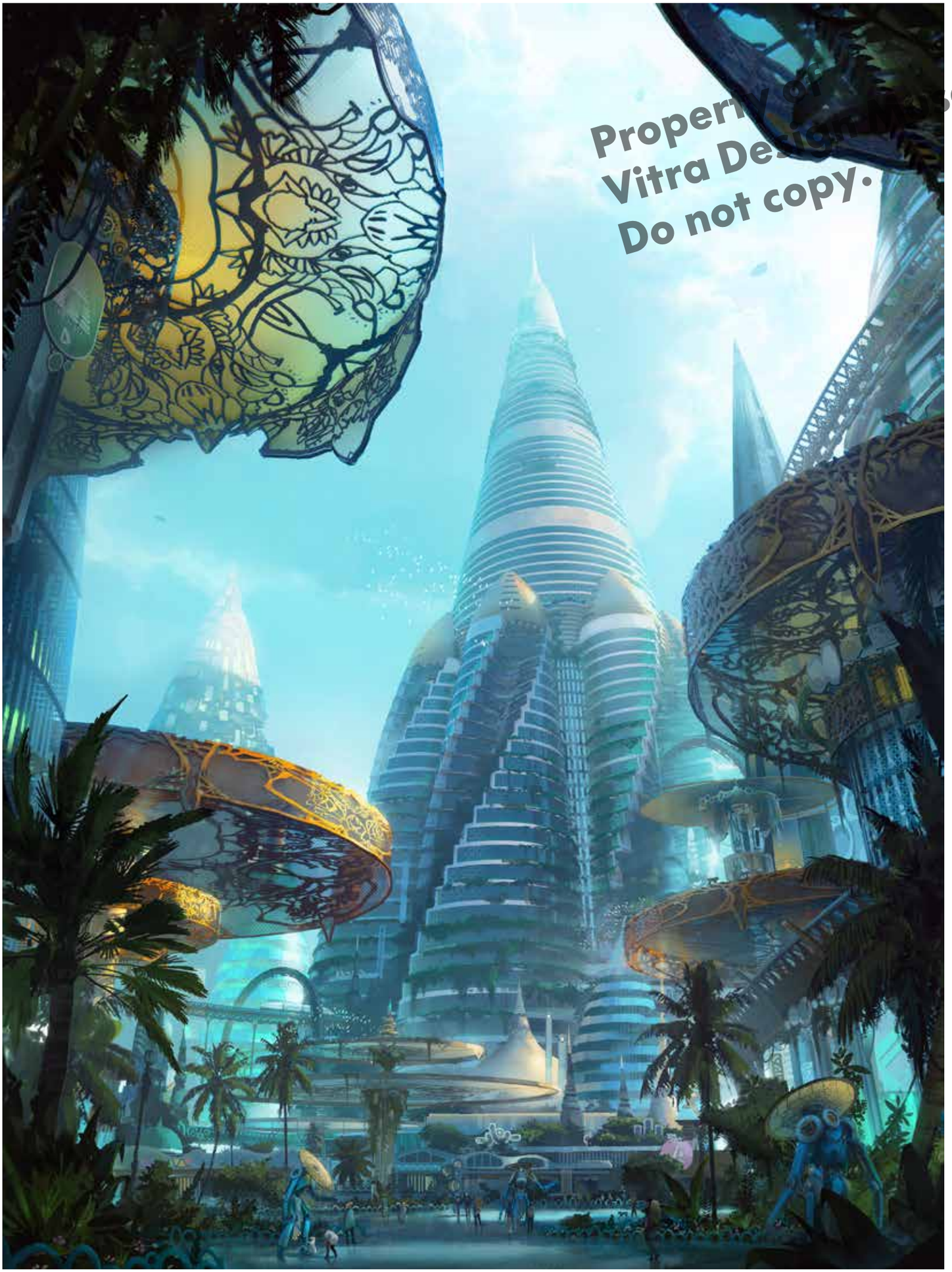
Wind turbines have a limited lifetime due, on the one hand, to stress on the masts, which for onshore wind farms are often made from pre-stressed concrete and subjected to continual vibrations from the wind. On the other hand, the longevity of the structures can come down to revised government financial programmes for renewables or new, larger, and more efficient facilities replacing the old ones, which explains why so many wind power plants are



