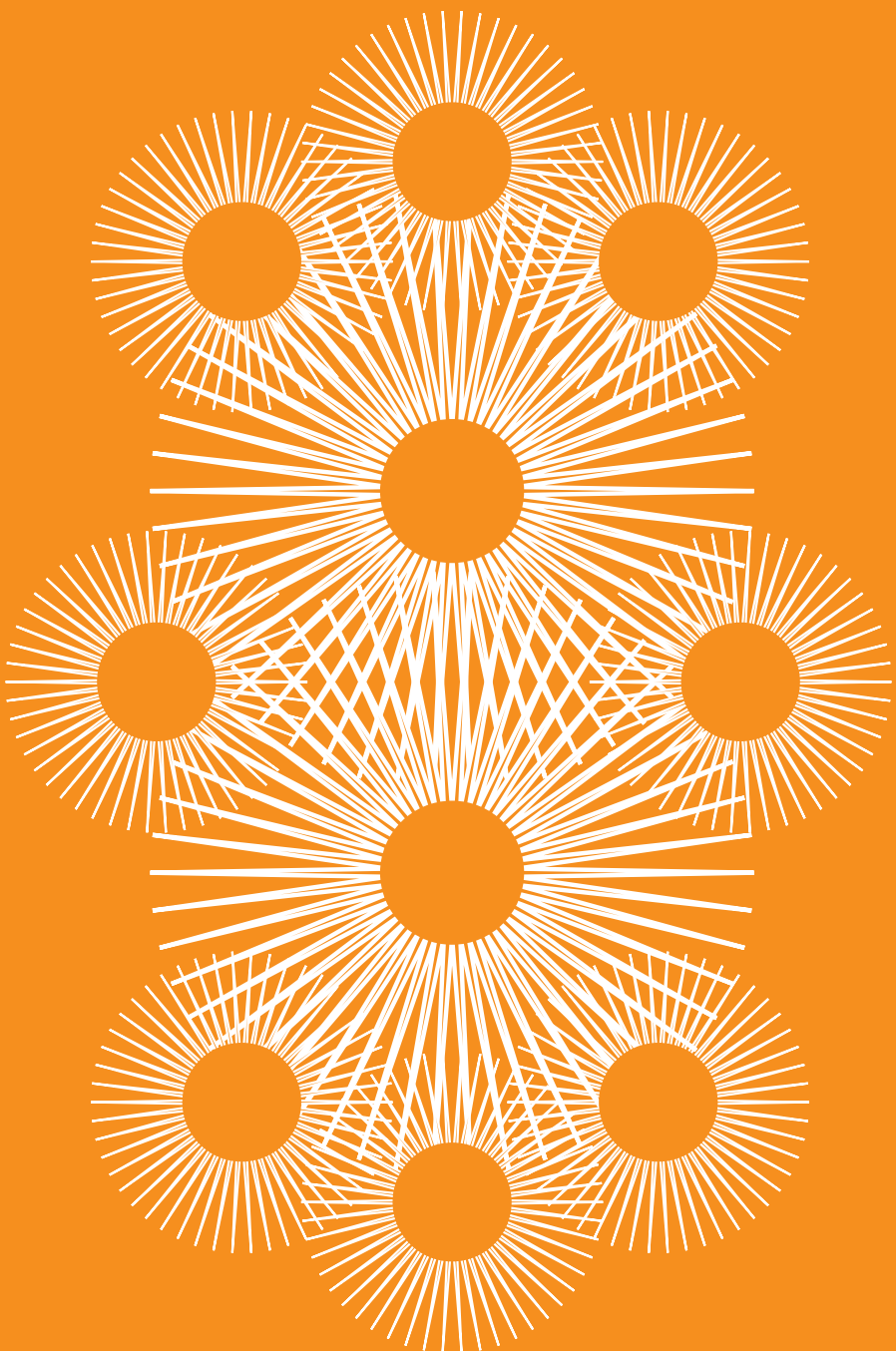
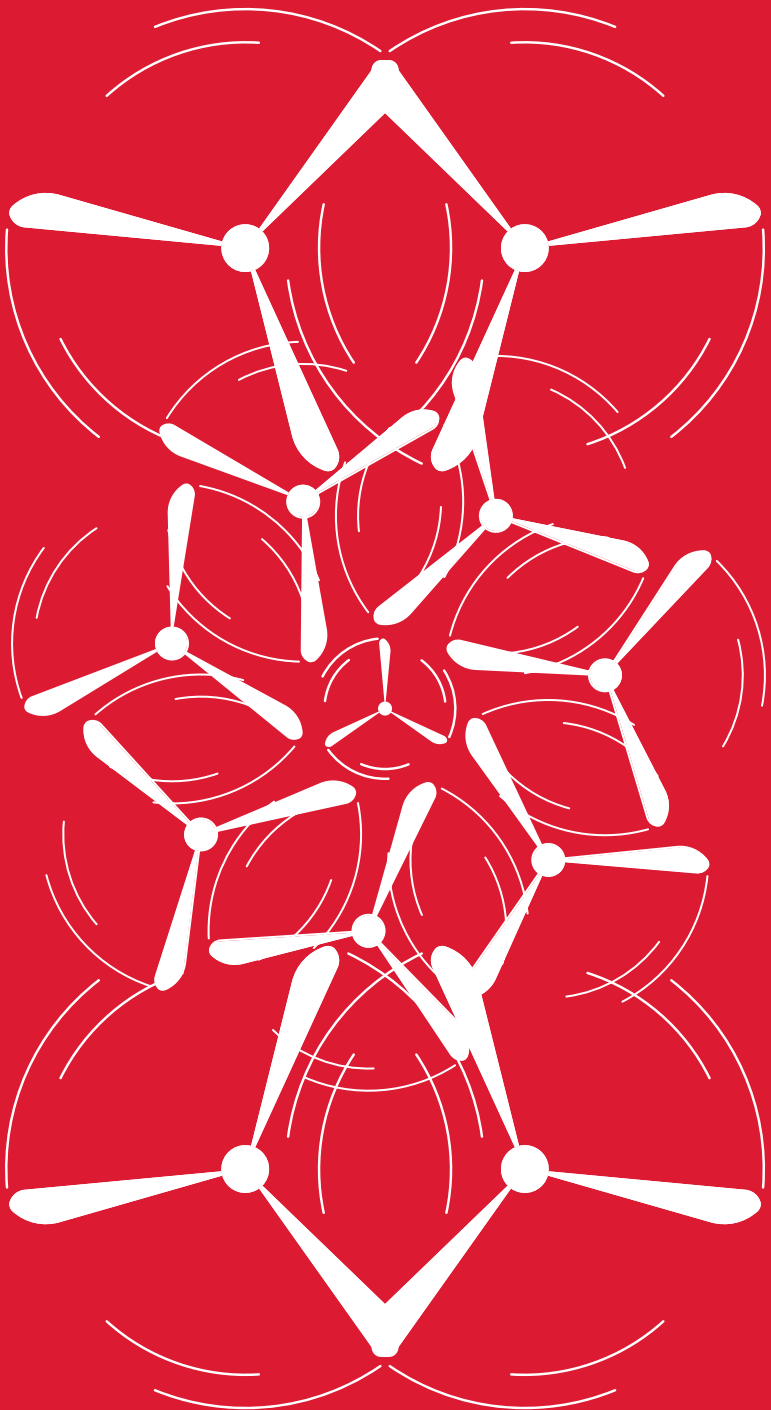


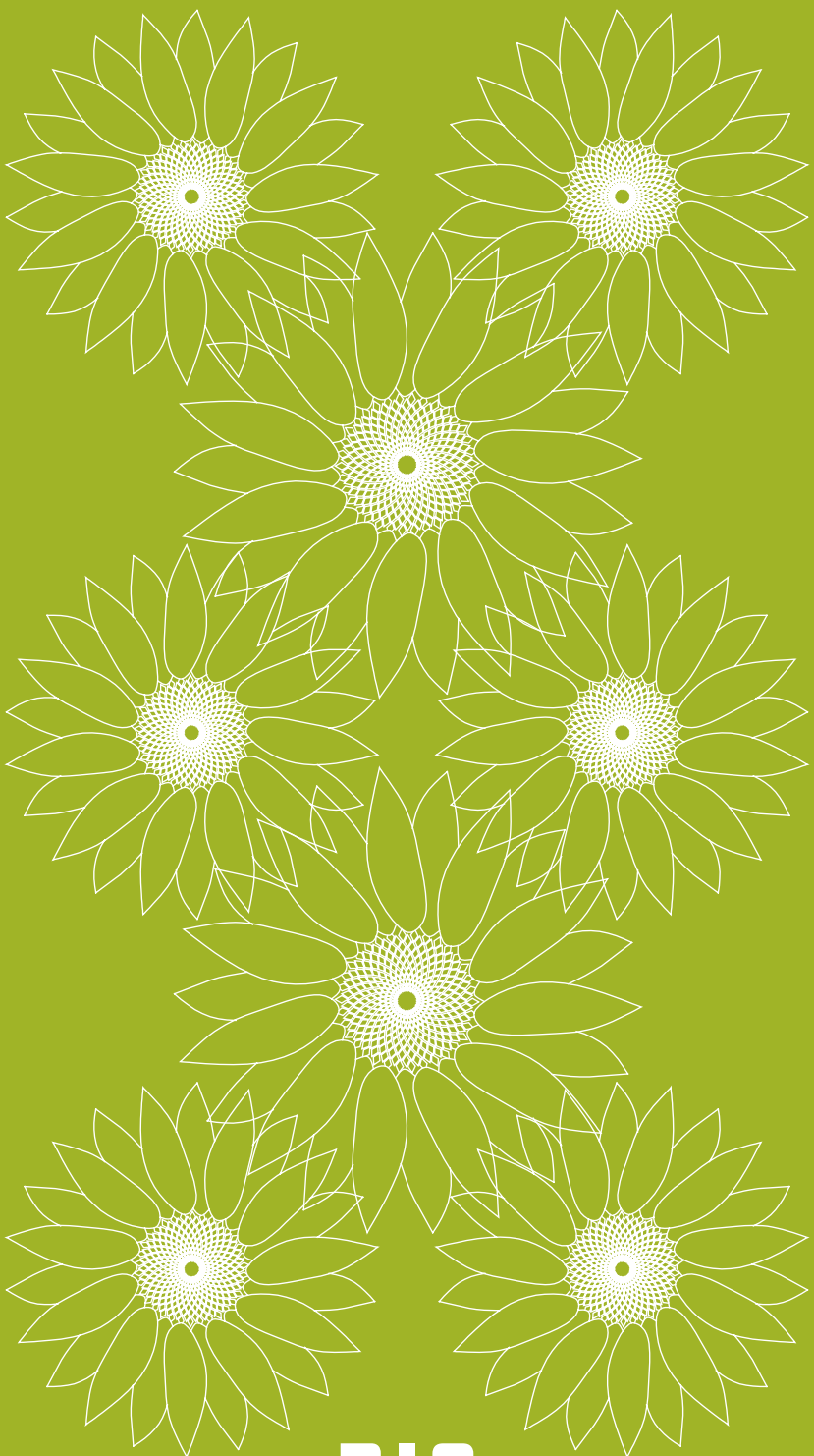
SOLAR POWER

landartgenerator.org



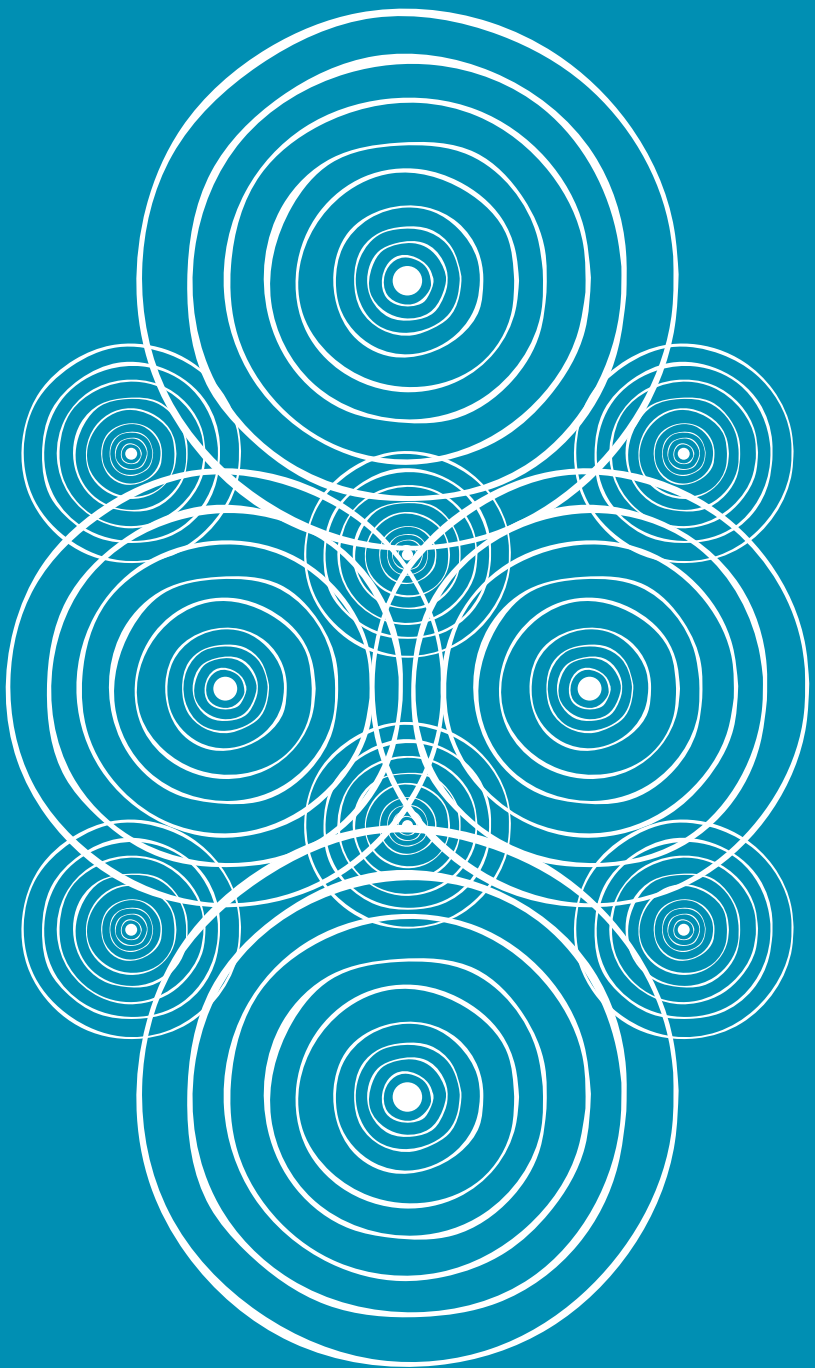
WIND POWER

landartgenerator.org



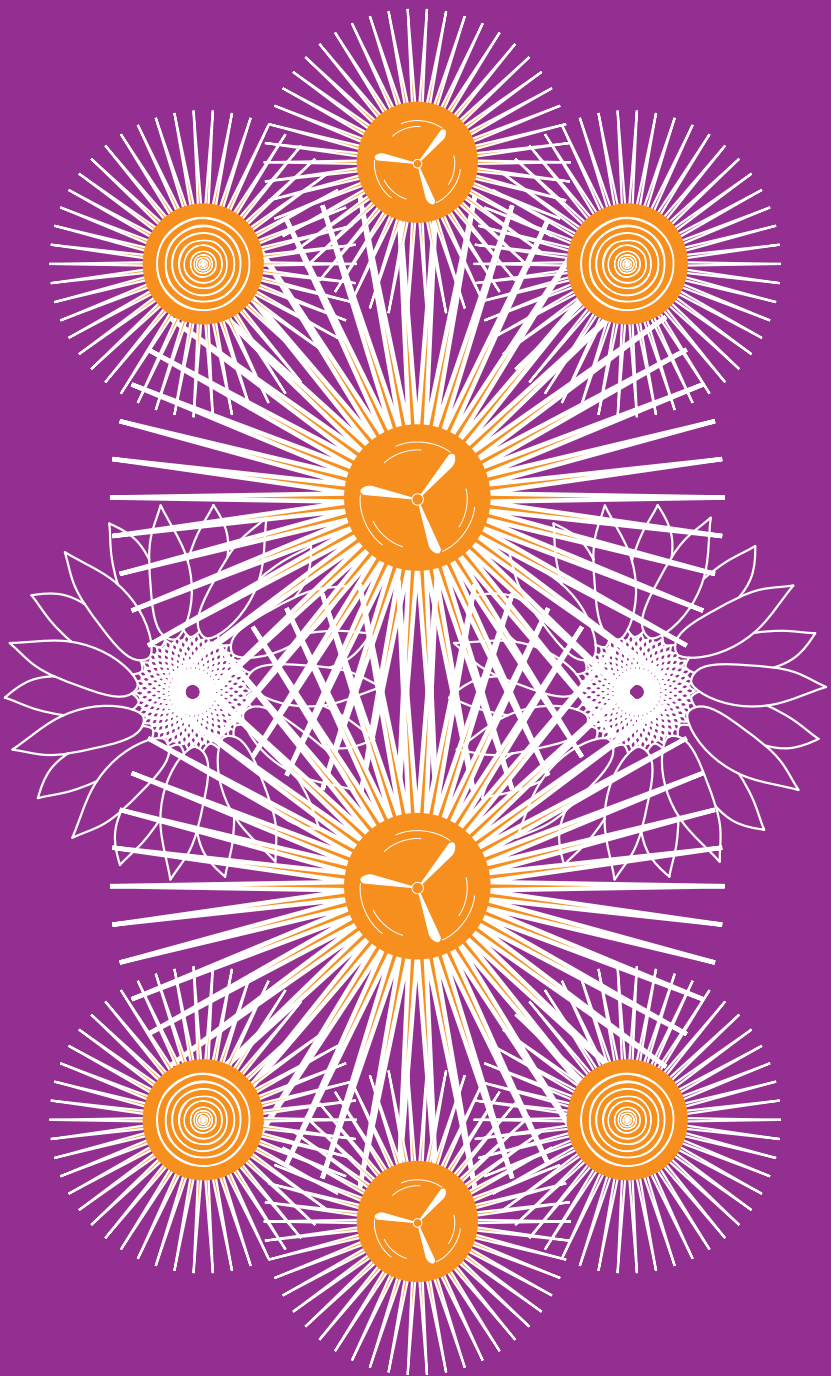
BIO POWER

landartgenerator.org



HYDRO POWER

landartgenerator.org



KNOWLEDGE IS POWER

landartgenerator.org

ART

BEYOND THE WAVE

ENERGY TECHNOLOGY
organic photovoltaic (OPV)

846 HOUSES
can be powered by this artwork (4,230 MWh per year)

DESIGN TEAM
Jaesik Lim, Ahyoung Lee, Sunpil Choi, Dohyoung Kim, Hoeyoung Jung, Jaeyeol Kim, Hansaem Kim

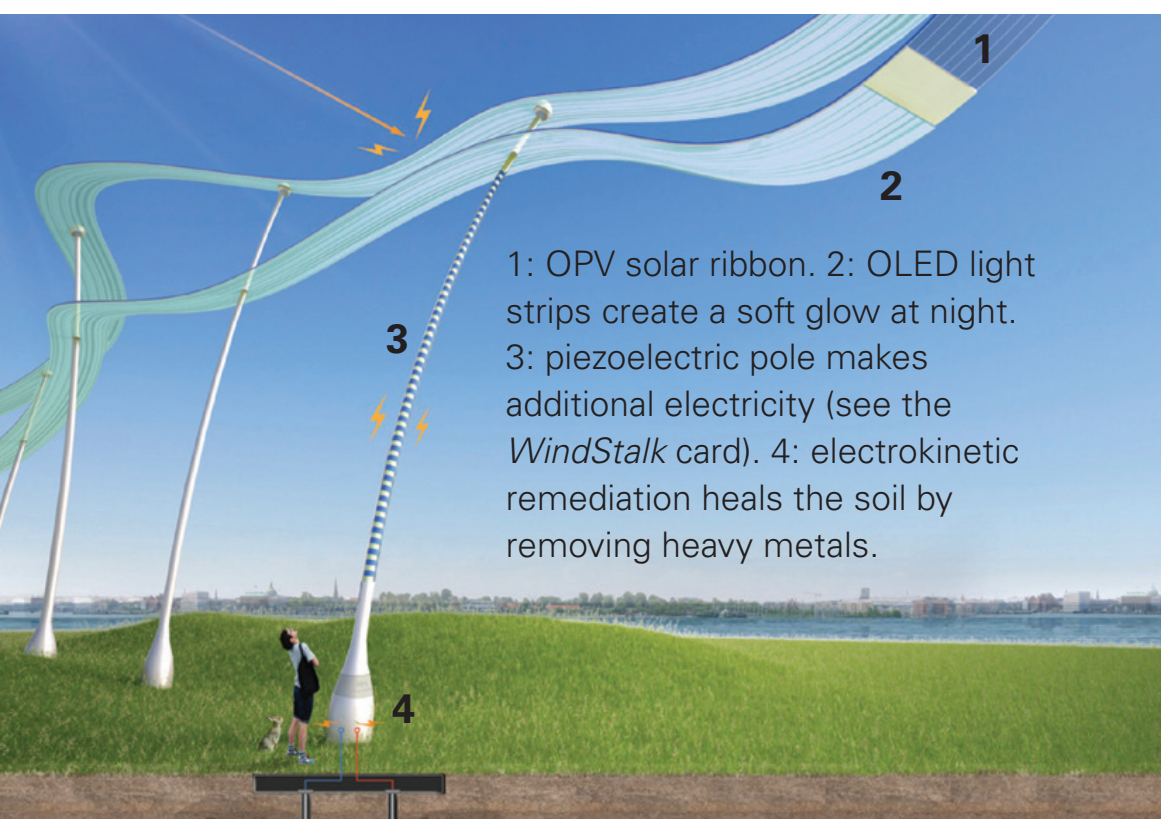
INFO

BEYOND THE WAVE

ENERGY TECHNOLOGY
organic photovoltaic (OPV)

The waving ribbons in this artwork are all made from a flexible and colorful type of solar technology. The artists invite you to explore underneath, have a picnic, walk around, or take a nap. It's designed to be a calming space where you can think about the relationship between people and nature, and about all of the electricity that the beautiful pink ribbons are making from the power of the sun!

LAGI 2014 COPENHAGEN



1: OPV solar ribbon. 2: OLED light strips create a soft glow at night. 3: piezoelectric pole makes additional electricity (see the *WindStalk* card). 4: electrokinetic remediation heals the soil by removing heavy metals.

TECH

ORGANIC PHOTOVOLTAIC (OPV)

OPV uses organic polymers to absorb sunlight and transmit electrical charges. Organic PV can be manufactured in solutions that can be painted or rolled onto proper substrate materials. Current OPV technology has peak power output of about half that of mono-crystalline silicon PV per unit area, but its production cost, flexibility, and performance in ambient light mean that it can—in some cases—outperform conventional PV over time. It can be sewn into backpacks, laptop cases, tents, jackets, and integrated into creative building façades (or art!).

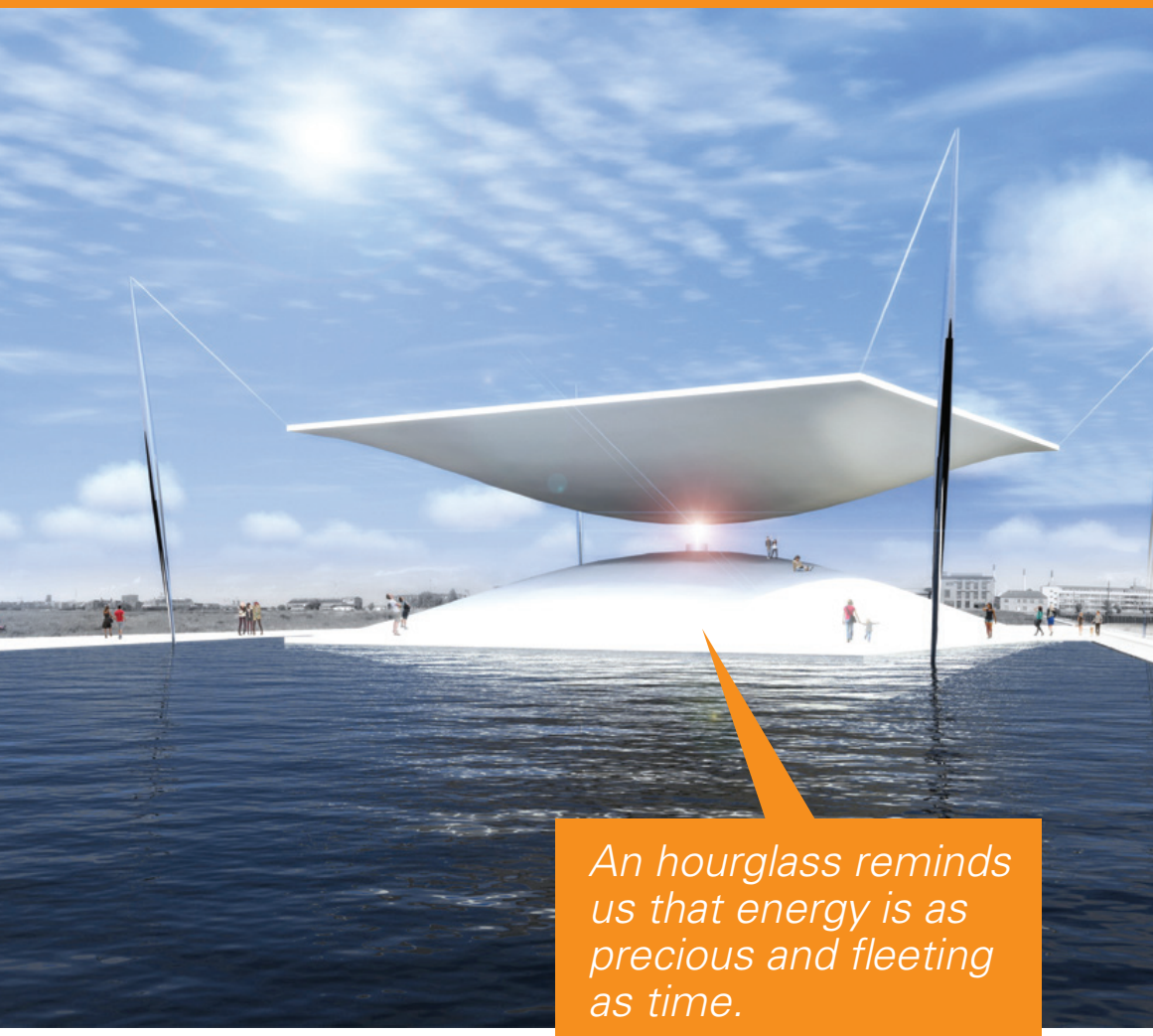
CHARACTERISTICS
flexible, colorful, translucent

IMAGE ABOVE
© Heliatek GmbH, André Wirsig.

THIS CARD WORKS WITH
Beyond the Wave, 99 Red Balloons, WindNest

ART

THE SOLAR HOURGLASS



An hourglass reminds us that energy is as precious and fleeting as time.

ENERGY TECHNOLOGY
solar thermal CSP (solar power tower)

1,500 HOUSES
can be powered by this artwork (8,250 MWh per year)

DESIGN TEAM
Santiago Muros Cortés

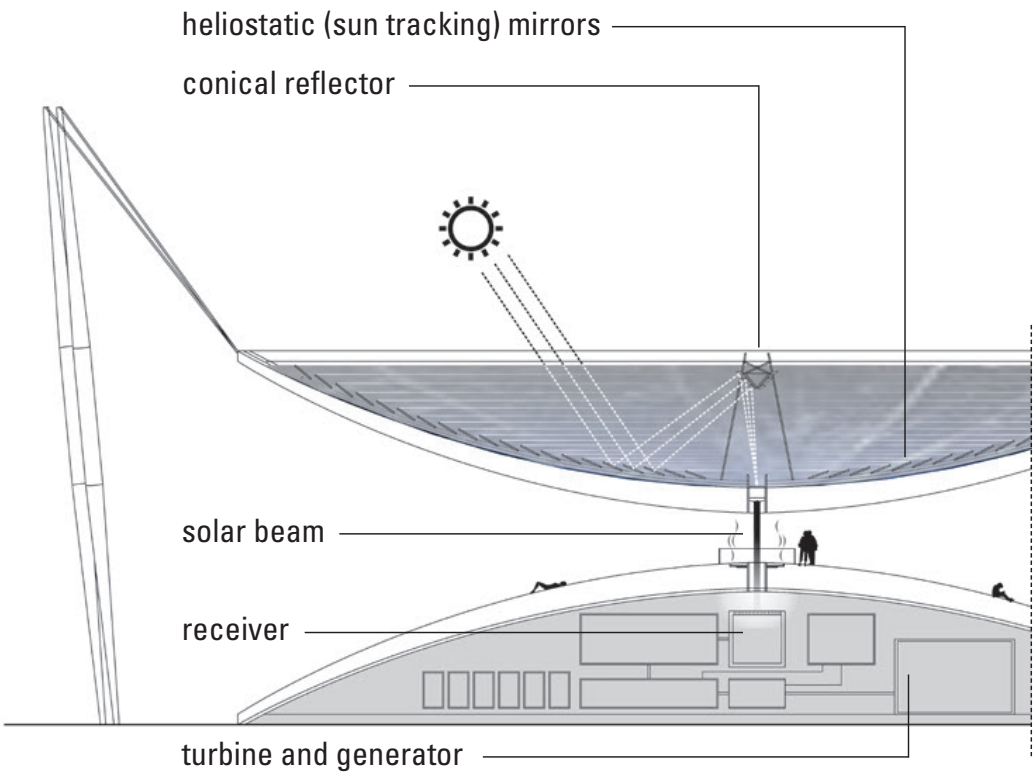
INFO

THE SOLAR HOURGLASS

ENERGY TECHNOLOGY
solar thermal CSP (solar power tower)

Rather than using sand to measure time, *The Solar Hourglass* uses the power of the sun. Sun-tracking mirrors focus thermal energy onto a central parabolic-shaped mirror to create a vertical beam of intense light and heat—a beacon across the harbor that powers a large generator below. Visitors can get close to an insulated glass cylinder and safely feel the heat on their hand. This new kind of public park is a breathtaking setting for inspiration, education, and relaxation.

LAGI 2014 COPENHAGEN



TECH

SOLAR THERMAL CSP
SOLAR POWER TOWER

This type of concentrated solar thermal power consists of an array of mirrors at the ground level that track the sun's location in the sky and focus its heat onto a single collector positioned high atop a central tower pylon structure (or beam it to a ground-mounted collector with another set of mirrors). By using a high heat capacity material such as molten salt in the collector (which transfers heat to water to run a steam turbine) energy can be stored to produce electricity even after the sun has set.

CHARACTERISTICS
reflective, beam of light, intense heat, energy storage

THIS CARD WORKS WITH
The Solar Hourglass

IMAGE ABOVE
The 110 MW SolarReserve Crescent Dunes plant in Nevada has 1,100 MWh of energy storage. Image courtesy of SolarReserve.

ART

TRANSPIRE

ENERGY TECHNOLOGY
solar thermal CSP (parabolic trough)

6,000 HOUSES
can be powered by this artwork (33,000 MWh per year)

DESIGN TEAM
Christopher Choa, Rachael Pengilley, Shaffee Jones-Wilson, Maged Hanna

INFO

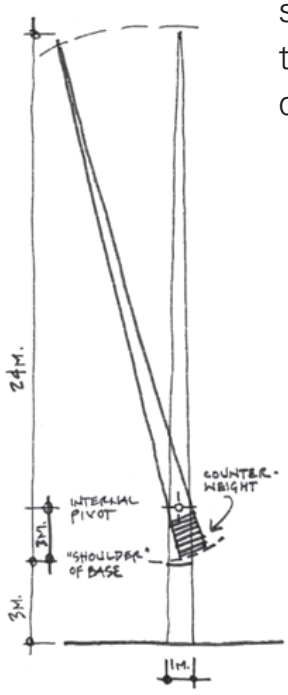
TRANSPIRE

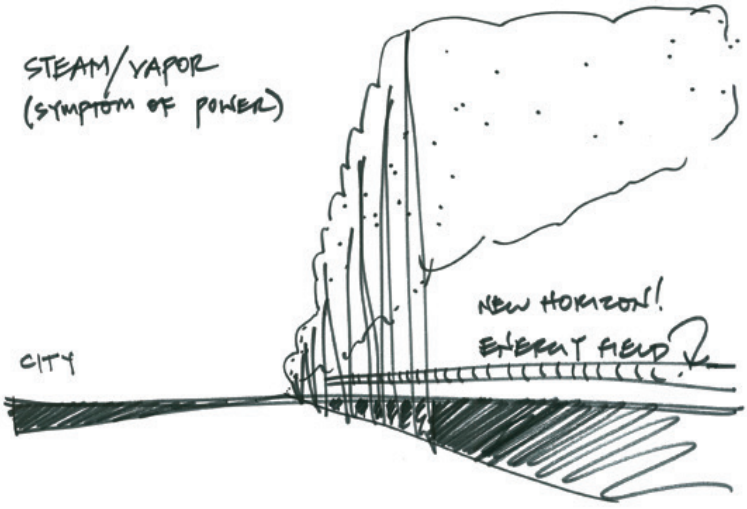
ENERGY TECHNOLOGY
solar thermal CSP (parabolic trough)

Transpire makes the invisible visible. One hundred iconic stainless-steel spires sway like reeds and produce a soft shape-shifting cloud and rainbow that can be seen for miles. At night the cloud serves as a canvas for video projection. Hidden behind the spires, thermal energy (parabolic trough) powers steam turbines. The cloud is formed from low-pressure steam vented along the spire's edges, an integral part of the power plant's cooling cycle.

LAGI 2010 DUBAI / ABU DHABI

Sketches by the design team show the relationship between the primary parts and the design of the kinetic spires.





TECH

SOLAR THERMAL CSP
PARABOLIC TROUGH

The parabolic trough design consists of a series of long, highly polished parabolic reflecting surfaces that focus sunlight onto an absorber tube running along the focal point of the parabola. Heat transfer fluid running through the tube is heated to approximately 400°C. The parabolic shape of the reflector allows the troughs to be oriented on a north-south axis and track the sun in only one rotational axis from east to west each day.

CHARACTERISTICS
reflective, linear, beam of light

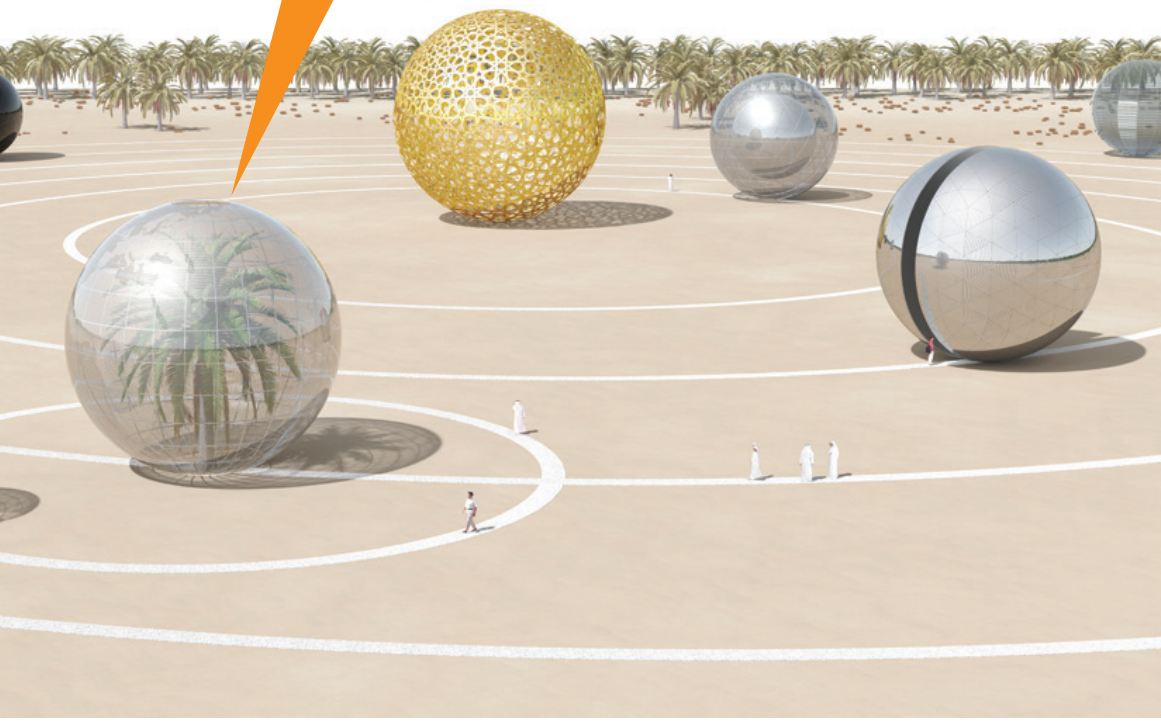
IMAGE ABOVE
SEGS power plant at Kramer Junction in the Mojave desert is owned and operated by FPL Energy.

THIS CARD WORKS WITH
Transpire

ART

SOLAR ECO SYSTEM

The Earth is represented by a palm tree within a photovoltaic sphere.



ENERGY TECHNOLOGY
solar photovoltaic (PV) panels/modules

180 HOUSES
can be powered by this artwork (990 MWh per year)

DESIGN TEAM
Antonio Maccà, Flavio Masi

INFO

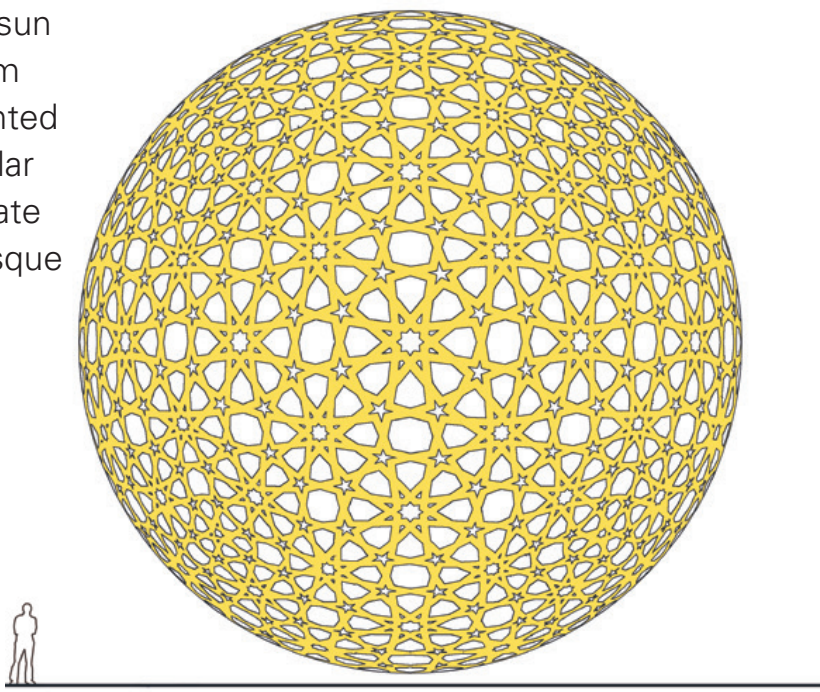
SOLAR ECO SYSTEM

ENERGY TECHNOLOGY
solar photovoltaic (PV) panels/modules

Solar Eco System celebrates the relative position of the planets around the sun on December 2, 1971, the day the United Arab Emirates was founded. The new photovoltaic sun for Abu Dhabi generates light and electricity for the city from the astronomical sun. The surrounding planets are clad in various types of specialty photovoltaics (PV) (CIGS) and represent the most salient features of each. The Earth becomes a spherical PV greenhouse surrounding one existing palm tree.

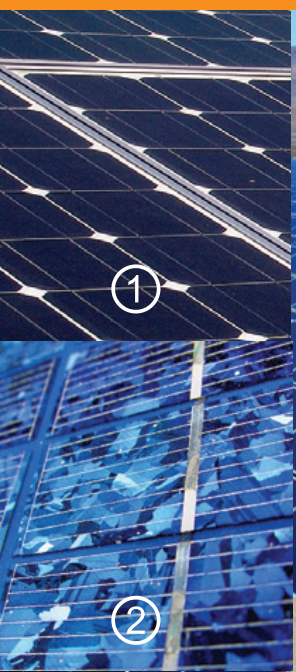
LAGI 2010 DUBAI / ABU DHABI

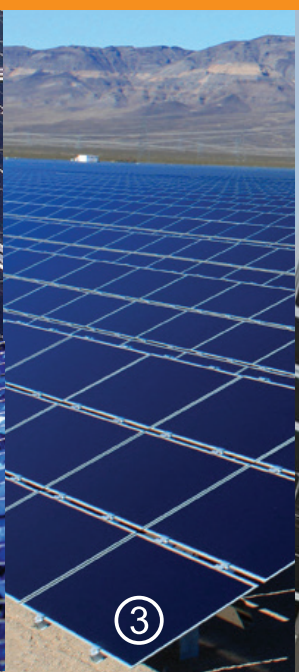
The photovoltaic sun is made of custom fabricated gold-tinted polycrystalline solar modules that create a beautiful arabesque sphere.