122 Garden furniture made from recycled rotor blades: Wings for Living, 2023

131





READER

BACK TO THE FUTURE OF TECHNOLOGY

MÉDOR* DIDN'T WANT TO PAY FOR MY TRIP

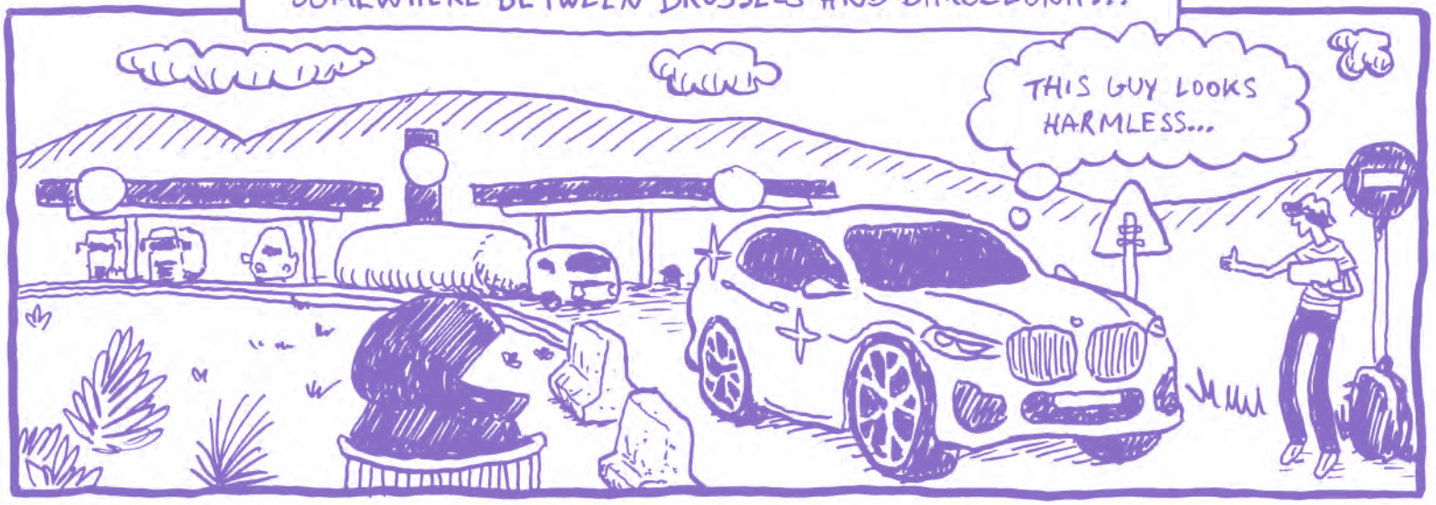
*THE BELGIAN MAGAZINE THAT ORIGINALLY PUBLISHED THIS PIECE

BY GUILLAUME LION WITH KRIS DE DECKER

THE DON QUIXOTE OF THE 21ST CENTURY

TRANSLATED FROM FRENCH BY MIRA MATTHEW

SOMEWHERE BETWEEN BRUSSELS AND BARCELONA...



DESIGN'S ENERGY TRANSITION

Rethinking Products, Reducing Energy, and Redesigning Behaviours

CATHARINE
ROSSI

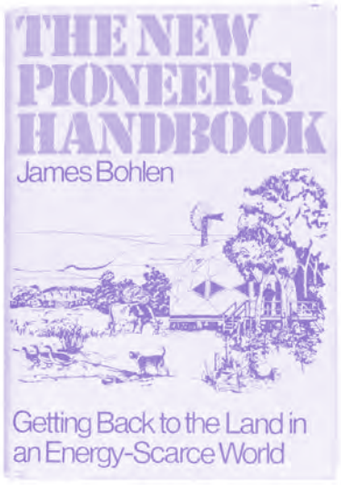
Design is inextricable from energy. The functions, forms, and materials of objects are dependent on the type, availability, and affordability of energy systems. Fossil fuels have enabled nearly every type of innovation in modern design, from the electrically powered factory buildings and machinery of mass production to the software and cloud computing of digital platforms. Just as Barnabas Calder has described in his energy-based history of modern architecture, so the history of modern design would look very different without oil, coal, and gas.[1]

Yet design's addiction to fossil fuels is toxic and must end. Since the 1970s, Earth has been in global overshoot; humanity has been using more resources than the planet can regenerate.[2] Fossil fuels are depleting, and natural resources are being eradicated.[3] The Plantationocene's extractivist ethos has caused huge devastation to wildlife, communities, and habitats. The ownership, impact, and availability of energy are furthermore unevenly distributed: in 2020, higher-income households in the United Kingdom consumed nearly five times more energy than the lowest-income households, and yet the latter have been hit harder by soaring energy prices as a higher proportion of their income is spent on energy bills.[4] For both environmental and social justice, design needs to lead the global transition to renewable energy; this essay focuses on a selection of design experiments seeking to do just that.

The twenty-first century has seen significant improvements in the energy efficiency of design products, as well as greater availability and affordability of low- and renewable energy technologies such as organic light-emitting diode (OLED) lighting, solar panels, and wind turbines. However, such advances are offset by an ever-greater global demand for energy, fuelled in part by the proliferation of electronic and digital devices. In 2020, the information and communications technology (ICT) sector, which includes devices such as computers, smart phones, and other Internet-connected devices, as well as the data centres and communication networks they require, accounted for an estimated 4–6 per cent of global electricity consumption, and this is expected to rise this decade.[5] The majority (up to 80 per cent) of this consumption occurs in the production phase.[6]

In 2017, the environmental campaigner Greenpeace examined global reliance on technologies of this kind. It recognized their benefits, including potentially enabling smarter, more efficient energy use. However, it found that "behind this innovative 21st-century technology lie supply chain and manufacturing processes still reliant on 19th-century sources of energy, dangerous mining practices, hazardous chemicals, and poorly designed products."[7] This is echoed by Kate Crawford and Vlader Joler's research in 2018; their *Anatomy of an AI* is a forensically detailed diagram of the "material resources, human labor, and data" required to produce and operate an Amazon Echo (launched in 2014).[8] A similar diagram could be drawn up for any other device. The question of design and energy is clearly inseparable from design's more general environmental, social, and ethical impacts.

→ FIG. 157



152 Cover of the book *The New Pioneer's Handbook* by James Bohlen, New York, 1975

Countercultural Design and Rising Energy Consciousness in the 1960s and 1970s

This knowledge of design's destructive appetite for energy isn't new. The 1960s and early 1970s saw a surge in environmental consciousness and an uptake in alternative visions for the future of energy among designers and the public, aided by a cluster of publications, such as Rachel Carson's *Silent Spring*, Victor Papanek's *Design for the Real World*, the Club of Rome's report *The Limits to Growth*, and E. F. Schumacher's *Small is Beautiful*.[9] The *Whole Earth Catalog (WEC)* and *Dome Cookbook* provided manuals for low-energy ways of living, such as the