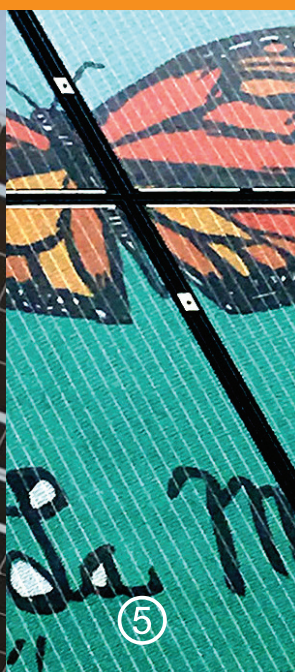


TECH

SOLAR PHOTOVOLTAIC (PV) PANELS/MODULES







Solar panels come in a variety of types. The most common is made from Silicon (Si)—either monocrystalline ① or polycrystalline ②. Others use different semiconductors such as Copper-Indium Gallium Selenide (CIGS) and Cadmium Telluride (CdTe) ③. Solar panels can be integrated into buildings within frame-less glass ④, tinted, or laminated with special films that make the panel appear as a solid color or even a printed image ⑤ while still generating electricity.

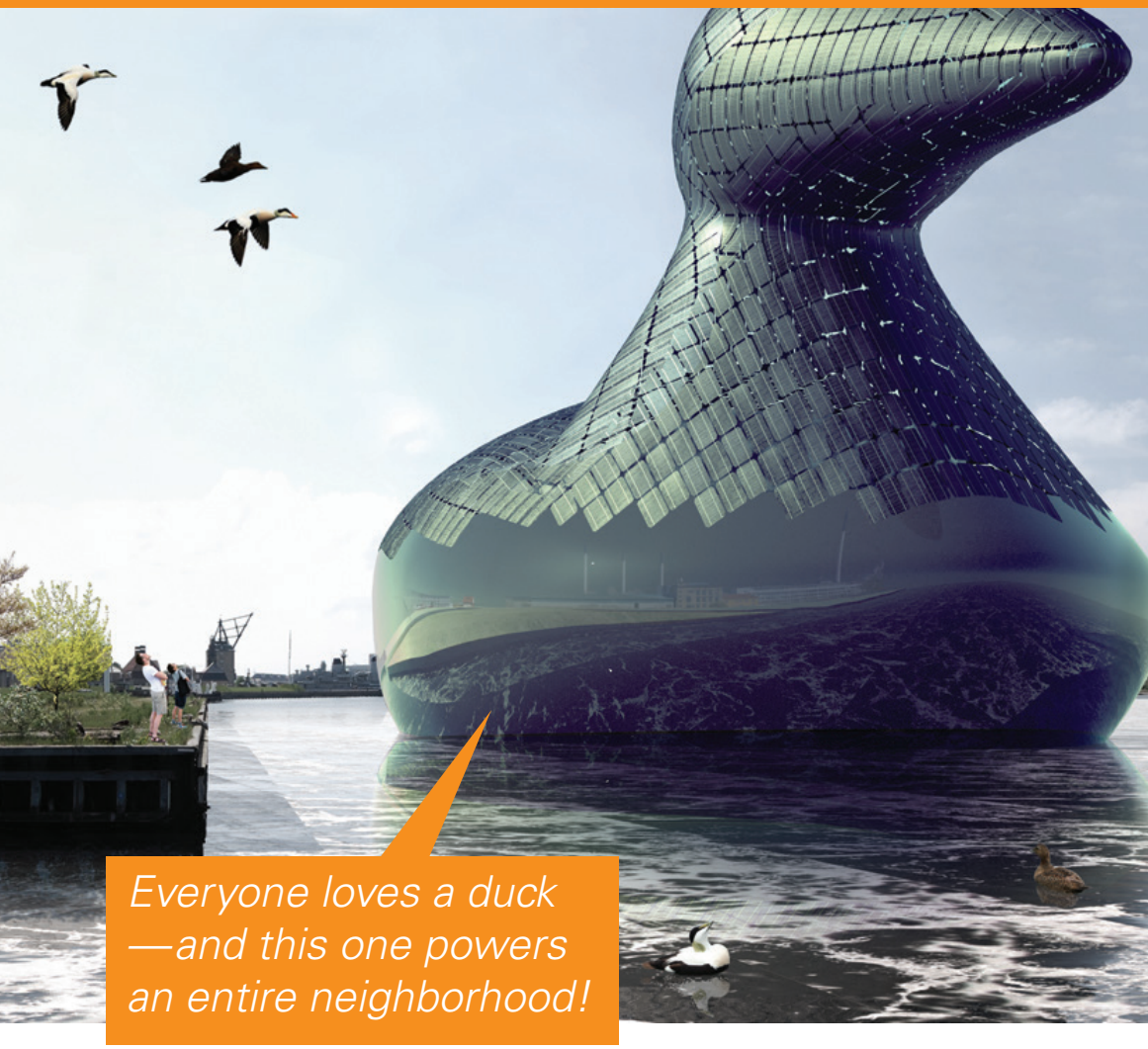
CHARACTERISTICS
flat, thin, rigid, usually dark color, can be tinted or laminated, glass face

IMAGES (1–5)
Siemens AG; Scott Robinson; Sempra LLC; Lumos Solar; and LAGI Solar Mural® "La Monarca" San Antonio, TX (photo by Penelope Boyer).

THIS CARD WORKS WITH
Energy Duck, Night & Day, Solar Eco System, Solar Sound Field

ART

ENERGY DUCK



Everyone loves a duck —and this one powers an entire neighborhood!

ENERGY TECHNOLOGY
solar photovoltaic (PV) panels/modules

80 HOUSES
can be powered by this artwork (400 MWh per year)

DESIGN TEAM
Hareth Pochee, Adam Khan, Louis Leger, Patrick Fryer

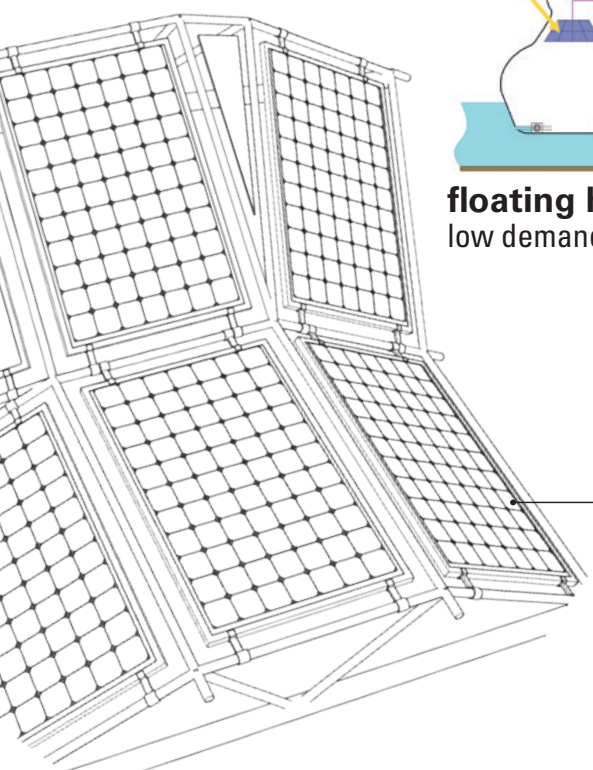
INFO

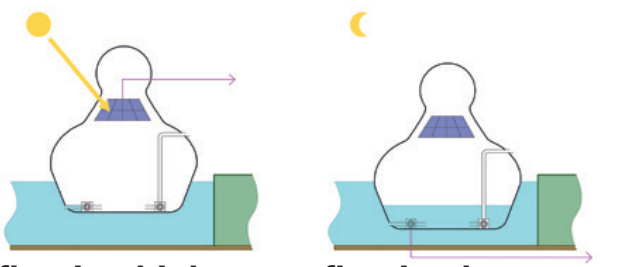
ENERGY DUCK

ENERGY TECHNOLOGY
solar photovoltaic (PV) panels/modules

Energy Duck is an entertaining and iconic sculpture, a renewable energy generator, a tourist destination, and a buoyant energy storage device. As lights switch on at the end of the day, the price of electricity is at its peak. Just then the *Duck* begins to sink slowly under the weight of the artwork as micro-hydro turbines in its belly send power to the grid. In the morning when energy demand is low, the solar panels pump water out of its belly and again it is floating high!

LAGI 2014 COPENHAGEN





floating high
low demand for energy

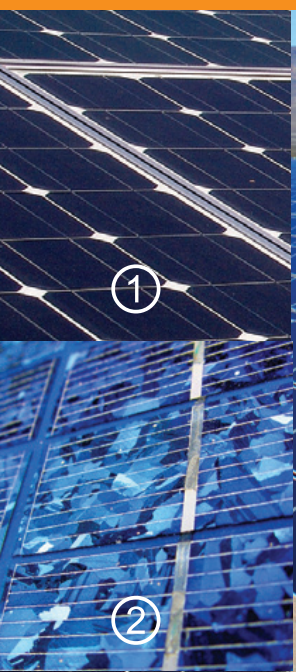
floating low
high demand for energy

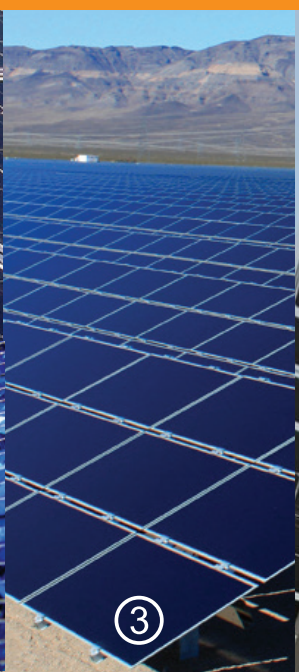
Look up “solar duck curve” to learn why energy storage is so important for a 100% renewable future.

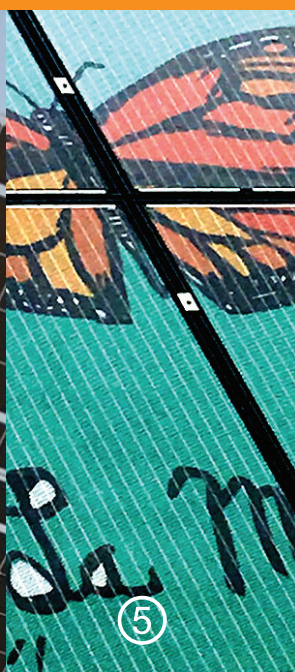
Solar modules are mounted to a space frame structure, which segments to form the curved surface of the *Duck*.

TECH

SOLAR PHOTOVOLTAIC (PV) PANELS/MODULES







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CHARACTERISTICS
flat, thin, rigid, usually dark color, can be tinted or laminated, glass face

IMAGES (1–5)
Siemens AG; Scott Robinson; Sempra LLC; Lumos Solar; and LAGI Solar Mural® "La Monarca" San Antonio, TX (photo by Penelope Boyer).

THIS CARD WORKS WITH
Energy Duck, Night & Day, Solar Eco System, Solar Sound Field

ART

99 RED BALLOONS

ENERGY TECHNOLOGY
organic photovoltaic (OPV)

2,500 HOUSES
can be powered by this artwork (12,500 MWh per year)

DESIGN TEAM
Scott Rosin, Meaghan Hunter, Danielle Loeb, Emeka Nnadi, Kara McDowell, Jocelyn Chorney, Indrajit Mitra, Narges Ayat, Denis Fleury

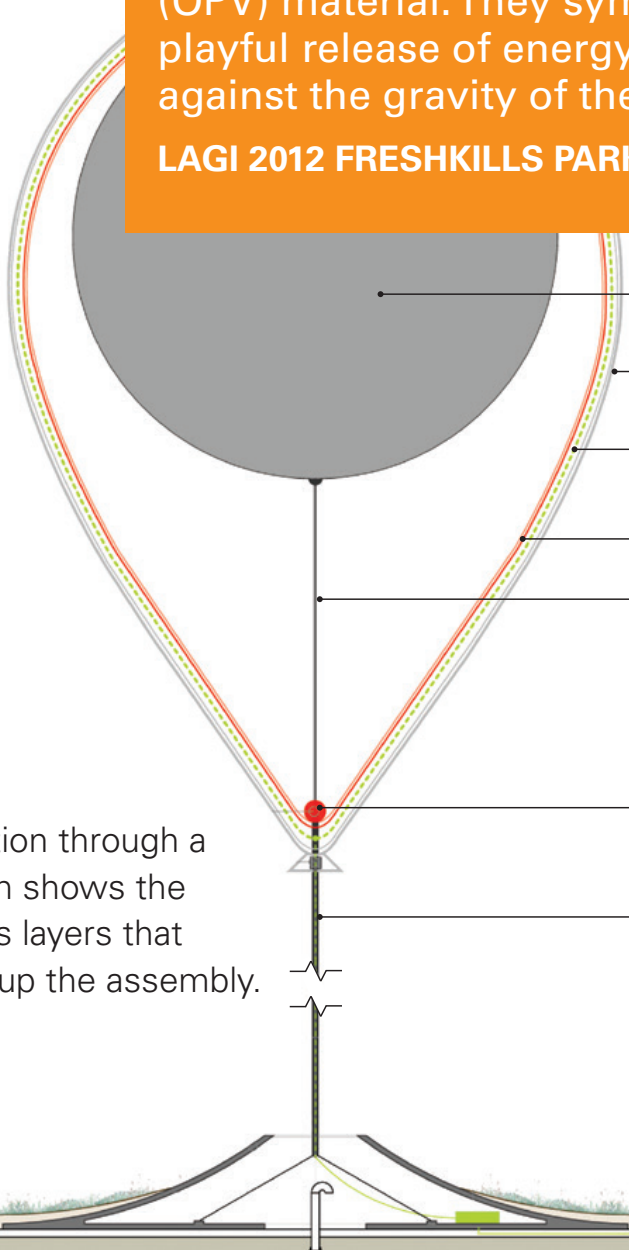
INFO

99 RED BALLOONS

Inspired by an excerpt from the 1984 song by Nena, 99 identical balloon-shaped photovoltaic solar generators rise from the landscape. Each balloon is an organic resin membrane lined with semi-transparent organic photovoltaic (OPV) material. They symbolize a playful release of energy pulling against the gravity of the earth.

LAGI 2012 FRESHKILLS PARK, NYC

ENERGY TECHNOLOGY
organic photovoltaic (OPV)



A section through a balloon shows the various layers that make up the assembly.

TECH

ORGANIC PHOTOVOLTAIC (OPV)

OPV uses organic polymers to absorb sunlight and transmit electrical charges. Organic PV can be manufactured in solutions that can be painted or rolled onto proper substrate materials. Current OPV technology has peak power output of about half that of mono-crystalline silicon PV per unit area, but its production cost, flexibility, and performance in ambient light mean that it can—in some cases—outperform conventional PV over time. It can be sewn into backpacks, laptop cases, tents, jackets, and integrated into creative building façades (or art!).

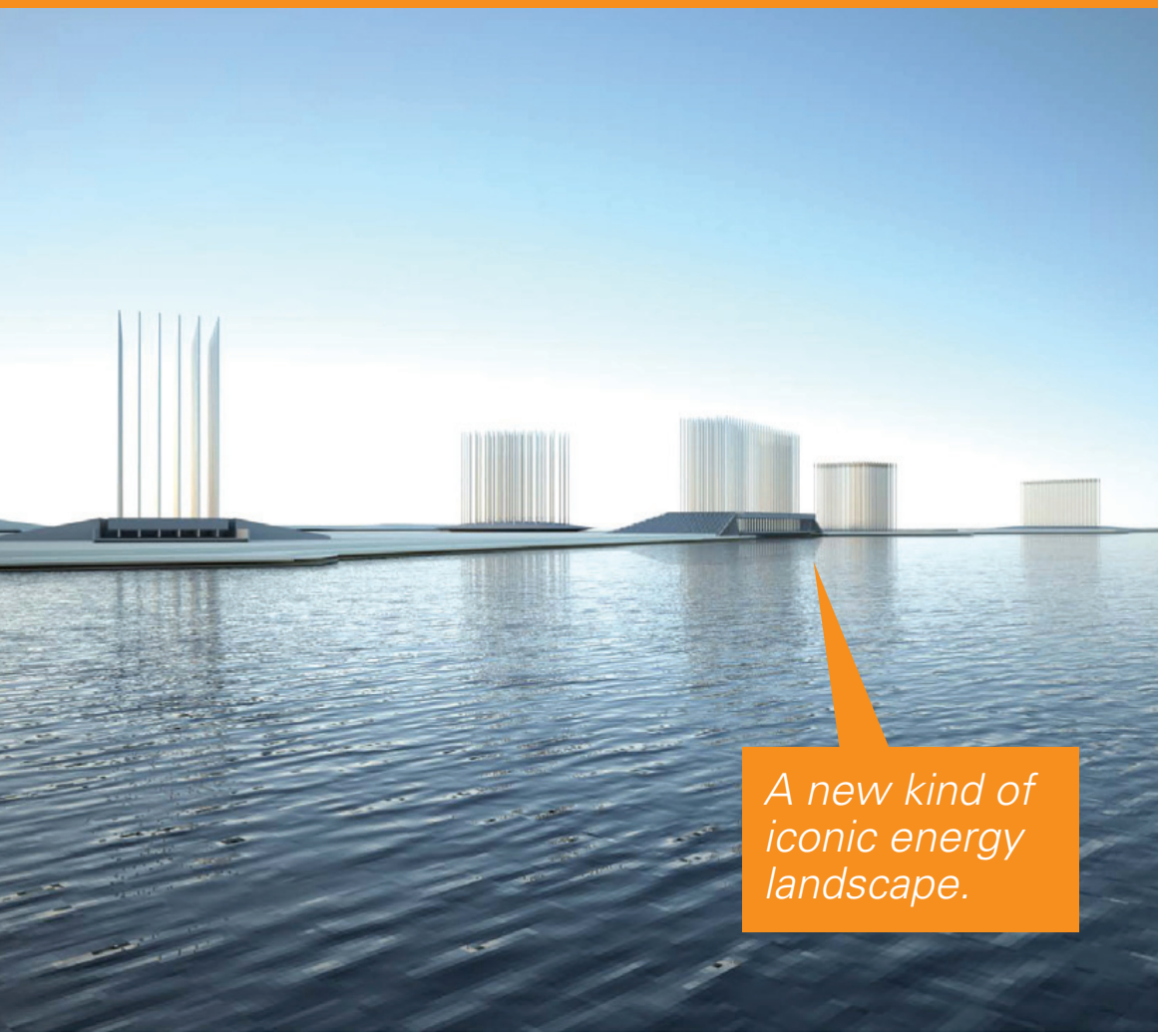
CHARACTERISTICS
flexible, colorful, translucent

IMAGE ABOVE
© Heliatek GmbH, André Wirsig.

THIS CARD WORKS WITH
Beyond the Wave, 99 Red Balloons, WindNest

ART

SOLAR SOUND FIELD



ENERGY TECHNOLOGY
solar updraft tower; solar photovoltaic panels

1,820 HOUSES
can be powered by this artwork (9,100 MWh per year)

DESIGN TEAM
Sage and Coombe Architects: T. Kelly Wilson, Timothy Dunne, John Parker, Richard Kress, Peter Hansen, Christoph Timm, Peter Coombe, Allen Slamic, John Reed

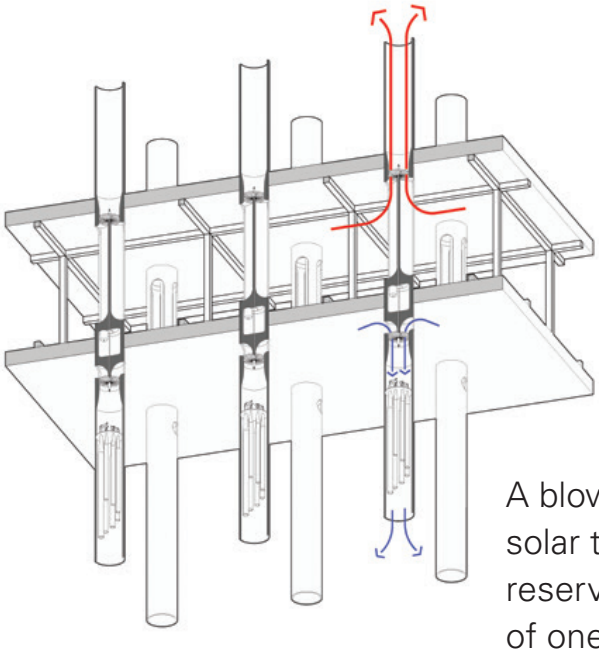
INFO

SOLAR SOUND FIELD

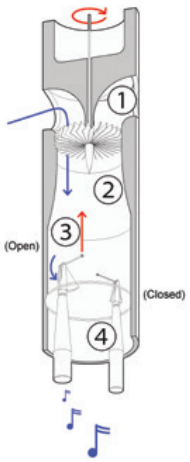
ENERGY TECHNOLOGY
solar updraft tower;
solar photovoltaic panels

Five musical machines each contain an acoustic chamber, a glass greenhouse, and an array of 60-meter tall chromium steel pipes. A stream of hot and buoyant air heated by the sun within the greenhouse rises up the chimneys. This airflow creates a sustained musical note through the resonance chambers and drives a turbine to generate electricity. Electricity is also generated by 24,000 m^2 of photovoltaic cells below the greenhouse glass.

LAGI 2010 DUBAI / ABU DHABI



Detail of the sound pipe chamber.



A blower ① powered by the solar turbine pushes air into the reservoir ②. Once the valve ③ of one of the flue pipes ④ is put into position, the air enters the pipe to play a note.

TECH

SOLAR UPDRAFT TOWER

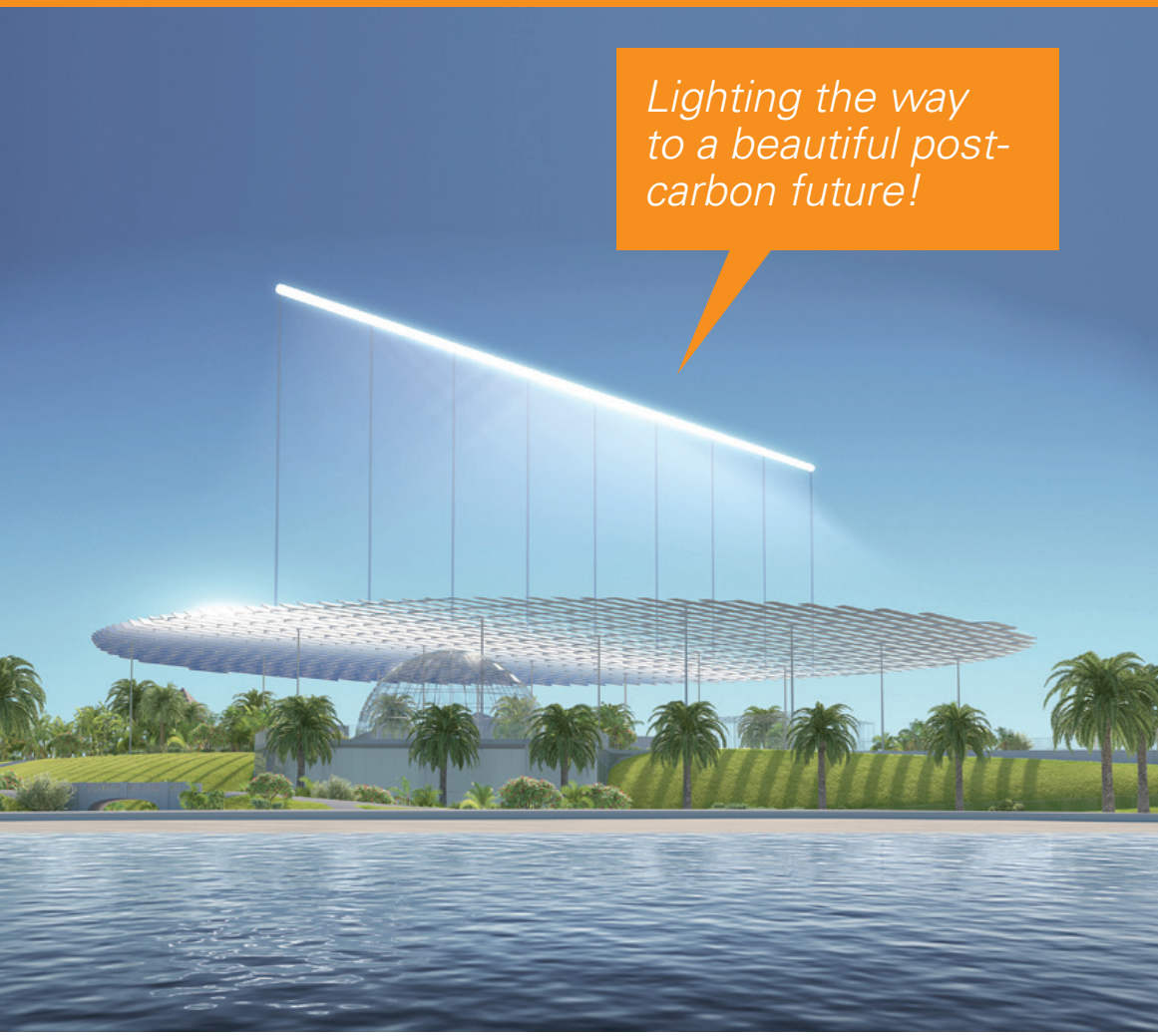
The stack effect is the natural property of air within a closed space to rise vertically with buoyancy when heated in relation to ambient air temperature. The greater the heat differential the faster the resulting air movement. This differential is made as great as possible in the updraft tower by 1) heating the air at ground level via a greenhouse with thermal storage, and 2) building the tower tall enough so that the ambient temperature of the air is naturally lower by a few degrees at the mouth. Solar updraft technology uses the stack effect to power turbines located at the base of a very tall tower.

CHARACTERISTICS
tall, wide base, inhabitable,
warm air flowing

THIS CARD WORKS WITH
Solar Sound Field

ART

SUN RAY



ENERGY TECHNOLOGY
solar thermal CSP
linear Fresnel reflector

220 HOUSES
can be powered by this artwork (1,100 MWh per year)

DESIGN TEAM
Antonio Maccà

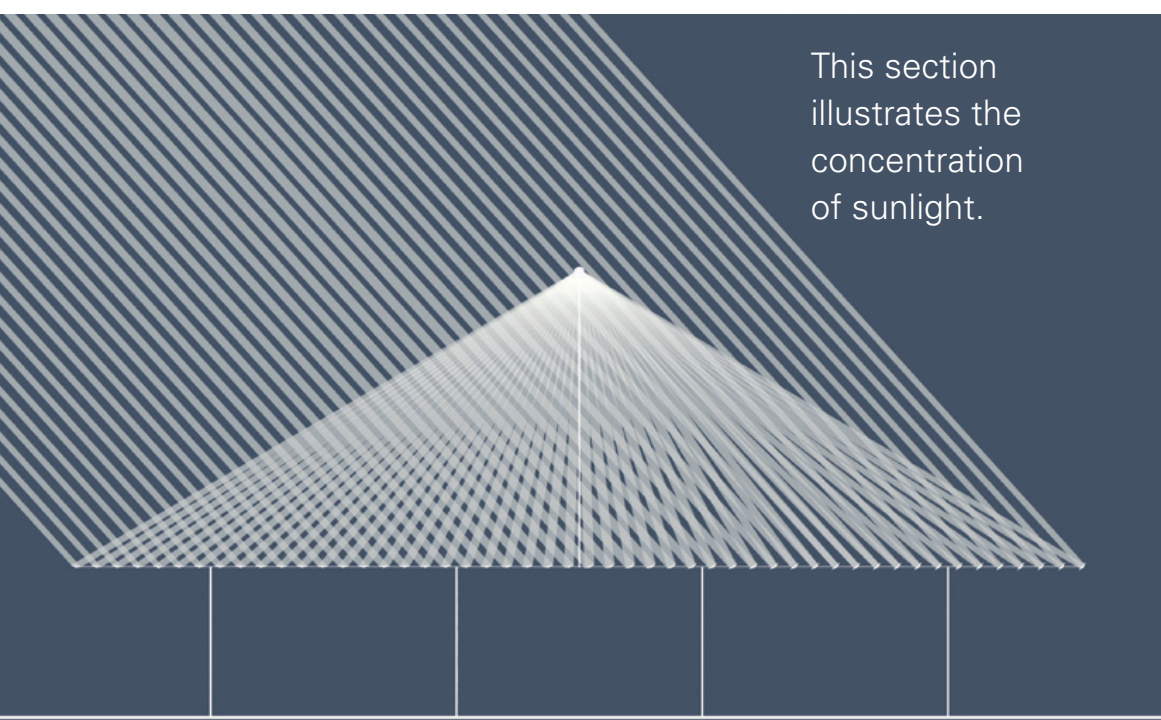
INFO

SUN RAY

ENERGY TECHNOLOGY
solar thermal CSP
linear Fresnel reflector

Sun Ray's solar field is a dynamic canopy composed of rows of flat linear mirrors equipped with a single-axis sun tracking system. The "specular sun," which measures 85 meters in diameter, reflects sunlight and converges it throughout the day onto the fixed cardinal linear receiver situated in the common focal point of the reflectors. Energy storage and conversion equipment are housed underground.

LAGI 2018 MELBOURNE



This section illustrates the concentration of sunlight.

TECH

SOLAR THERMAL
CSP LINEAR FRESNEL REFLECTOR

Linear Fresnel reflectors (LFR) use long, thin segments of flat mirrors to focus sunlight onto a fixed absorber located at a common focal point of the reflectors. Similar to the more common parabolic trough, this single-axis tracking concentrated reflector system heats up a transfer fluid which in turn heats water to run a steam turbine. Fresnel geometry allows flat surfaces to act in a way that mimics a parabolic mirror.

CHARACTERISTICS
reflective, flat,
linear, directional
line of light, shadow

IMAGE ABOVE
Kimberlina Power Plant in Bakersfield, CA. Image courtesy of AREVA Solar.

THIS CARD WORKS WITH
Sun Ray

ART

NIGHT & DAY
HYDRO-SOLAR GENERATOR

Solar and pumped hydro storage are a great combination!

ENERGY TECHNOLOGY
solar photovoltaic panels (with pumped hydro energy storage)

200 HOUSES
can be powered by this artwork (1,000 MWh per year)

DESIGN TEAM
Kevin Kudo-King, Annie Aldrich, James Juricevich, Evan Harlan, Vikram Sami, Erin Hamilton, Gabriela Frank, MacKenzie Cotters, Lauren Gallow, Jonathan Nelson (Olson Kundig)

INFO

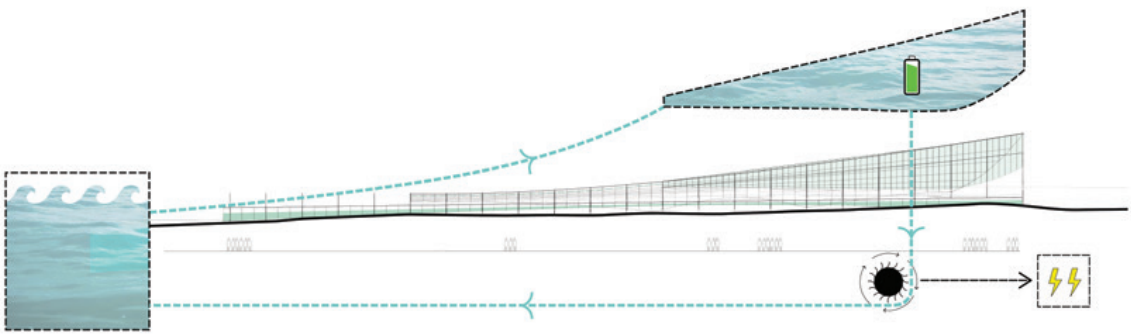
NIGHT & DAY
HYDRO-SOLAR GENERATOR

ENERGY TECHNOLOGY
solar photovoltaic panels (with pumped hydro energy storage)

The *Hydro-Solar Generator* is a power generator that works night and day to leverage the full potential of the site's natural resources of water and sunshine. The machine takes the form of a pedestrian bridge linking public spaces that have become fragmented over time. The 5,400 m^2 solar sail's curvature is optimized for annual solar energy harvest. During the day 82% of the solar power is pushed to the grid while 18% is utilized for pumping water into the hydro battery.

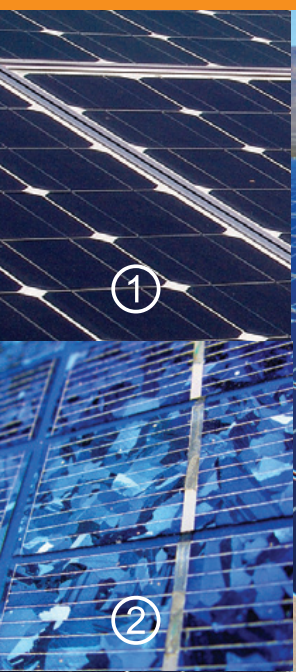
LAGI 2018 MELBOURNE

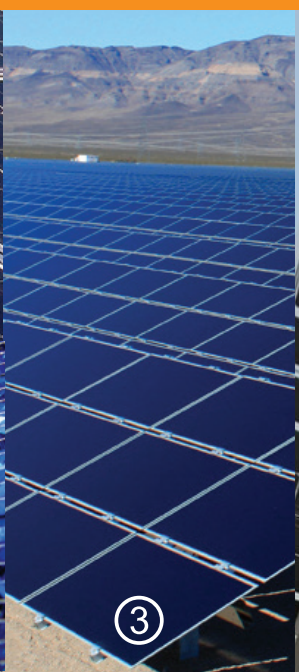
The pumped hydro storage machine can provide 350 kWh of electricity after the sun has set.

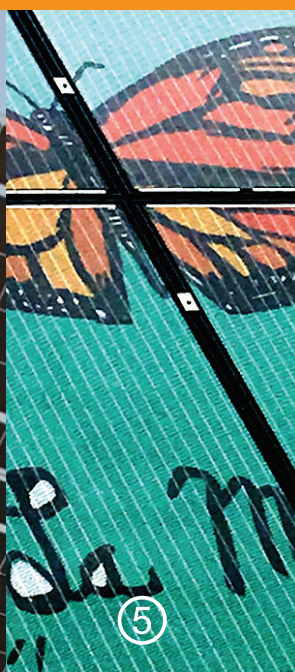


TECH

SOLAR PHOTOVOLTAIC (PV) PANELS/MODULES







Solar panels come in a variety of types. The most common is made from Silicon (Si)—either monocrystalline ① or polycrystalline ②. Others use different semiconductors such as Copper-Indium Gallium Selenide (CIGS) and Cadmium Telluride (CdTe) ③. Solar panels can be integrated into buildings within frame-less glass ④, tinted, or laminated with special films that make the panel appear as a solid color or even a printed image ⑤ while still generating electricity.

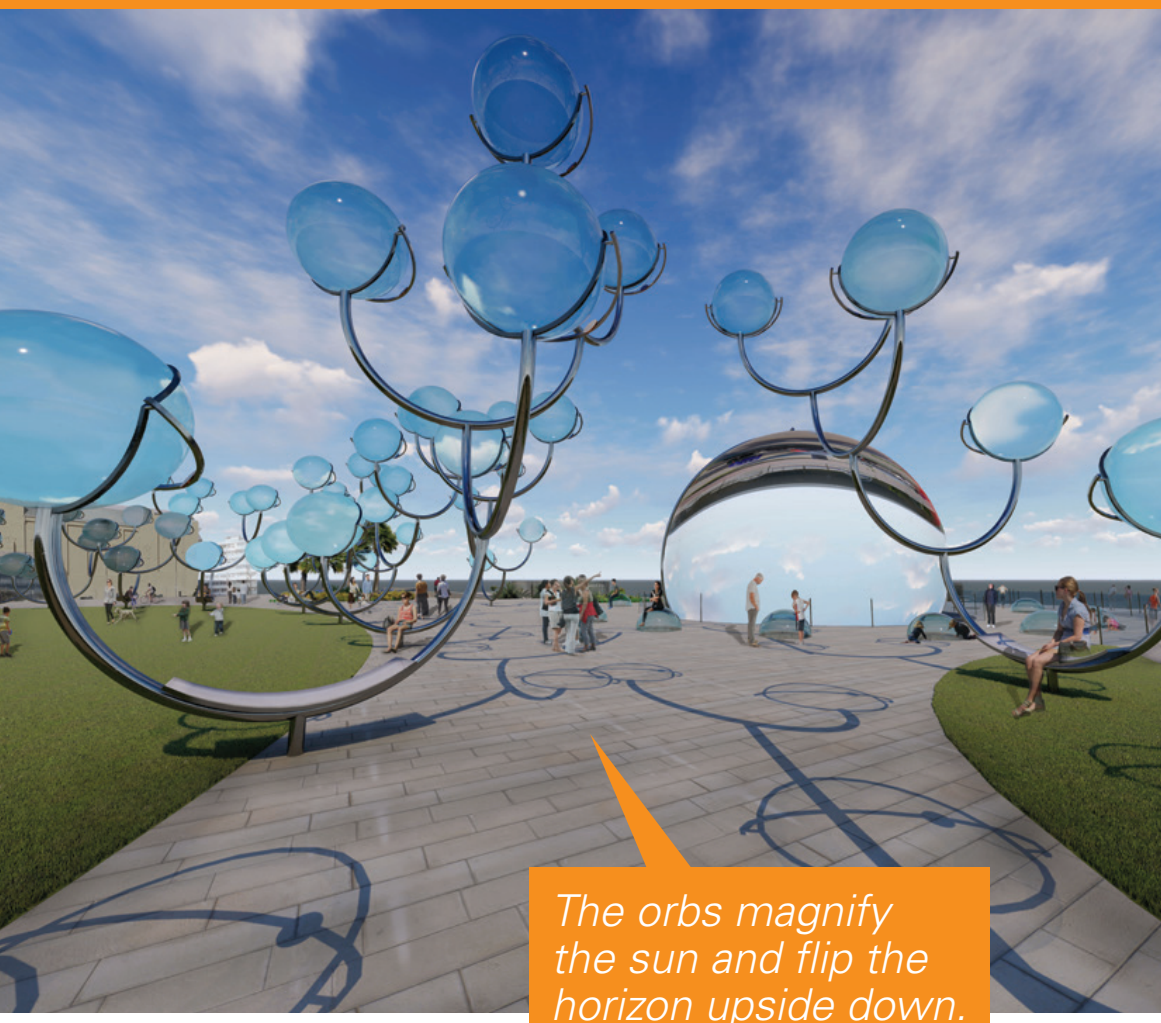
CHARACTERISTICS
flat, thin, rigid, usually dark color, can be tinted or laminated, glass face

IMAGES (1–5)
Siemens AG; Scott Robinson; Sempra LLC; Lumos Solar; and LAGI Solar Mural® "La Monarca" San Antonio, TX (photo by Penelope Boyer).

THIS CARD WORKS WITH
Energy Duck, Night & Day, Solar Eco System, Solar Sound Field

ART

SOLAR ORBS



The orbs magnify the sun and flip the horizon upside down.

ENERGY TECHNOLOGY
concentrated photovoltaic

110 HOUSES
can be powered by this artwork (550 MWh per year)

DESIGN TEAM
Kaitlin Campbell, Chad Grevelding, Bridget Snover, Kyle Stillwell

INFO

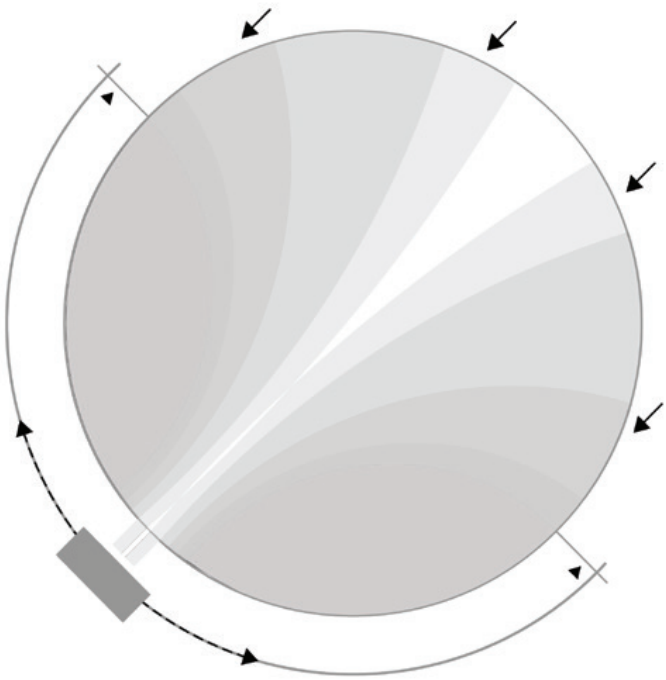
SOLAR ORBS

ENERGY TECHNOLOGY
concentrated photovoltaic

The design of *Solar Orbs* utilizes spherical solar concentrators to focus sunlight onto a photovoltaic + thermal solar cell. The high-performance cell tracks the concentrated light throughout the day, gliding in the shadow of the sphere along a dual axis system. The concept of spherical solar concentrators was first introduced by Andre Broessel, the founder of Rawlemon.