1 Barnabas Calder, *Architecture: From Prehistory to Climate Emergency*. London: Penguin vintage classics, Pelican Books, 2021.
2 Earth Overshoot Day, Global Footprint Network, "Media Backgrounder: Earth Overshoot Day" (n. d.), www.overshootday.org/newsroom/media-backgrounder/, accessed 23 August 2023.
3 Jane Penty, *Product Design and Sustainability: Strategies, Tools and Practice*. Abingdon, Oxon, and New York: Routledge, 2019, p. 10.
4 Evan Boyle, "Rethinking Energy Studies: Equity, Energy and Ivan Illich (1926-2002)", *Energy Research & Social Science*, vol. 95 (January 2023), pp. 1-3, here p. 2; and UK Office for National Statistics, "Energy prices and their effect on households" (1 February 2022), www.ons.gov.uk/economy/inflationandpriceindices/articles/energypricesandtheireffectonhouseholds/2022-02-01, accessed 23 August 2023.
5 UK Parliament Post, "Energy Consumption of ICT" (1 September 2022), post.parliament.uk/research-briefings/post-pn-0677/#:~:text=Information%20and%20Communication%20Technology%20(ICT,use%20over%20the%20next%20decade, accessed 20 August 2023.
6 Gary Cook, Elizabeth Jardim (authors), and Nancy Bach (ed.), *Greenpeace Reports: Guide to Greener Electronics* (October 2017), p. 3, www.greenpeace.org/usa/reports/greener-electronics-2017, accessed 15 July 2023.
7 Ibid., p. 3.
8 Kate Crawford and Vladan Joler, *Anatomy of an AI System* (2018), www.anatomyof.ai, accessed 29 August 2023.
9 Rachel Carson, *Silent Spring*. Boston, MA: Houghton Mifflin Company, 1962; Victor Papanek, *Design for the Real World: Human Ecology and Social Change*. Chicago, IL: Academy Chicago Publishers, 1971; Donella H. Meadows, et al., *The Limits to Growth: A Report for The Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books, 1972; E. F. Schumacher, *Small is Beautiful: A study of Economics as if People Mattered*. London: Blond & Briggs Ltd., 1973.

A NEW ENGINE FOR SPACESHIP EARTH

The Future of Mobility in a Warming World

STEPHAN RAMMLER

We live in extremely transformative times. Interacting megatrends, like climate change, population growth, urbanization, digitalization, and multiple geopolitical upheavals within the limits of the given habitable space of the planet, are increasingly taking on the character of a chaotic transformation *by disaster*. As a design-led, political response to this growing crisis, the term transformation stands for a targeted, systemic, and collaborative socio-ecological reshaping of our society.

Against this background, what this essay points out are a few of the necessary considerations in approaching the question of which challenges are to be expected in shaping a socio-ecological transformation of mobility *by design*. The challenges are already enormous, because accompanying the need for transformation are additional mobilization and acceleration effects. These include the expected development of transportation in globalized late modernity that will be characterized by continued growth, continued acceleration, and a continued increase in the interdependence of global transportation infrastructures and transportation processes. This development can be conceptualized as *hypermobilization.*

Transformation Must Respond to Late Modernity's Hypermobilization

With the term "the Great Acceleration", Anthropocene researchers have subsumed the steep rise of all socio-economic, ecological, and geographical metrics from the middle to the end of the twentieth century. The pace and volatility of these changes have further increased in the past 20 years. The term "hypermobilization" refers to the further *quantitative, quasi-hypertrophic* increase in traffic on the one hand and to the *qualitative* changes that the massive *digital transformation* in mobility has entailed and will continue to entail on the other.

Such a dynamic of growth and acceleration in mobility, besides population growth, is due above all to the effects of affluence and individualization, long-term cultural globalization, the intensely cost-reducing and efficiency-increasing effects of technology,[1] the enormous dynamics of global migration, and the powerful global division of labour. Every attempt at political transformation will confront these dynamics, which leads us to the next finding.

The Mobility of the Future Must be Space-Saving, Post-Fossil, and Resilient

The fossil fuel-powered starter battery of *Spaceship Earth*[2] has reached the end of its useful life because of the many negative effects involved with combustion. The results for humanity are vulnerabilities, distribution conflicts, and demands for resilience and adaptation that will drastically escalate in the coming years.[3] The only alternative to the current situation is the rapid retrofitting of the spaceship's main engine – that is, a shift in our primary energy use to a renewable, in essence solar, basis. This places massive demands on the reshaping of transportation systems, which remain primarily fossil fuel-driven today.

Another decisive influence on the future of mobility is the "crowded crowd", that is, the concentration of the growing world population in ever-denser geographical spaces. Today, the great majority of humanity already lives in urban or urbanizing regions. This proportion will continue to grow.

The transformation of *energy culture* and how to deal with the increasing *shortage of space* are the two most important transitory aspects of the development of mobility in the twenty-first century. In addition, as already mentioned, digitalization will play a central role. With that in mind, three overarching and interacting design models for sustainable (urban) mobility can be distinguished:

Sun City should be regarded as a metaphorical model of the post-fossil fuel re-cultivation of the planet and of the *decarbonization of the energy flows of the social organism*, especially its flows of traffic and transport.

ElectriCity marks the paradigm shift implied in the *electrification of all social subsystems*, especially mobility. It is essentially regeneratively produced electrical power that will make it possible in the future to forgo fossil sources of energy and the emissions produced by their combustion.

1 Digital innovations in particular play a role because innovations in products, use, and systems contribute to increasing transportation efficiency as well as attracting users of both old and new services and modes of transport.

2 This metaphor became widely known through Richard Buckminster Fuller; see R. Buckminster Fuller, *Operating Manual for Spaceship Earth*. New York: E. P. Dutton & Co., 1968.

3 See Stephan Rammler et al., *Resiliente Mobilität. Ansätze für ein krisenfestes und soziales Verkehrssystem* ("Resilient Mobility: Approaches for a crisis-proof and social transport system"). Bonn: Friedrich-Ebert-Stiftung, 2021.

ENERGY AND EQUITY

From: Ivan Illich, *Toward a History of Needs*. New York: Pantheon Books, 1978.