LAGI 2018 MELBOURNE

The solar cell is set on a tracking system that moves behind the water-filled acrylic sphere.



TECH

CONCENTRATED PHOTOVOLTAIC (CPV)

CPV uses photovoltaic cells, but rather than rely on the standard intensity of naturally occurring solar radiation energy, the CPV system concentrates the sunlight and directs a magnified beam onto a smaller area solar cell specifically designed to handle the greater energy and heat. Because the solar cell can be much smaller, the amount of semiconductor material required is far less for the same watt capacity output when compared to standard PV.

CHARACTERISTICS
reflective, lens, magnification, optics, kinetic, heliostatic, dual-axis tracking

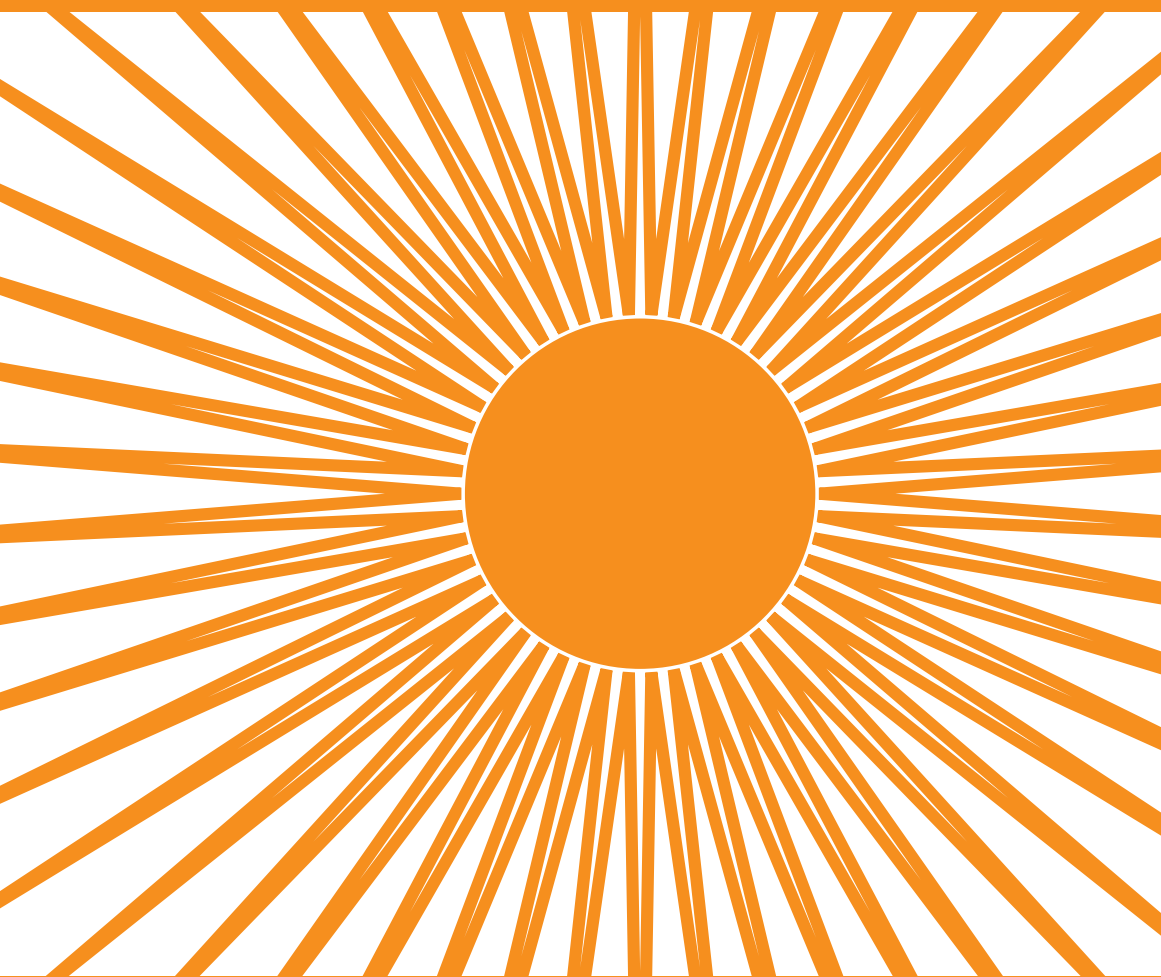
IMAGE ABOVE
CPV installation. Image courtesy of SolFocus, Inc.

THIS CARD WORKS WITH
Solar Orbs

TECH

WILD CARD

Play this card with any solar **ART** or **INFO** card.



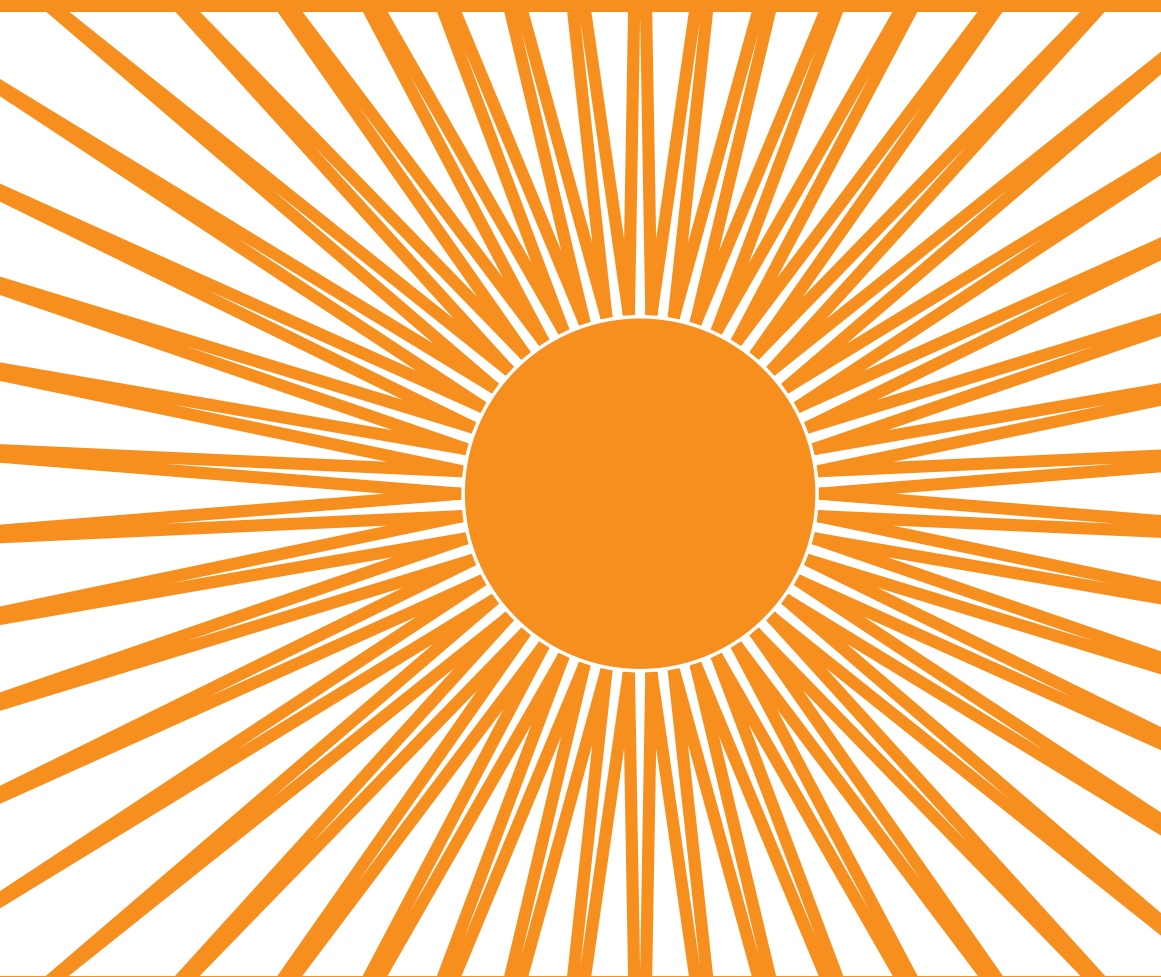
DESIGN INNOVATION

Innovation happens when you dare to think creatively about challenges. The next decade promises to be an exciting time for new energy products and solutions, both in clean generation and in energy storage. Many of the new technologies, like solar paints, modular solar tiles, and clear solar window glass can be incorporated into the design of our cities, landscapes, and public art.

TECH

WILD CARD

Play this card with any solar **ART** or **INFO** card.



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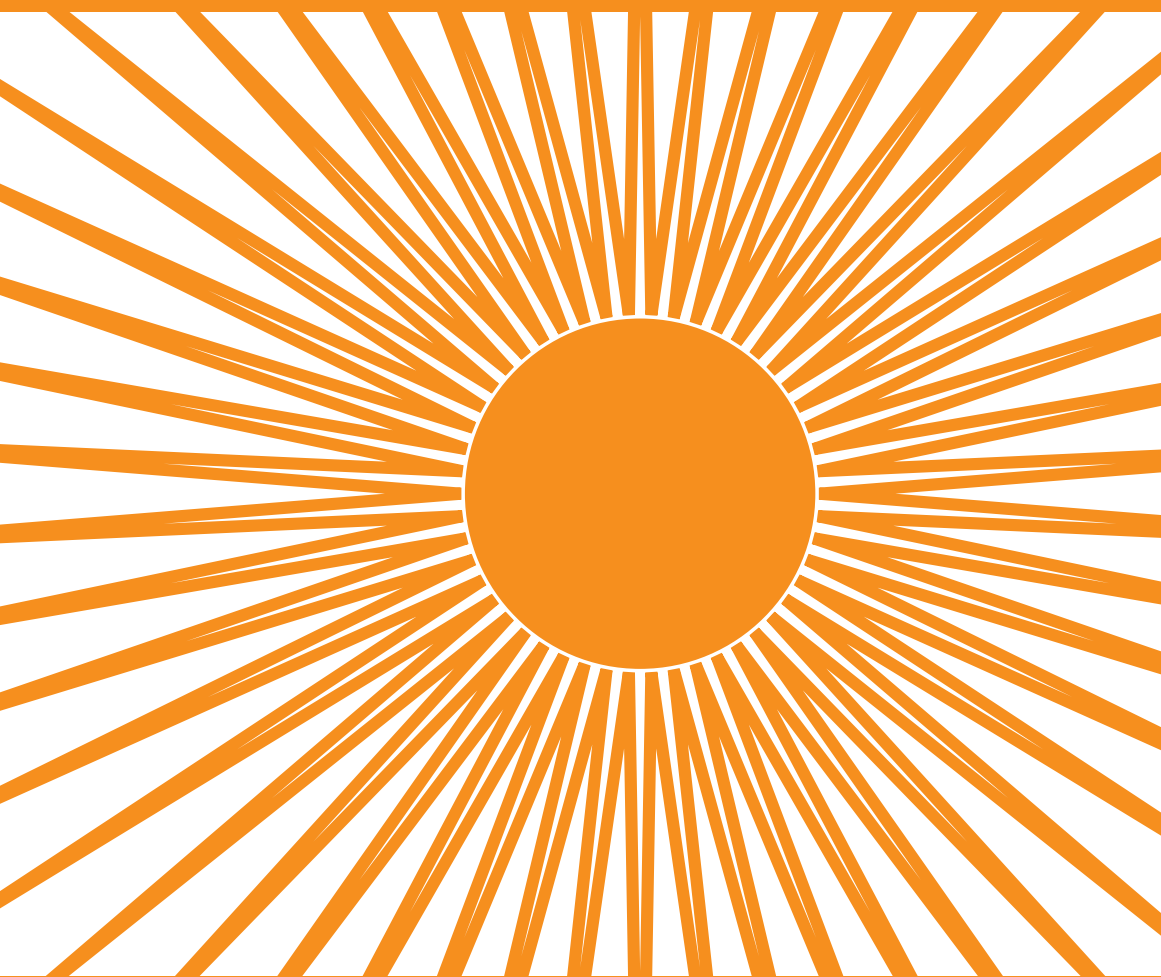

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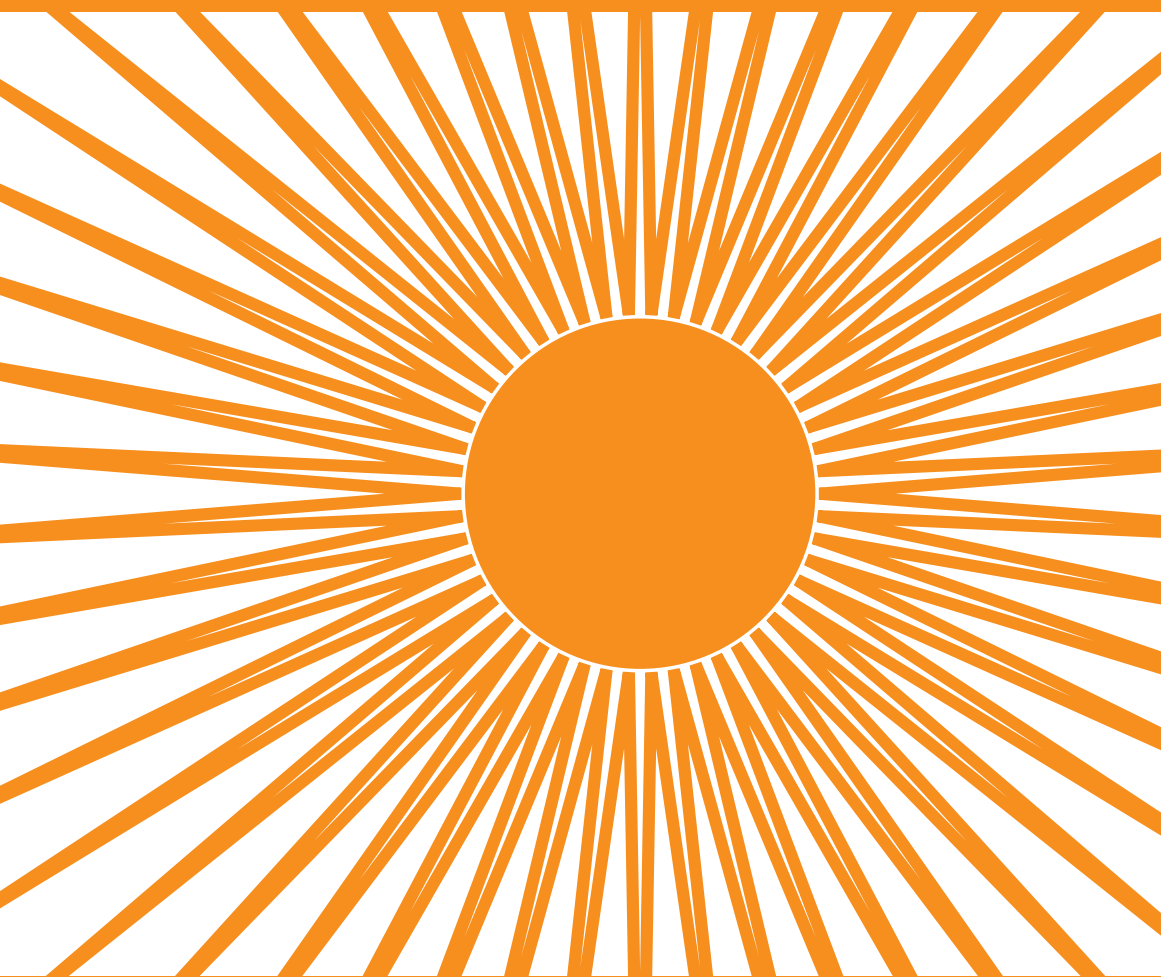

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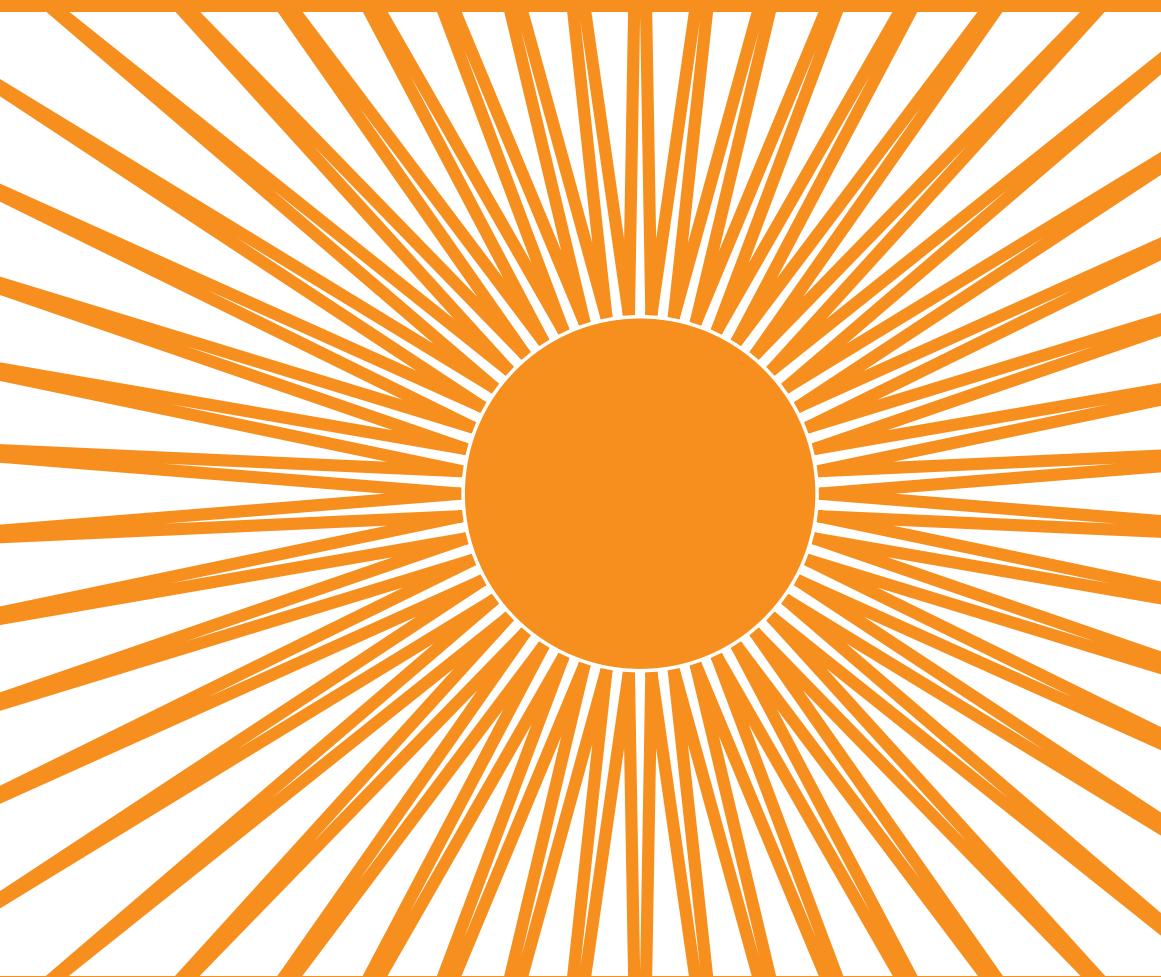

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ART

FRESH HILLS

ENERGY TECHNOLOGY
horizontal axis wind turbine

50 HOUSES
can be powered by this artwork (250 MWh per year)

DESIGN TEAM
Matthew Rosenberg, Matt Melnyk, Emmy Maruta, Robbie Eleazer

INFO

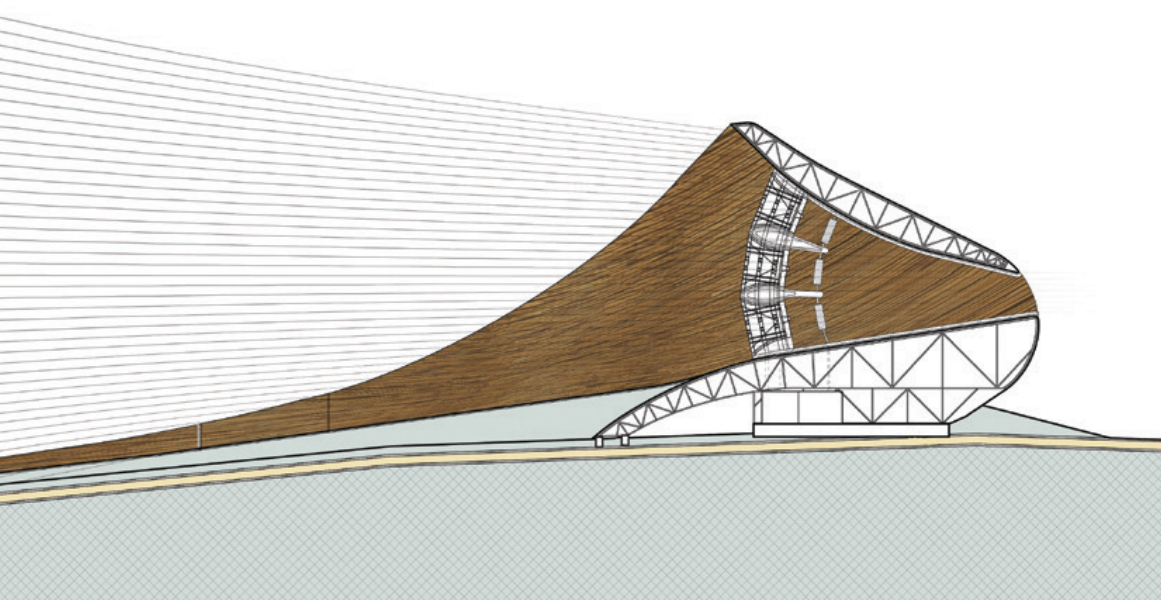
FRESH HILLS

ENERGY TECHNOLOGY
horizontal axis wind turbine

As the wind rushes up each side of the hill, it is concentrated into landforms that increase the velocity of flow and channel the energy to turbines located around a calm and pastoral central plaza. The landforms are generated by grafting the site's wind rose diagram onto the landscape to create a seamless exchange between site-specific data and a work of land art that harvests the energy of its environment.

LAGI 2012 FRESHKILLS PARK, NYC

Wind rushes into the bamboo land forms, and accelerates as it approaches the turbine.



TECH

HORIZONTAL AXIS WIND TURBINE (HAWT)

Horizontal axis wind turbines have been around for centuries. In the past 50 years their design has become increasingly efficient and streamlined to the 3-blade that we see dotting many of our landscapes. As the diameter (wind-swept area) increases, the power capacity goes up quickly and turbines are getting larger every year (approaching 200 meters diameter). A ducted (compact acceleration) wind turbine (right image) uses a cone or lens to concentrate the wind, increasing its velocity as it passes through the turbine (Venturi effect) and generating more electricity than a “free-running” turbine of the same diameter.

CHARACTERISTICS
dynamic, large, rotate, circle

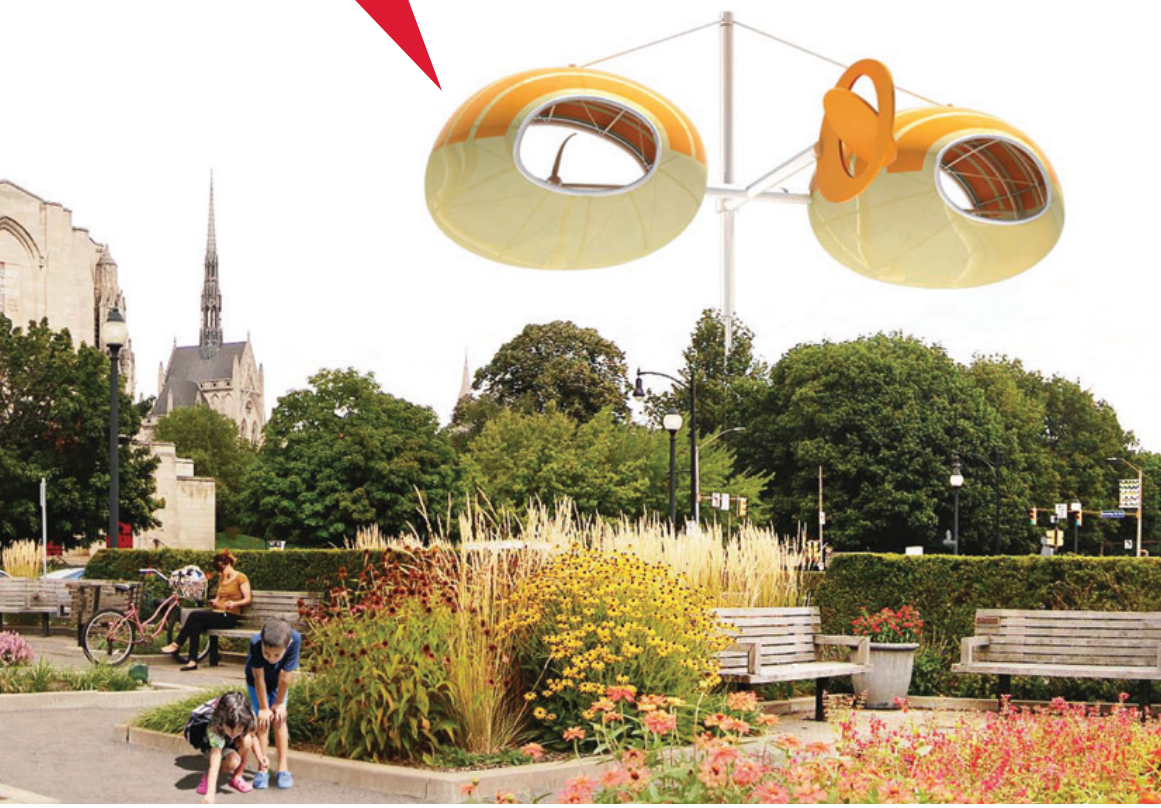
THIS CARD WORKS WITH
Fresh Hills, WindNest

IMAGES ABOVE
Onshore turbine; Offshore turbine (U.S. DOE); Ducted turbine in Fukuoka Prefecture Japan (Wikimedia Commons).

ART

WINDNEST

This artwork can power a carousel!



ENERGY TECHNOLOGY
horizontal axis wind turbine; organic photovoltaic

20 HOUSES
can be powered by this artwork (100 MWh per year)

DESIGN TEAM
Trevor Lee (Suprafutures)

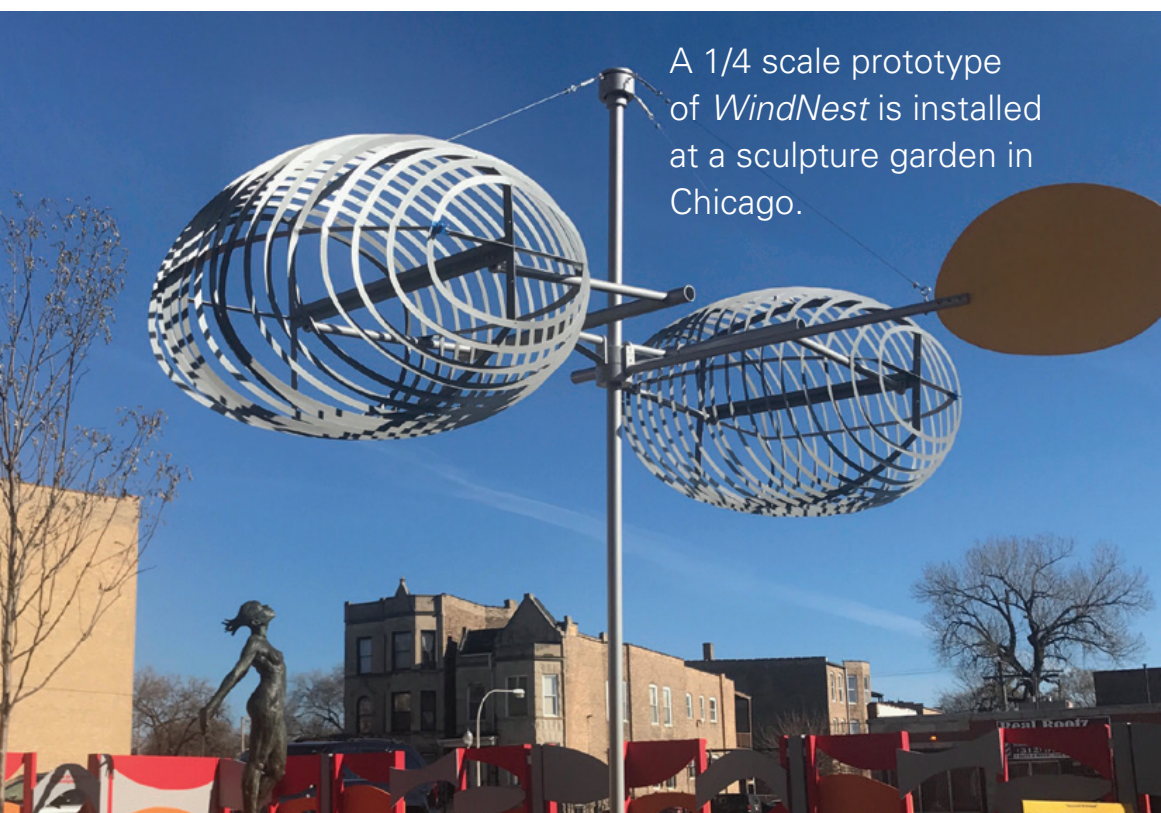
INFO

WINDNEST

ENERGY TECHNOLOGY
horizontal axis wind turbine;
organic photovoltaic

WindNest demonstrates the potential for our sustainable infrastructures to be joyful contributions to creative placemaking. Visitors experience a set of moving cloud formations overhead. As they linger on their way through this beautiful place, they will discover that the pods above them are generating clean electricity with a mix of wind and solar technologies—a power plant as full of wonder as the carousel it powers.

LAGI 2010 DUBAI / ABU DHABI



A 1/4 scale prototype of *WindNest* is installed at a sculpture garden in Chicago.

TECH

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CHARACTERISTICS
dynamic, large, rotate, circle

THIS CARD WORKS WITH
Fresh Hills, WindNest

IMAGES ABOVE
Onshore turbine; Offshore turbine (U.S. DOE); Ducted turbine in Fukuoka Prefecture Japan (Wikimedia Commons).

ART

WIND GRAZERS

ENERGY TECHNOLOGY
high altitude wind power

105 HOUSES
can be powered by this artwork (525 MWh per year)

DESIGN TEAM
Jennifer Sage, Peter Coombe, Andrew Kao, Allen Slamic, Taewook Cha, Trevor Sell, John Reed

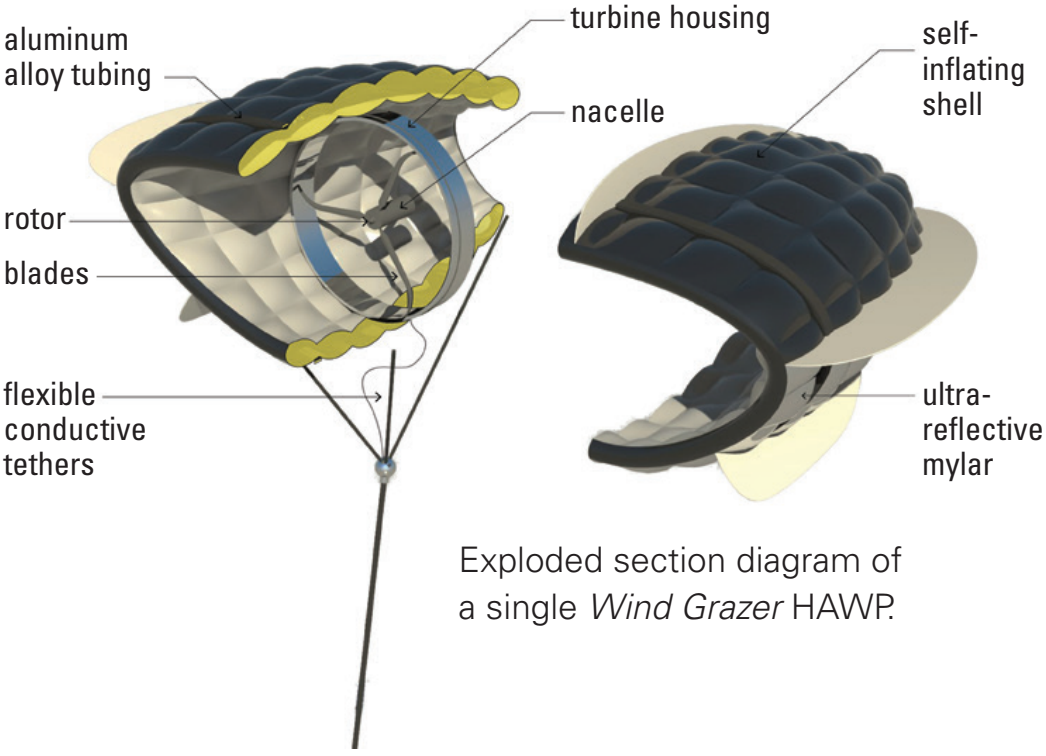
INFO

WIND GRAZERS

ENERGY TECHNOLOGY
high altitude wind power

A field of 200 turbines hovers in the sky, gridded like rows of crops recalling the site's agricultural past. Retractable tethers of equal lengths anchor an aerial array of turbines and project the topography into the sky, making it visible to the surrounding city. Each turbine is held aloft by helium-filled aerostats with horizontal axis wind turbines. At high altitudes these turbines can take advantage of very high speed winds, unimpeded by land surface friction and turbulence.

LAGI 2012 FRESHKILLS PARK, NYC



Exploded section diagram of a single *Wind Grazer* HAWP.

TECH

HIGH ALTITUDE WIND POWER

The power of the wind at high altitudes is stronger and more consistent than winds nearer to the ground. However, getting access to this source of energy presents an awesome design challenge. Experimentation has led to a variety of HAWP types including kites, sails, aerostats, airfoils, drogues, rotating blimps, and gliders like the one pictured above, designed to soar through crosswinds in a constant circle while multiple turbines on the wings send power to the grid below through a tether.

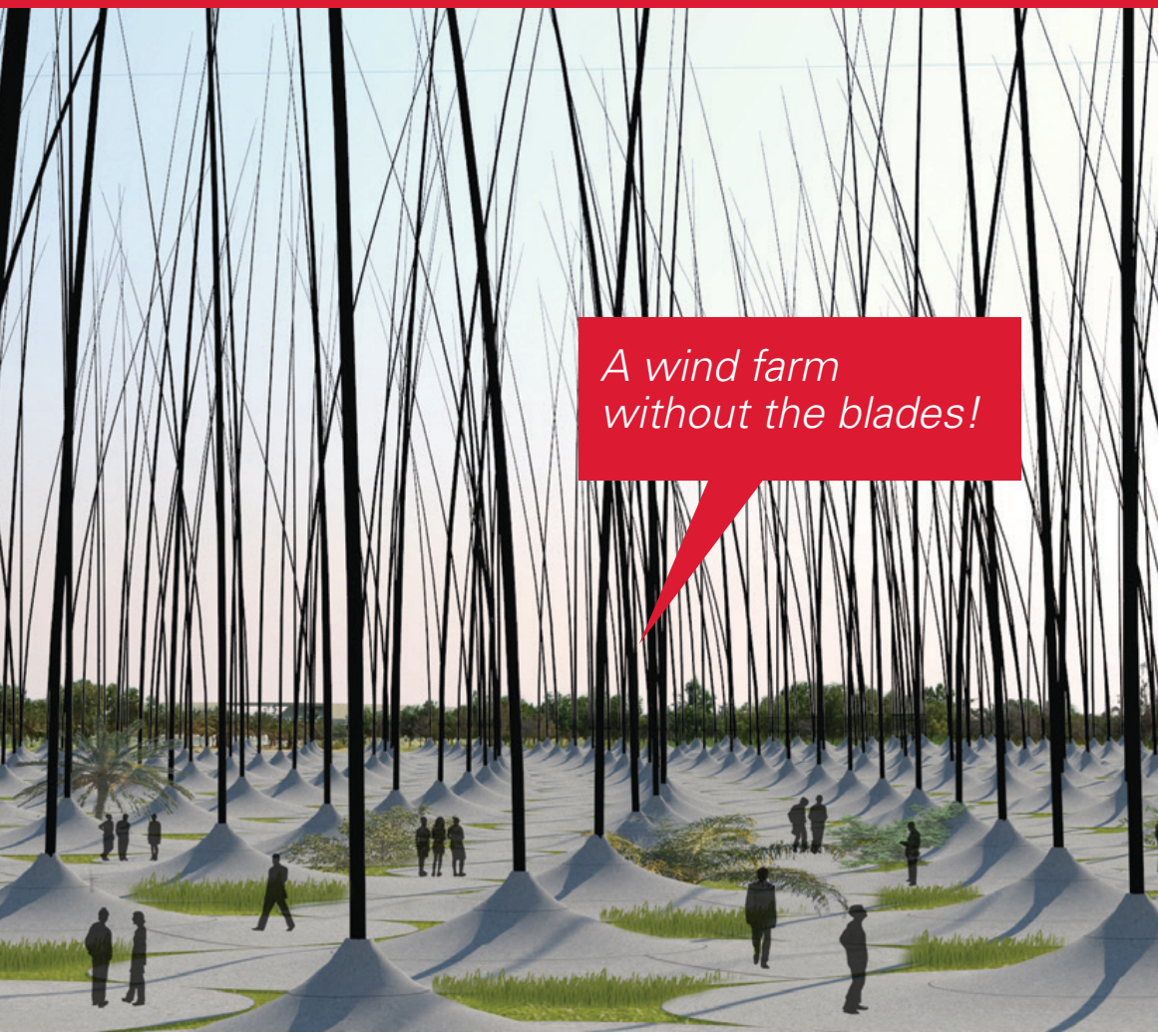
CHARACTERISTICS
dynamic, movement, tied to the ground, soaring in the clouds

IMAGE ABOVE
Image courtesy of Joby Energy.

THIS CARD WORKS WITH
Wind Grazers, UNWIND

ART

WINDSTALK



ENERGY TECHNOLOGY
kinetic energy harvesting (from wind) with piezoelectric disks

4,000 HOUSES
can be powered by this artwork (20,000 MWh per year)

DESIGN TEAM
Darío Núñez Ameni, Thomas Siegl, Gabrielle Jesiolowski, Radhi Majmudar, Ian Lipsky

INFO

WINDSTALK

ENERGY TECHNOLOGY
kinetic energy harvesting
(from wind) with piezoelectric disks

WindStalk is inspired by the way that a field of grass blades wave in the wind. The artwork consists of 1203 carbon fiber reinforced resin stalks, 55 meters high. The top 50 centimeters of the stalks are lit up by an LED array that glows with the strength of the wind. Like a sunflower, the stalks are arrayed along a logarithmic spiral. Visitors can walk on the bases of the stalks and listen to the sound that the wind makes as it rushes overhead.

LAGI 2010 DUBAI / ABU DHABI

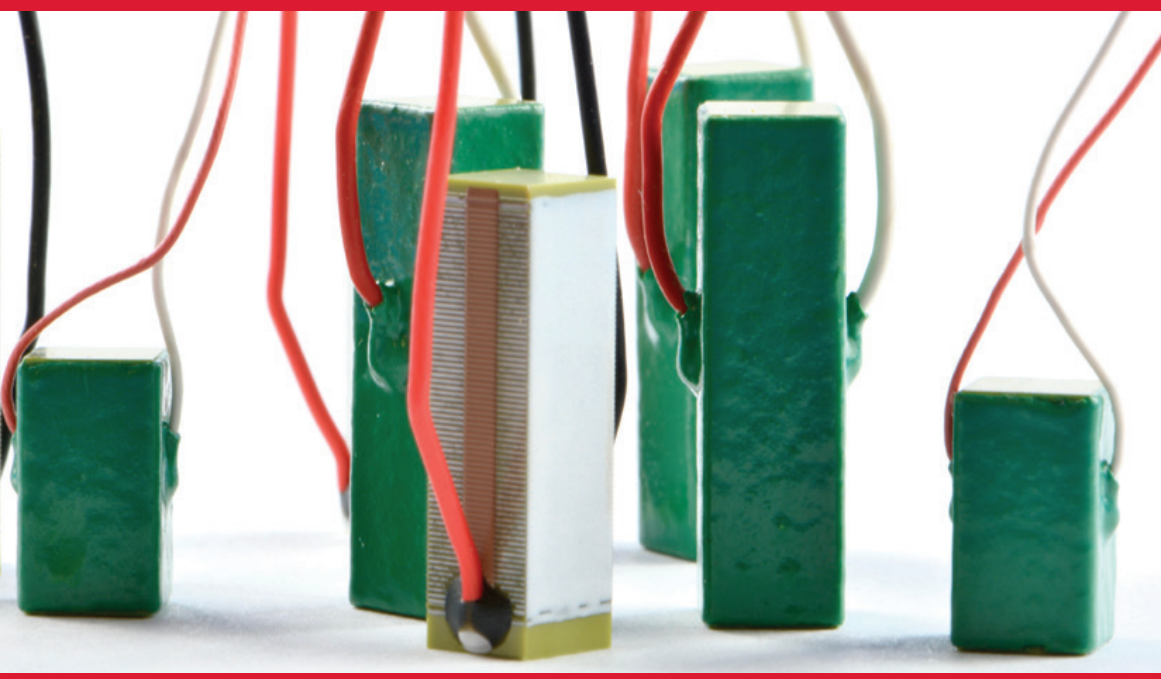
Within each hollow pole is a stack of piezoelectric ceramic discs. When the stalks sway in the wind the disks are forced into compression, generating a current.