IVAN ILLICH

The Energy Crisis

It has recently become fashionable to insist on an impending energy crisis. This euphemistic term conceals a contradiction and consecrates an illusion. It masks the contradiction implicit in the joint pursuit of equity and industrial growth. It safeguards the illusion that machine power can indefinitely take the place of manpower. To resolve this contradiction and dispel this illusion, it is urgent to clarify the reality that the language of crisis obscures: high quanta of energy degrade social relations just as inevitably as they destroy the physical milieu. The advocates of an energy crisis believe in and continue to propagate a peculiar vision of man. According to this notion, man is born into perpetual dependence on slaves, which he must painfully learn to master. If he does not employ prisoners, then he needs machines to do most of his work. According to this doctrine, the well-being of a society can be measured by the number of years its members have gone to school and by the number of energy slaves they have thereby learned to command. This belief is common to the conflicting economic ideologies now in vogue. It is threatened by the obvious inequity, harriedness, and impotence that appear everywhere once the voracious hordes of energy slaves outnumber people by a certain proportion. The energy crisis focuses concern on the scarcity of fodder for these slaves. I prefer to ask whether free men need them.

The energy policies adopted during the current decade will determine the range and character of social relationships a society will be able to enjoy by the year 2000. A low-energy policy allows for a wide choice of lifestyles and cultures. If, on the other hand, a society opts for high energy consumption, its social relations must be dictated by technocracy and will be equally degrading whether labelled capitalist or socialist.

At this moment, most societies – especially the poor ones – are still free to set their energy policies by any of three guidelines. Well-being can be identified with high amounts of per capita energy use, with high efficiency of energy transformation, or with the least possible use of mechanical energy by the most powerful members of society. The first approach would stress tight management of scarce and destructive fuels on behalf of industry, whereas the second would emphasize the retooling of industry in the interest of thermodynamic thrift. These first two attitudes necessarily imply huge public expenditures and increased social control; both rationalize the emergence of a computerized Leviathan, and both are at present widely discussed.

The possibility of a third option is barely noticed. While people have begun to accept ecological limits on maximum per capita energy use as a condition for physical survival, they do not yet think about the use of minimum feasible power as the foundation of any of various social orders that would be both modern and desirable. Yet only a ceiling on energy use can lead to social relations that are characterized by high levels of equity. The one option that is at present neglected is the only choice within the reach of all nations. It is also the only strategy by which a political process can be used to set limits on the power of even the most motorized bureaucrat. Participatory democracy postulates low-energy technology. Only participatory democracy creates the conditions for rational technology.

What is generally overlooked is that equity and energy can grow concurrently only to a point. Below a threshold of per capita wattage, motors improve the conditions for social progress. Above this threshold, energy grows at the expense of equity. Further energy affluence then means decreased distribution of control over that energy. The widespread belief that clean and abundant energy is the panacea for social ills is due to a political fallacy, according to which equity and energy consumption can be indefinitely correlated, at least under some ideal political conditions.

Labouring under this illusion, we tend to discount any social limit on the growth of energy consumption. But if ecologists are right to assert that non-metabolic power pollutes, it is in fact just as inevitable that, beyond a certain threshold, mechanical power corrupts. The threshold of social disintegration by high-energy quanta is independent from the threshold at which energy conversion produces physical destruction. Expressed in horsepower, it is undoubtedly lower. This is the fact that must be theoretically recognized before a political issue can be made of the per capita wattage to which a society will limit its members. Even if non-polluting power were feasible and abundant, the use of energy on a massive scale acts on society like a drug that is physically harmless but psychically enslaving. A community can choose between methadone and “cold turkey” – between maintaining its addiction to alien energy and kicking it in painful cramps – but no society can have a population that is hooked on progressively larger numbers of energy slaves and whose members are also autonomously active.

THE SOLAR WALL
of Sufficiency in the American Suburb in the 1950s

Technologies

DANIEL A. BARBER

In late 1960, the architect Aladar Olgyay designed a house with the solar engineer Mária Telkes, for her to live in. It was the last of a series of collaborations between the two Hungarian émigrés in the United States. Both of their careers focused on energy and climate as aspects of the design of the American suburb – each deeply committed, though in distinct ways, to promoting a new kind of architectural discussion in the immediate post-World War II period. Seemingly anachronistic, this new discussion reflected a powerful anxiety about resource scarcity, at play both during and after the war, when the contours of the post-war energy regime were not yet well established.

Today, anxieties over energy emerge from a different set of causes and effects, though they are still focused on considering ways of life without reliance on fossil fuels. The house that Olgyay and Telkes designed envisions a relatable life-world confluent with the promise that a new kind of design approach portends. It does so through a considered design intelligence, in relationship with new technologies – though not yet, it is important to note, with solar photovoltaics. Photovoltaic technology did not become applicable to residential architecture until the 1970s, and then just barely. Olgyay and Telkes proposed a novel solar heating system using phase-change chemical solutions to store and distribute the heat – a sort of technologically assisted passive approach aimed at a year-round capacity for consistent thermal comfort. It also entailed some engagement with the system itself, and a sensitive design that optimized passive radiation and solar exposure in a truly hybrid system – the sun optimizing technology, and the design of a house that is seen as both an energy system and a way of life.

The projects discussed below reflect, albeit implicitly, an emphasis on energy-demand management – that provision of heat in houses can be met through renewable technologies *only after* heating expectations are adjusted according to reduced perception of needs. It is a design project that considers how people can be conditioned to experience comfort across a range of thermal conditions. While such a house is likely less "comfortable" on objective terms, at stake in the 1950s and today are how design methods can articulate both ways of living and ways of building that require less energy in absolute terms: design can encourage us to live comfortably enough. This premise of "sufficiency", distinct from the "efficiency" trajectory of most of what we consider sustainable architecture, is thus of increasing importance as we adapt to and mitigate climate instability.[1]

Olgyay and his twin brother Victor were by this time well-known as climate design consultants to architects around the world. In their 1957 book *Solar Control and Shading Devices* they articulated a climate-sensitive design method that catalyzed interest in new analyses and approaches. Their experiments with the Thermoheliodon at the Princeton Architectural Laboratory refined these efforts as the decade progressed.[2] Influential in their time as teachers, researchers, and advocates, this influence has persisted not only in a generation of students that learnt from them, at Princeton and later at the University of Texas Austin, but also through the translation of their complex design approach into the performance software application Eco-tect, now embedded in a number of computational design software programmes. Much of how we approach and assess climate-sensitive design develops out of the Olgyays' mid-century methodological proposals.