Within each base is an array of shock absorbers (linear alternators) that convert the mechanical power of the swaying stalk into electrical power.

Chambers for pumped hydro storage.

TECH

KINETIC ENERGY HARVESTING
PIEZOELECTRIC DISKS



Kinetic energy (energy in motion) can be harvested and converted into electricity using technologies such as linear alternators and piezoelectric stack actuators. Piezoelectric materials naturally convert the mechanical strain of bending or pressure into electricity. They can be placed in pavers, roadways, or stacked inside long objects that sway in the wind. Linear alternators generate an electrical current through induction—a magnet moving back and forth through the center of a copper coil (solenoid).

CHARACTERISTICS
columnar, springy, bending, elastic, movement, coil, action, jump!

IMAGE ABOVE
Piezoelectric stack actuators. Image courtesy of Piezotechnik GmbH.

THIS CARD WORKS WITH
WindStalk

ART

AETHERIUS

ENERGY TECHNOLOGY
kinetic energy harvesting (from wind) with hydraulic cylinders

840 HOUSES
can be powered by this artwork (4,200 MWh per year)

DESIGN TEAM
Marilu Valente

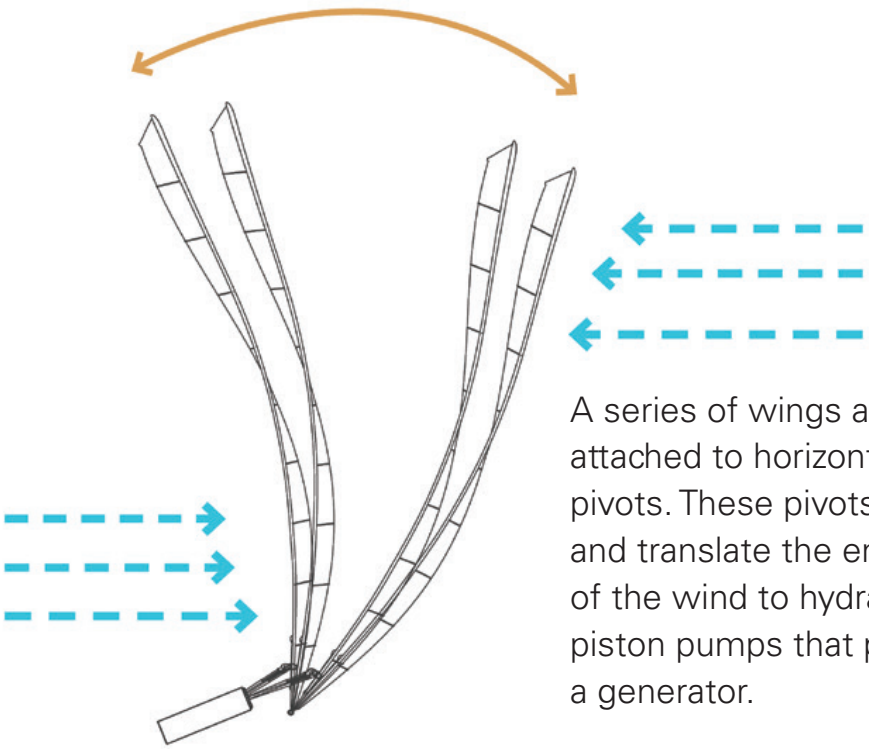
INFO

AETHERIUS

ENERGY TECHNOLOGY
kinetic energy harvesting (from wind) with hydraulic cylinders

Aetherius expresses the poetic potential and beauty of the wind. It moves according to wind speed, frequency, and direction—responding to unpredictability. A series of ultra-light wings move in a synchronized wave as the wind rushes across the surface of the artwork, reminiscent of the way that a fish moves through the water. The undulating façade reflects its environment, generates electricity, and creates a dynamic experience for visitors.

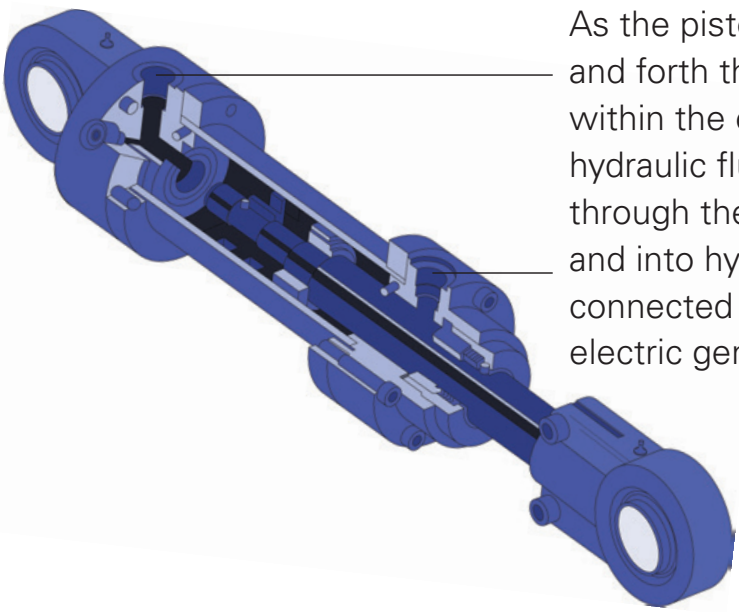
LAGI 2014 COPENHAGEN



A series of wings are attached to horizontal pivots. These pivots rotate and translate the energy of the wind to hydraulic piston pumps that power a generator.

TECH

KINETIC ENERGY HARVESTING
HYDRAULIC CYLINDERS



As the piston moves back and forth the pressure within the chamber causes hydraulic fluid to flow quickly through these two apertures and into hydraulic lines connected to a turbine and electric generator.

Hydraulic cylinders or pistons are a way to harvest kinetic energy (energy in motion). A force applied to the piston pumps a fluid through a closed loop to power a hydraulic motor that drives an electric generator. Any force or action that applies repeating pressure, such as ocean waves, wind, or even a playground seesaw can be converted into electricity in this way.

CHARACTERISTICS
linear movement, pressure, swinging, swaying, shaking

THIS CARD WORKS WITH
Aetherius

ART

ROTOR
IMMERSIVE WIND ENERGY

ENERGY TECHNOLOGY
vertical axis wind turbine

21 HOUSES
can be powered by this artwork (105 MWh per year)

DESIGN TEAM
Louis Gadd, Aimee Goodwin, Danny Truong

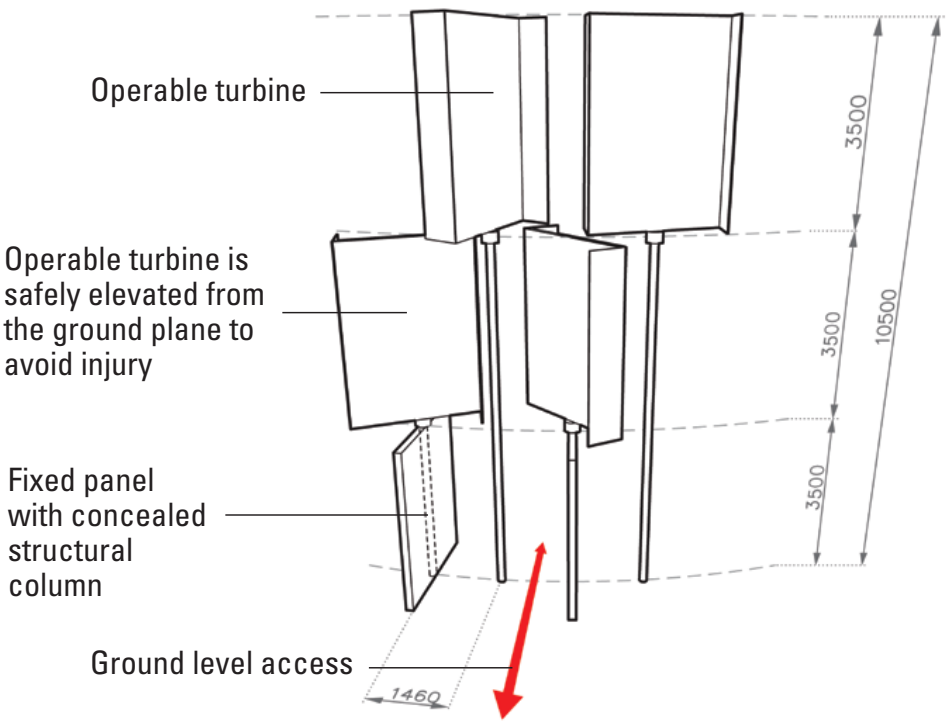
INFO

ROTOR
IMMERSIVE WIND ENERGY

ENERGY TECHNOLOGY
vertical axis wind turbine

Rotor is a circular array of 1.5 kW Savonius type vertical axis wind turbines. The custom rotor is made from stainless steel—polished to produce a highly reflective surface. The result is an immersive artwork that communicates the poetry of wind and engages people in ways that large wind turbines can't. The artwork harnesses the innate beauty of the invisible phenomena of wind and renders it visible to the public.

LAGI 2018 MELBOURNE



TECH

VERTICAL AXIS WIND TURBINE (VAWT)

Vertical axis wind turbines (VAWT) are generally either Darrieus or Savonius in type (named after their early 20th century inventors). A simple distinction is that Darrieus-type turbines use aerofoil blades and Savonius-type turbines use wind scoops. Gorlov helical turbine (GHT) is a variation on a standard Darrieus type. VAWTs have lower cut-in speeds (the wind speed at which they begin to produce electricity) than HAWTs and can be positioned lower to the ground.

CHARACTERISTICS
spinning, motion, reflective, kinetic, circle, screen

IMAGE ABOVE
RevolutionAir WT1KW (GHT type design). Image courtesy of PRAMAC. Design by Philippe Starck.

THIS CARD WORKS WITH
Rotor

ART

UNWIND

Energy is at play in the skies over this net-zero public park!

ENERGY TECHNOLOGY
high altitude wind power

380 HOUSES
can be powered by this artwork (1,900 MWh per year)

DESIGN TEAM
David Donley, Michael Cinalli

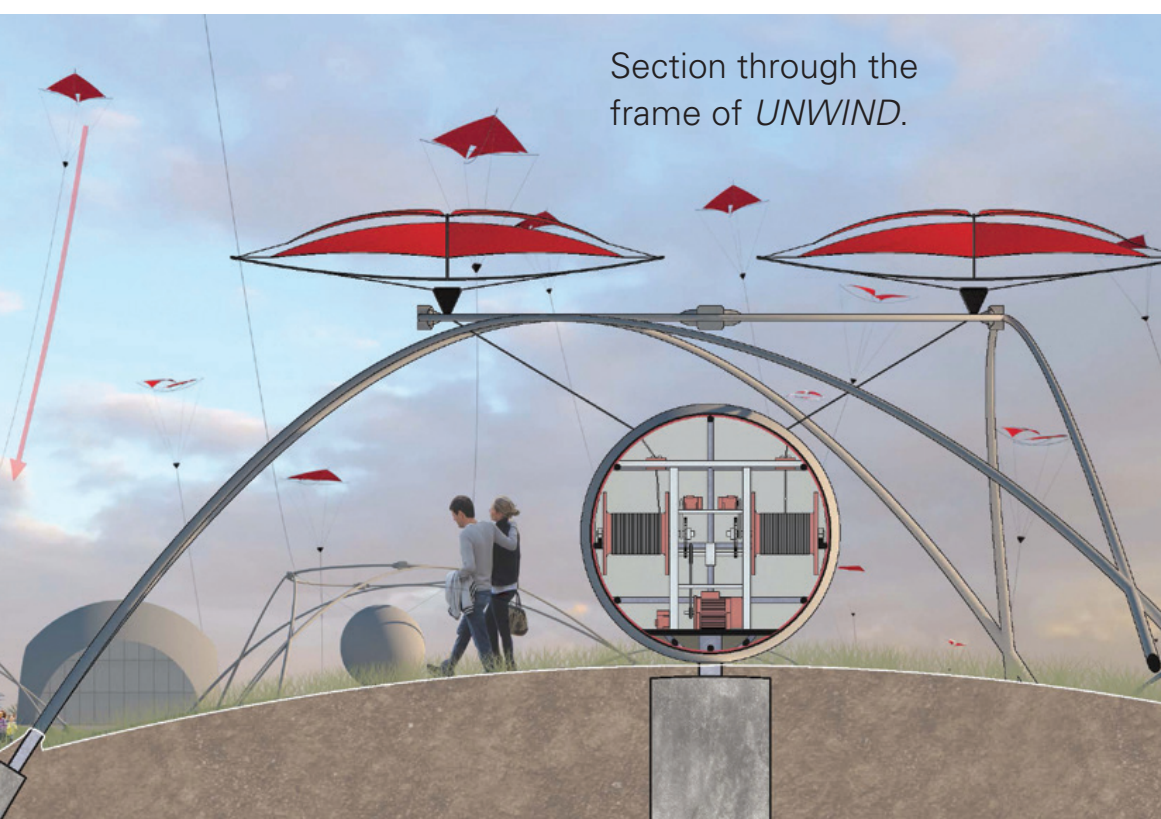
INFO

UNWIND

ENERGY TECHNOLOGY
high altitude wind power

Each unit in *UNWIND* operates on a system of two kites that cycle in a yo-yo style. As the first kite reaches its maximum height, the second kite begins its ascent. Inside the spheres are two spools connected to ratcheted gears that engage a flywheel, which regulates the sporadic speed of the unspooling kites into a consistent output speed. This rotational energy is harnessed by a generator that produces electricity.

LAGI 2018 MELBOURNE



Section through the frame of *UNWIND*.

TECH

HIGH ALTITUDE WIND POWER

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CHARACTERISTICS
dynamic, movement, tied to the ground, soaring in the clouds

IMAGE ABOVE
Image courtesy of Joby Energy.

THIS CARD WORKS WITH
Wind Grazers, UNWIND

TECH

WILD CARD

Play this card with any wind **ART** or **INFO** card.

DESIGN INNOVATION

Innovation happens when you dare to think creatively about challenges. The next decade promises to be an exciting time for new energy products and solutions, both in clean generation and in energy storage. New technologies that take advantage of turbulence, wind vortices, and aerostatic flutter can be incorporated into the design of our cities, landscapes, and public art.

TECH

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ART

GOLDEN ROOTS

A field of rye and poppies creates a natural energy landscape.

11 HOUSES
can be powered by this artwork (55 MWh per year)

DESIGN TEAM
Ronny Zschörper, Franziska Adler

ENERGY TECHNOLOGY **biomass**

INFO

GOLDEN ROOTS

ENERGY TECHNOLOGY **biomass**

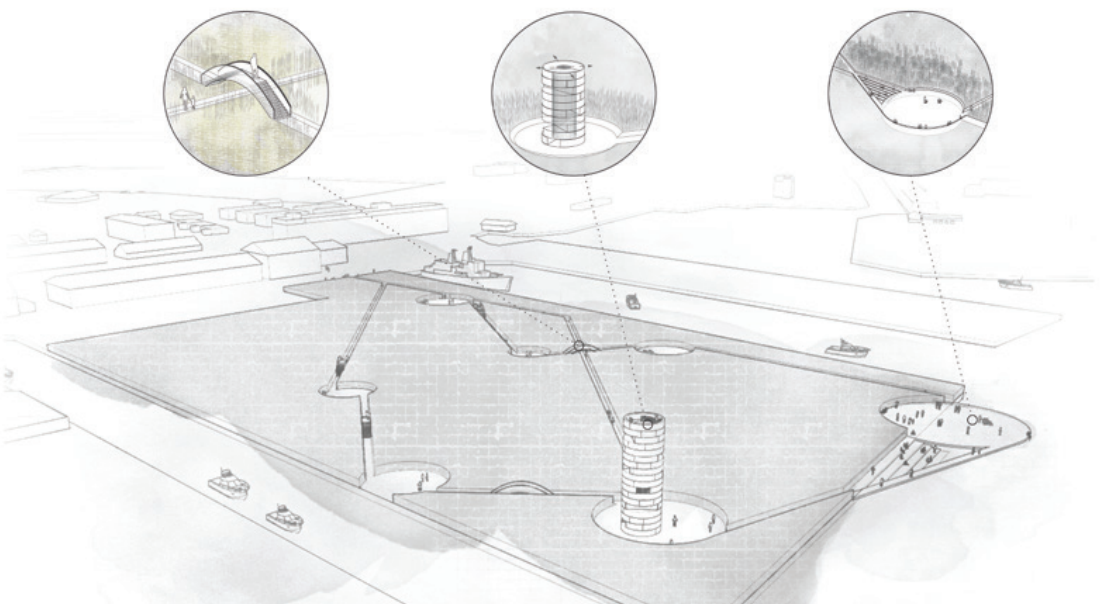
Golden Roots contrasts the urban environment with the experience of unspoiled nature. A system of paths and bridges guides visitors through a constellation of crop circles, bringing the calm countryside to life in the city. The fields are periodically harvested to generate high-energy biomass as well as to provide rye bales for the construction of observation towers, which change every season. The towers can rise up to 18 meters tall when maximum crop yields are achieved.

LAGI 2014 COPENHAGEN

Crossing Bridges
Bridges and underpasses provide barrier-free and unlimited access to the observation tower and the water's edge.

Observation Tower
The tower provides an additional view point with an altitude of 18 meters above the ground.

Water Platform
A direct water connection, additional entrance point, and a place to relax with a view of the city.



TECH

BIOMASS

Biomass can be combusted directly as a solid fuel or converted to liquid or gas biofuels. These biofuels can be used in either a combustion engine (conversion to mechanical energy) or in a fuel cell (conversion to electrical energy). Biogas is created through the breakdown of any organic material (biomass) in an oxygen-poor environment, such as a landfill or an anaerobic digester tank. Biogas is similar in composition to conventional natural gas and as such can be compressed or fed into a municipal gas grid and used for cooking, heating, lighting, transportation, and electricity production.

CHARACTERISTICS
hot, organic, fibrous, gaseous, earthy, grassy, fermented

IMAGE ABOVE
Sunflower field in Fargo, North Dakota.

THIS CARD WORKS WITH
Golden Roots

ART

SHIFTING ALGAE FOREST

ENERGY TECHNOLOGY
algae photobioreactor

20 HOUSES

can be powered by each algae tree

(100 MWh per year)

A hundred trees power 1,000 homes!

DESIGN TEAM

Jessica Wolff, Abhishek Sharma, Pamela Richot, Ekachai Pattamasattayasonthi

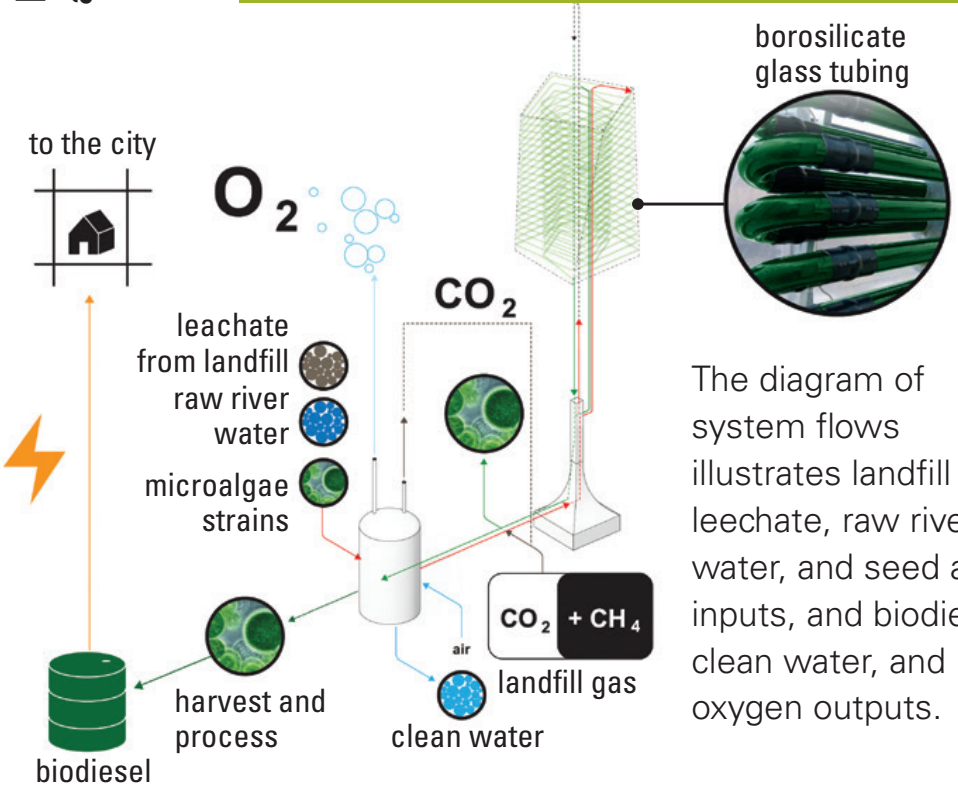
INFO

SHIFTING ALGAE FOREST

ENERGY TECHNOLOGY
algae photobioreactor

Shifting Algae Forest is a celebration of the hybrid ecologies that humans are formulating to protect and ensure the survival of our planet. The algae trees take the harmful legacy of urban waste streams and convert it into a newly productive landscape. As the "branches" of the bioluminescent algae trees glow at night, site users are informed of the amount of carbon dioxide that is actively being sequestered from the landfill during the day.