Telkes, for her part, had an extensive role in discussions of solar energy in the period – one that is now beginning to be celebrated.[3] Having been active in the Massachusetts Institute of Technology (MIT)'s Solar Energy

1 Development of the sufficiency imperative is in the context of the recent Intergovernmental Panel on Climate Change (IPCC) report on the mitigation of climate change. See Minal Pathak et al., "Technical Summary", in Priyadarshi R. Shukla et al. (eds), *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press: 2022, p. 71. See also Yamina Saheb, "COP 26: Sufficiency Should be First", *Buildings and Cities* (10 October 2021), online: https://www.buildingsandcities.org/insights/commentaries/cop26-sufficiency.html, accessed 7 July 2023.

2 The Thermoheliodon was a device that could simulate model climatic conditions for architectural designs: a lamp on an arch for capturing the path of the sun, air through fans, an earth pit, and humidity from atomizing nozzles. See also: Aladar Olgyay and Victor Olgyay, *Solar Control and Shading Devices*. Princeton, NJ: Princeton University Press, 1957. Much of the material that would later appear in the brothers' best-known work (Victor Olgyay, *Design with Climate: Bioclimatic Approach to Architectural Regionalism*. Princeton, NJ: Princeton University Press, 2019 [1963]) was written and in circulation by 1960. The story of the Olgyays, including their connections to Telkes, are explored at length in Daniel A. Barber, *Modern Architecture and Climate: Design before Air Conditioning*. Princeton, NJ: Princeton University Press, 2020.

3 A biopic on Mária Telkes, *The Sun Queen*, was released in April 2023 on the US-based Public Broadcasting System (PBS). Telkes' prominent role is celebrated not only in Barber's volume *Modern Architecture and Climate* cited above, but also in Daniel A. Barber, *A House in the Sun: Modern Architecture and Solar Energy in the Cold War*. Oxford: Oxford University Press, 2016. This essay draws on Barber's research for that book.

ATOMS FOR PEACE Convincing the World of the Goodness of Atomic Energy

DONATELLA GERMANESE

Introduction

In 2007, the International Atomic Energy Agency (IAEA) celebrated its 50th anniversary with the publication of a coffee-table book full of photographs from countries the agency had been supporting or inspecting around the world since its establishment on 29 July 1957 in Vienna. The title of the book – *Atoms for Peace: A Pictorial History of the International Atomic Energy Agency* – was chosen with good reason, since the idea of such an agency was developed by US President Eisenhower in his "Atoms for Peace" speech on 8 December 1953 before the General Assembly of the United Nations (UN). In short, Eisenhower used the occasion to suggest limiting the number of nuclear weapons held by nations, while promoting peaceful uses for atomic energy and supporting the creation of an international institution under the aegis of the UN to supervise this process. "Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities", Eisenhower stated. "A special purpose would be to provide abundant electrical energy in the power-starved areas of the world. Thus, the contributing powers would be dedicating some of their strength to serve the needs rather than the fears of mankind."[1]

Eisenhower's words made clear that harnessing the atom was to include the energy sector as well as agriculture, industry, and health, shifting attention away from, but not excluding, military use. In fact, the world's atomic arsenal was increased for deterrence,[2] while nuclear power plants needed a longer process of development before they were able to produce *profitable* electricity for cities. Nevertheless, nuclear power immediately became a symbol of progress, sparking competition for primacy in power generation for civilian use, regardless of how few megawatts (MW) were generated. In June 1954, the Soviet Union realized its target to be the world's first nation to provide a small municipality (Obninsk) with electricity via a nuclear power plant (generating 5 MW). During the following ten years, other nation's nuclear power plants were connected to the power grid: in the UK in August 1956 (Calder Hall, 49 MW); the USA in December 1957 (Shippingport, 60 MW); France in April 1959 (Marcoule, 39 MW); Canada in June 1962 (Rolphton, 22 MW); Belgium in October 1962 (Mol, 10 MW); Italy in May 1963 (Latina, 153 MW); Japan in October 1963 (Tokai, 12 MW); and Sweden in May 1964 (Agesta, 10 MW).[3]

After Eisenhower's speech, during the negotiations that took place over the following years, which eventually resulted in the establishment of the IAEA, the US government was not idle. It promptly launched a special programme to positively influence worldwide public opinion on "Atoms for Peace" by means of the ad hoc production of educational films, books, radio broadcasts, and exhibitions.[4] For example, the film *A is for Atom* was produced by General Electric, distributed abroad by the United States Information Service (USIS), and screened at atomic-themed exhibitions. Walt Disney's *Our Friend the Atom* can be regarded as the sequel to this film, broadcast on television as part of the Disneyland series "Tomorrowland", and published as a book.[5] Walt Disney himself appears at the beginning of the film to promote atomic energy, presenting models of the first nuclear-powered submarine, *Nautilus*, which was manufactured by the engineering company General Dynamics. The film set showcases several of the celebrated General Dynamics posters on the "Atoms for Peace" topic designed by Erik Nitsche.[6]

→ FIG. 187

The United States Information Agency (USIA), which reported to the US Congress, provided a concise overview of activities carried out in 1954, situating the programme clearly in the context of the Cold War:

1 Dwight D. Eisenhower, "Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly" (8 December 1953), www.iaea.org/about/history/atoms-for-peace-speech, accessed 14 June 2023. For a critical appraisal of the IAEA's history, see Angela N. H. Creager and Maria Rentetzi, "Sharing the 'Safe' Atom? The International Atomic Energy Agency and Nuclear Regulation through Standardisation", in Bernadette Bensaude-Vincent et al. (eds), *Living in a Nuclear World: From Fukushima to Hiroshima*. London and New York: Routledge, 2022, pp. 111-31.

2 See Paul Erickson et al., *How Reason Almost Lost Its Mind: The Strange Career of Cold War Rationality*. Chicago, IL: University of Chicago Press, 2013, p. 85; John Krige, "Atoms for Peace, Scientific Internationalism, and Scientific Intelligence", *Osiris*, vol. 21, no. 1 (2006), pp. 161-81.

3 These figures have been taken from the "IAEA Country Nuclear Power Profiles", which provides historical information on nuclear power plants in 38 IAEA member states; see https://cnpp.iaea.org/pages/index.htm accessed 14 June 2023.

4 For the forerunners of campaigns like these at a national level in the late 1940s, see Paul Boyer, *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age*. Chapel Hill, NC, and London: University of North Carolina Press, 1985, pp. 291-302.

5 See Ina Heumann and Julia B. Köhne, "Imagination einer Freundschaft – Disneys *Our Friend the Atom*: Bomben, Geister und Atome im Jahr 1957", *Zeitgeschichte*, vol. 35, no. 6 (2008), pp. 372-95; and Frank Schumacher, "The Symbolic Confrontation: Visual Power and American Opinion Management in West-Germany, 1949-1955", *Cahiers Charles V*, no. 28 (June 2000), pp. 125-48, here p. 136.

6 Jacob Darwin Hamblin, *The Wretched Atom: America's Global Gamble with Peaceful Nuclear Technology*. Oxford: Oxford University Press, 2021, pp. 67-70. See also Elizabeth Walker Mechling and Jay Mechling, "The Atom According to Disney", *Quarterly Journal of Speech*, vol. 81, no. 4 (1995), pp. 436-53.

"The Agency had in worldwide distribution during the last half of 1954 a number of 'peaceful uses' films. Among them were *A is for Atom, The Atom in Industry, The Atom and Biological Science, The Atom and Agriculture* and *The Atom and the Doctor*. US Information Service (USIS) centers abroad distributed significant books and documents on peaceful atomic uses. Through the *Wireless File* and *Voice of America* broadcasts, the world received a constant flow of news stories and commentaries on every stage of the developing atomic story. The success of this intensive information programme is best demonstrated by one dramatic fact: The Russians have recently imitated it."[7]

The United States saw the necessity of a long-term diplomatic strategy. A key event such as the first International Conference on the Peaceful Uses of Atomic Energy, held in Geneva in 1955 with sponsorship from the United Nations, was preceded and followed by a multitude of US exhibitions – most of them touring the world to achieve maximum dissemination of the message.[8]

Peaceful Uses of Atomic Energy Explained to the People

In 1954, the USIA initiated *Atoms for Peace* exhibitions in Rome, West Berlin, and São Paulo. The programme got off to a brilliant start in Rome on the evening of 15 June in a crowded Piazza del Popolo, with government representatives and ambassadors cheering on the visitors. The exhibition venue for *Mostra atomica* was composed of five trailers parked in the piazza, forming a rectangle near the monumental marble Fountain of Neptune. The trailers were an unusual venue for exhibitions, especially in Italy, where museums abound, and their arrangement was rather reminiscent of a weekly market. However, the architects Peter G. Harnden and Lanfranco Bombelli Tiravanti, who authored the *Atoms for Peace* exhibition with their team of architects and designers, had already successfully used trailers to host Marshall Plan exhibitions and popularize the North Atlantic Treaty Organization (NATO) in the early 1950s.[9] Overall, the exhibition design was an inexpensive solution; the expandable metal trailers were ideal for touring exhibitions and appropriate for staging visions of the future. Reactions to the exhibition about the "atomic age" confirmed this impression.

→ FIG. 181

→ FIG. 182

An assortment of equipment for the new atomic era was on display: visitors could see actual items and instruments related to the atomic industry, including a dummy wearing a rubber suit for workers' protection in radioactive areas; Geiger counters; portable detectors of radioactive ore for use in prospecting; lead cans and an assortment of different size containers for the shipment of radioisotopes; remote handling tongs for working with radioactive materials; and photographs portraying everyday scenes of work in the nuclear industry. Adding a playful and fun twist, there was an interactive device in the form of a table-mounted Van de Graaff generator that could make the hair of curious visitors stand on end. An entire trailer was dedicated to the subject of medicine. In a small treatment room set up in one corner, a dummy lay on a hospital bed, its body covered by a white sheet. An attendant wearing a white coat would pass a rod connected to a Geiger counter over the dummy's body to detect its hidden radioactive buttons. The purpose of demonstrations such as these was to give visitors a glimpse into the new diagnostic methods based on nuclear medicine.

→ FIG. 184

→ FIG. 183

All in all, the objects on display – short explanatory texts, photography and diagrams of different sizes, short films, as well as large wall displays of single words or symbols – introduced people to the new, manifold domain of applied nuclear science.

The Cold War and the Exhibition Atoms for Peace

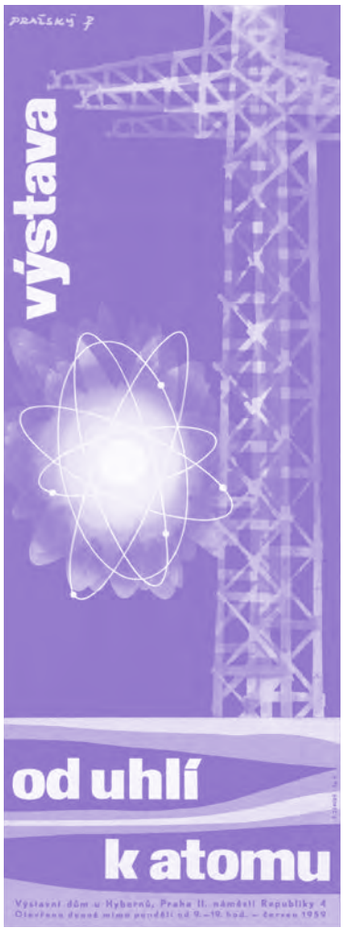
A couple of weeks after the *Atoms for Peace* exhibition opened in Rome, Clare Boothe Luce, the US Ambassador to Italy, expressed her opinion in a confidential conversation with the director of the US Information Agency, Theodore Streibert, about the countries that were eligible for support in atomic matters. A memorandum recorded that:

"The Ambassador said that she felt that [reactor] plants should be promised for countries actively anti-communistic as this would tend to decrease local enthusiasm for Communism. She pointed out the Soviets had admitted their recognition of the propaganda potential provided by peaceful use of atomic energy when they shortly after the Rome exhibit announced the opening of

7 United States Information Agency (USIA), *3rd Review of Operations: July-December 1954*. Washington, DC: U.S. Government Printing Office, 1955, pp. 2-3.

8 The list of countries visited from 1954 to 1958 according to the USIA's *3rd Review of Operations* comprised: Argentina, Belgium, Brazil, Chile, Colombia, Denmark, Dominican Republic, Egypt, Germany, Greece, Iceland, India, Iraq, Italy, Japan, Lebanon, Mexico, Norway, Pakistan, Panama, Peru, Switzerland, Syria, Turkey, United Kingdom, Uruguay, Venezuela, Yugoslavia.

9 See section below, "Designing and Organizing Mobile Atomic Exhibitions".



179 Adolf Pražsky, poster for the exhibition *Od uhlí k atomu* (From Coal to Atom), Prague, 1959.

→ FIG. 186

a reactor pile for industrial use in the Soviet Union. The Ambassador said that we must be on the alert against the Soviets offering piles to power-hungry countries and attempt to counter any such moves."[10]

Referring to the Russian nuclear power plant in Obninsk, which was connected to the electricity grid on 27 June 1954, Luce's remarks illustrate what aspects of Cold War diplomacy were potentially at stake in developing civilian uses for atomic energy and sharing the related technology beyond matters of nuclear weapons. On both sides of the Iron Curtain, the hegemonic powers promised technical assistance and the transfer of know-how – albeit with safeguards – to allied or "brother" countries such as Italy and the Czech Republic, respectively. Furthermore, the United States and the Soviet Union started directly competing for cooperation with the non-aligned states. Since the Soviet Union was spurring the US on to compete, Nikita Khrushchev declared that the "aid which the capitalist countries are planning to provide to the states which have recently won their independence should also be viewed as a kind of Soviet aid to those countries".[11] But as the case of India demonstrates, the non-aligned countries could be quite adept at juggling the diplomatic fronts.[12] This happened even in the arena of atomic exhibitions. In 1955, a US *Atoms for Peace* exhibition toured for months throughout India, drawing a total of 1,700,000 visitors, according to the organizers' report.[13] A photograph of the New Delhi stop shows India's Prime Minister Nehru and his daughter, Mrs. Indira Gandhi, visiting the USIA *Atoms for Peace* exhibit in New Delhi, accompanied by Dr. K. S. Krishnan of India's Atomic Energy Commission.[14] At the same time, Nehru and Homi J. Bhabha, head of the Atomic Energy Commission of India, had intensified diplomatic relations with Moscow, which hastily responded by sending its *Atoms for Peace* exhibition to New Delhi in October 1955 instead of showing it in Prague as scheduled.[15] A further Cold War race of atomic exhibitions – almost in a chain reaction – took place in occupied Berlin. Exhibitions on the peaceful atom opened in West Berlin from September to November 1954, in February to March 1955 in East Berlin, and in West Berlin for the second time in May 1955.[16] The US government paid close attention to the first West Berlin atomic show involving the United States Atomic Energy Commission (AEC), a collaboration that resulted in the display of a larger number of working models.[17] This time, the exhibition was hosted on a site used for trade fairs rather than on wheels, but its structure and basic ideas were those of *Mostra atomica*, the first iteration of the US travelling atomic exhibition that had started out in Rome on 15 June 1954.

Designing and Organizing Mobile Atomic Exhibitions

The Italian architecture and design magazine *Domus* featured the *Atoms for Peace* exhibition with a spectacular cover shot of the nocturnal opening of *Mostra atomica* in Rome.[18] The article featured on the cover contained eye-catching photographs that pleased the magazine's large readership, although its detailed technical information was targeted at trade fair constructors. The feature specified that the trailers had the chassis lowered, that four double-extending telescopic beams were mounted on them, and that the sides of the vehicles were secured at the beams' ends. Within two minutes, by operating an electrical device, the sides of the trailer – guided by the telescopic beams – would move outwards and widen the interior space to a size of 6.5 × 7.8 metres. The article revealed that the Presentations Branch of USIS had designed the trailers for this very purpose.[19]

10 National Archives and Records Administration (NARA), Record Group 59 (Dept. of State Central Files), Entry A1-205-KA (Cultural Affairs: E. Europe 1950-54), Box 2467, Document 511.65/7-954 of 9 July 1954, declassified.

11 Nikita S. Khrushchev, "Speech to the Presidium of the Communist Party of the Soviet Union, December 29, 1955", in Pavel A. Satiukov (ed.), *Missiia druzhby: prebyvanie N. A. Bulganina i N. S. Khrushcheva v Indii, Birme, Afganistane*. Moscow: Pravda, 1956, p. 353, quoted from David C. Engerman, *The Price of Aid: The Economic Cold War in India*. Cambridge, MA: Harvard University Press, 2018, p. 125.

12 See Jayita Sarkar, *Ploughshares and Swords: India's Nuclear Program in the Global Cold War*. Ithaca, NY, and London: Cornell University Press, 2022; and Engerman, *The Price of Aid*. For Mexico's position, see Gisela Mateos and Edna Suárez-Díaz, "'We are not a rich country to waste our resources on expensive toys': Mexico's version of *Atoms for Peace*", *History and Technology*, vol. 31, no. 3 (2015), pp. 243-58.

13 USIA, *5th Review of Operations: July 1-December 31, 1955*. Washington, DC: U.S. Government Printing Office, 1956, p. 7.

14 USIA, *4th Review of Operations: January 1-June 30, 1955*. Washington, DC: U.S. Government Printing Office, 1955, p. 3.

15 Michaela Šmidrkalová, "Celebrating the Czechoslovak Atom: From 'Atoms for Peace' to Expo 58", *Annals of Science*, vol. 80, no. 1 (January 2023), pp. 38-61.

16 See Schumacher, "The Symbolic Confrontation", pp. 134-38.

17 Ibid., p. 135, f. n. 20.

18 *Domus*, no. 298 cover; see also the article by Peter G. Harnden et al., "Mostra atomica", *Domus*, no. 298 (September 1954), pp. 64-66. For a detailed study of the atomic exhibition's tour of Italy, see Donatella Germanese, "The Ingredients of a Successful Atomic Exhibition in Cold War Italy", *Annals of Science*, vol. 80, no. 1 (January 2023), pp. 10-37.

19 *Domus*, no. 298 (September 1954), p. 64.

187 Erik Nitsche, *Atoms for Peace* poster for General Dynamics, 1955.
188 Clauss Peter Gross, poster for the US Information Service *Atom* exhibit, Cologne, 1955.
189 Exhibition poster for *Atom für den Frieden* (Atom for Peace), Stuttgart, 1955.
190 Chuard, poster for the second United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1958.

191 Nikolay Silaev, poster *Atom v mirnych celjach!* (Atom for Peaceful Use!), 1960.

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Curatorial Assistance: Emma-Louise Arcade
Project Management: Carolina Madde
Exhibition Design: EMYL, Basel
Graphics: Helen Stelthove
Image Rights: Emma-Louise Arcade
Technical Director: Stefani Fricker
Exhibition Development: René Herzogenrath, Judith Brugger, Erika Müller
Senior Art Technicians: Niels Tofahrn, Manuel Köchli
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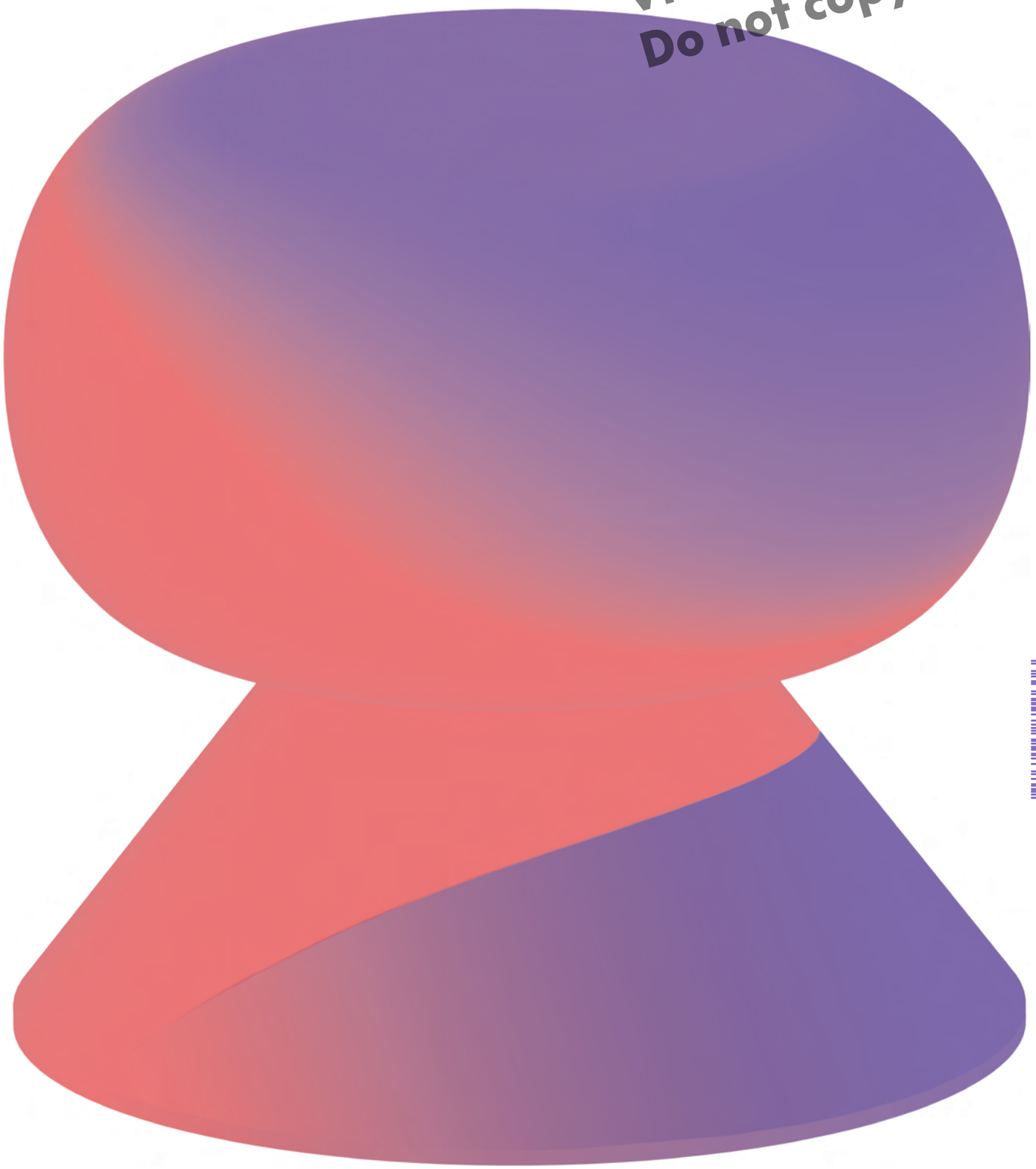

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Accompanying essays place the current projects in a wider context and provide insights into twentieth-century energy and design history. With contributions by Daniel Barber, Donatella Germanese, Carola Hein, Ivan Illich, Guillaume Lion, Stefan Rammler, and Catharine Rossi.