LAGI 2012 FRESHKILLS PARK, NYC



The diagram of system flows illustrates landfill gas, leechate, raw river water, and seed algae inputs, and biodiesel, clean water, and oxygen outputs.

TECH

ALGAE PHOTOBIOREACTOR

Biodiesel fuel can be produced from the naturally occurring oils (biolipids) that are found in algae, which can be cultivated by combining untreated waste water with CO_2 that is diverted from emissions streams at power plants, landfills, or other industrial sites. The density of fuel energy per unit of feedstock mass and the portability of liquid fuel makes algae biodiesel an important sustainable energy source for a post-carbon economy.

CHARACTERISTICS
green, saturated, tubes, dense

IMAGE ABOVE
Tubular glass photobioreactor by IGV Biotech via Wikimedia Commons.

THIS CARD WORKS WITH
Shifting Algae Forest

TECH

WILD CARD

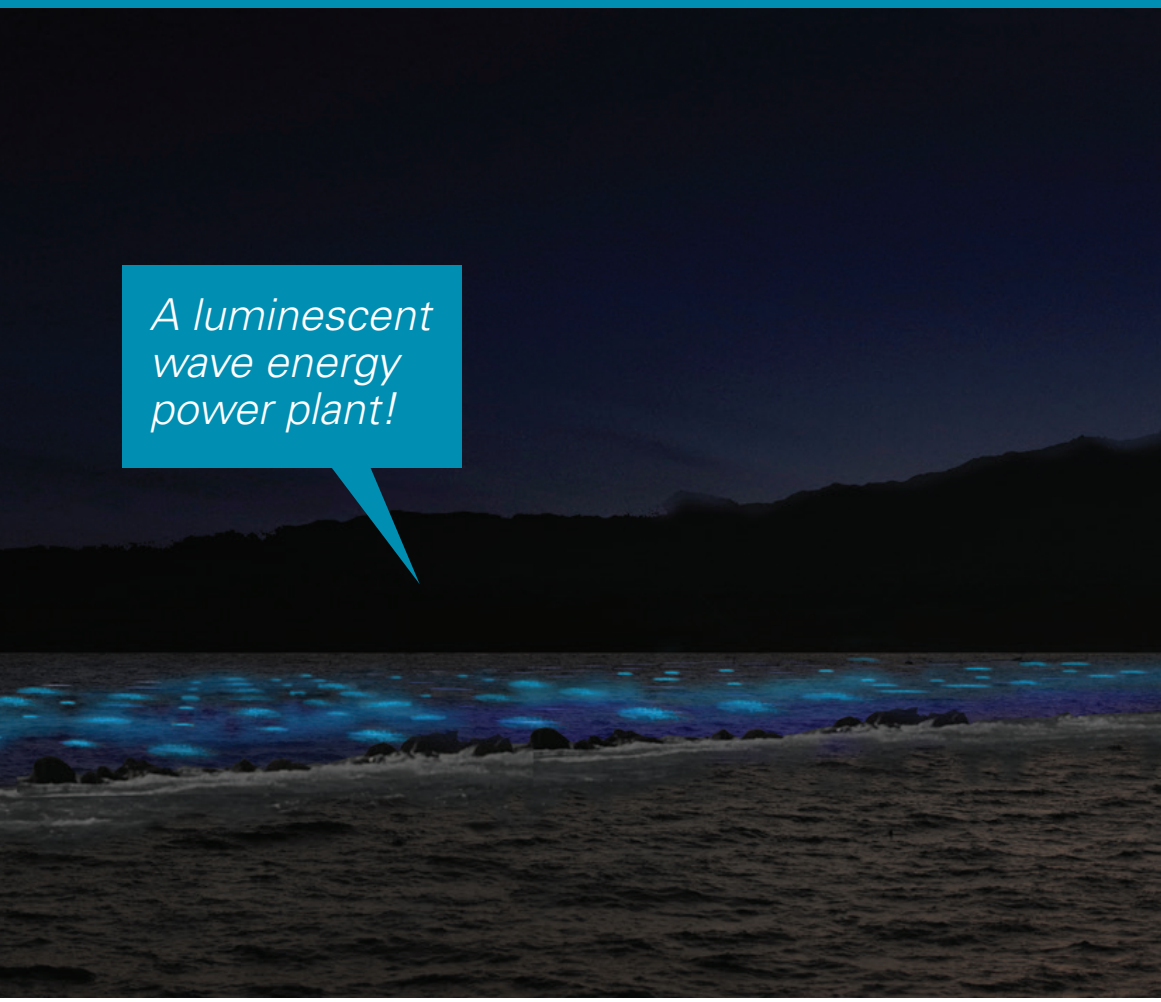
Play this card with any bio **ART** or **INFO** card.

DESIGN INNOVATION

Innovation happens when you dare to think creatively about challenges. The next decade promises to be an exciting time for new energy products and solutions, both in clean generation and in energy storage. Advances in our understanding of organic systems are leading to new energy technologies such as artificial photosynthesis and microbial fuel cells. How can we reveal the way these systems work through art in public space?

ART

NOCTILUCALES



ENERGY TECHNOLOGY
wave energy converter (hydrokinetic attenuator)

840 HOUSES
can be powered by this artwork (4,200 MWh per year)

DESIGN TEAM
Ricardo Avella, Andrés Tabora, Michael Henriksen, Carla Betancourt, Silvia Mercader, Laura Vera, Oriana De Lucia, Martin Von Bülow, Laura Vivas, Miguel Rosas

INFO

NOCTILUCALES

ENERGY TECHNOLOGY
wave energy converter (hydrokinetic attenuator)

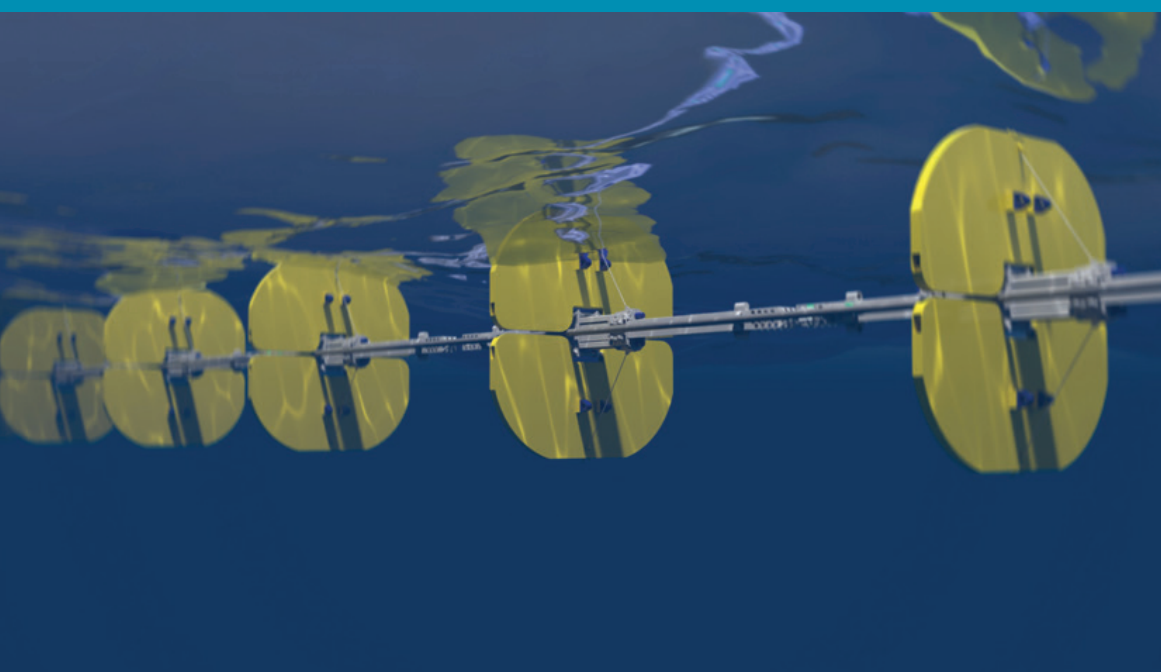
Noctilucales preserves the horizon line of the ocean. The artwork consists of a network of moving plates installed along cables. The movement of the plates creates hydraulic pressure, which is converted into electricity. Each moving plate casts a subtle glow at night. The energy collectors are seen as a field of lights, producing a bioluminescent effect similar to the one created by natural Noctilucales in some parts of the world.

LAGI 2016 SANTA MONICA

At dusk a soft glow appears on the far side of the breakwater. Energy production continues at all hours of the day.

TECH

WAVE ENERGY CONVERTER
HYDROKINETIC ATTENUATOR



Surface-following (attenuator type) wave generation uses long sets of interconnected segments that create pressure in chambers of oil as the parts shift their position under the influence of waves.

The oil pressure drives hydraulic motors to power electric generators.

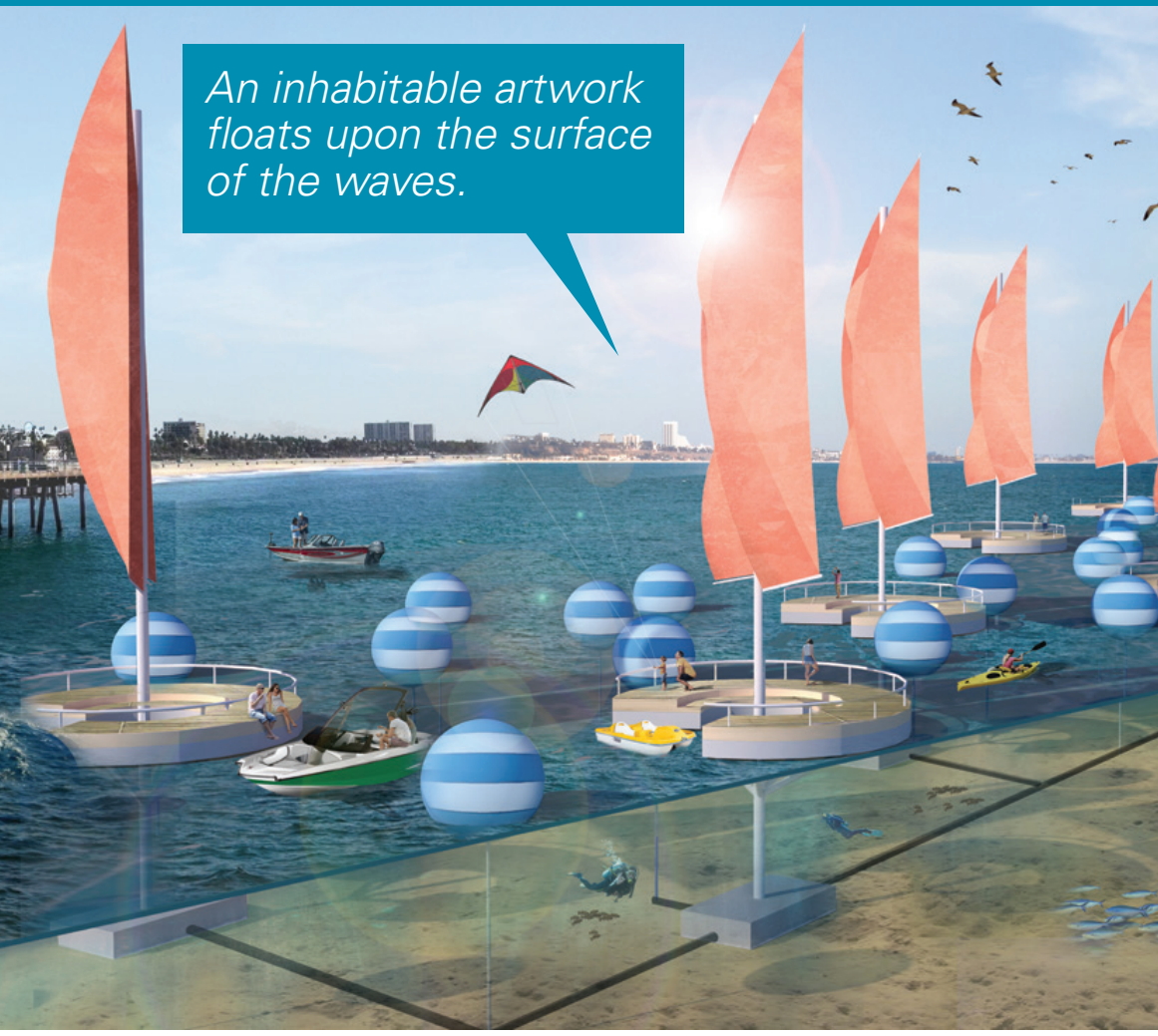
CHARACTERISTICS
rocking, floating, long, glowing, serpentine

IMAGE ABOVE
Image courtesy of Wavepiston™.

THIS CARD WORKS WITH
Noctilucales

ART

CATCHING THE WAVE



ENERGY TECHNOLOGY
wave energy converter (point absorber)

3,200 HOUSES
can be powered by this artwork
(16,000 MWh per year)

DESIGN TEAM
Christina Vannelli, Liz Davidson, Matthew Madigan

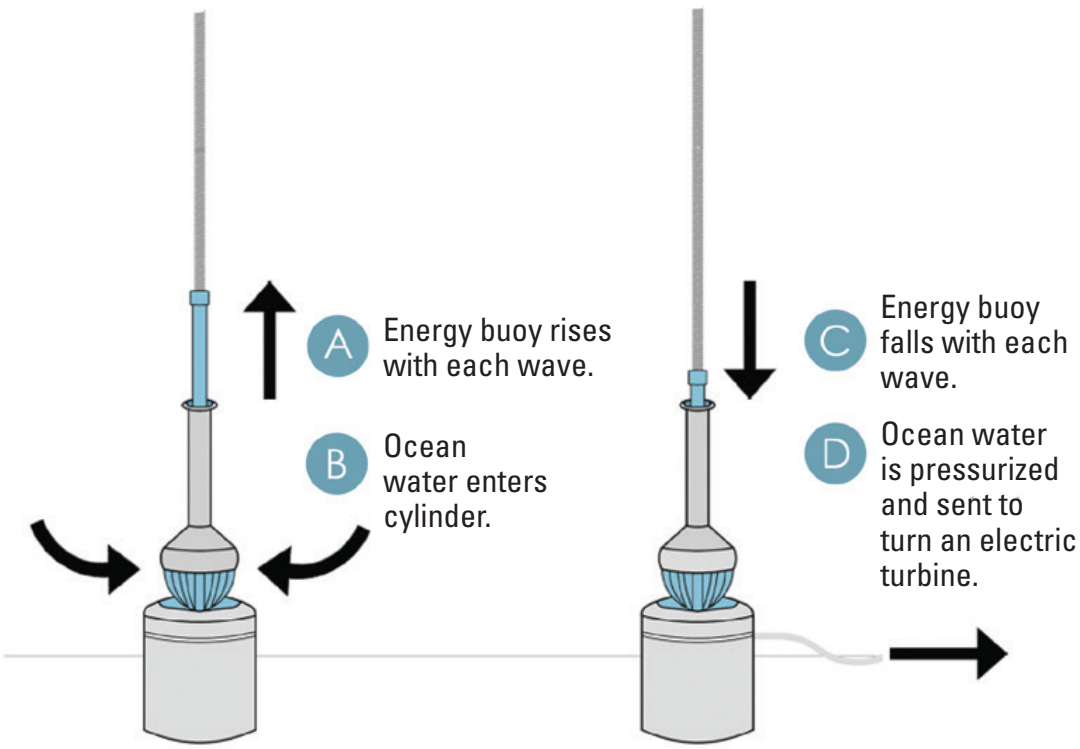
INFO

CATCHING THE WAVE

ENERGY TECHNOLOGY
wave energy converter (point absorber)

The area behind the Santa Monica Pier breakwater was once home to a yacht harbor filled with hundreds of sailboats and moorings. *Catching the Wave* recalls this history by celebrating the relationship of a sail ship and its mooring. The installation is made up of 60 buoys that capture wave energy. Each buoy is connected to a piston mounted on the ocean floor by a flexible tether. The movement of the piston first pulls in sea water, then pressurizes it to power an electric generator.

LAGI 2016 SANTA MONICA



TECH

WAVE ENERGY CONVERTER
POINT ABSORBER

Buoy type wave generators use the motion of the waves at a single point. Some use the up and down motion to transfer pressurized liquid or air within chambers to spin turbines.

Deeper water provides longer waves and more regular wave energy without as much potential for damage to equipment from cresting waves.

CHARACTERISTICS
buoy, up-down, bright, water, nodes, interconnected

IMAGE ABOVE
Image courtesy of Ocean Power Technologies, Inc.

THIS CARD WORKS WITH
Catching the Wave, Follies and Fog

ART

THE CLEAR ORB

ENERGY TECHNOLOGY
wave energy converter (oscillating water column)

764 HOUSES
can be powered by this artwork (3,820 MWh per year)
+ 2,200,000 liters of fresh water for the pier!

DESIGN TEAM
Jaesik Lim, Ahyoung Lee,
Jaeyeol Kim, Taegu Lim

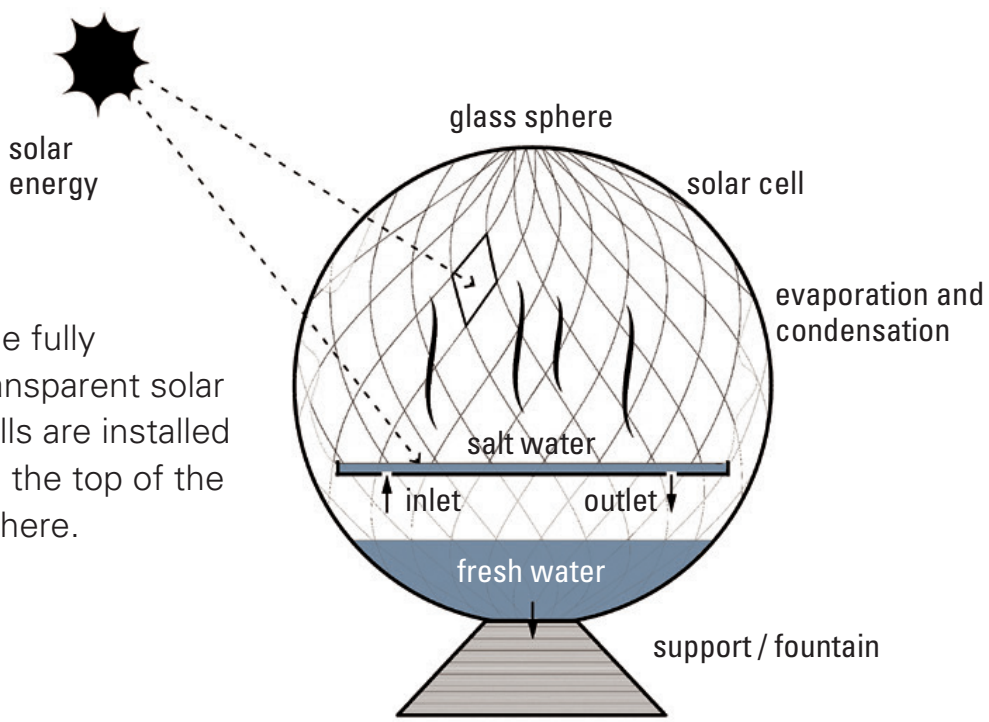
INFO

THE CLEAR ORB

ENERGY TECHNOLOGY
wave energy converter (oscillating water column)

The Clear Orb appears to float upon the surface of the ocean. The colors of the sky are refracted through the translucent solar photovoltaic glass upper section, while the lower hemisphere's reflective surface glitters with the sunlight playing on the ocean waves. The *Orb* is a solar still that produces fresh water from seawater through evaporation and condensation. Part of the energy generated by the oscillating water column pumps seawater into the evaporation tray.

LAGI 2016 SANTA MONICA

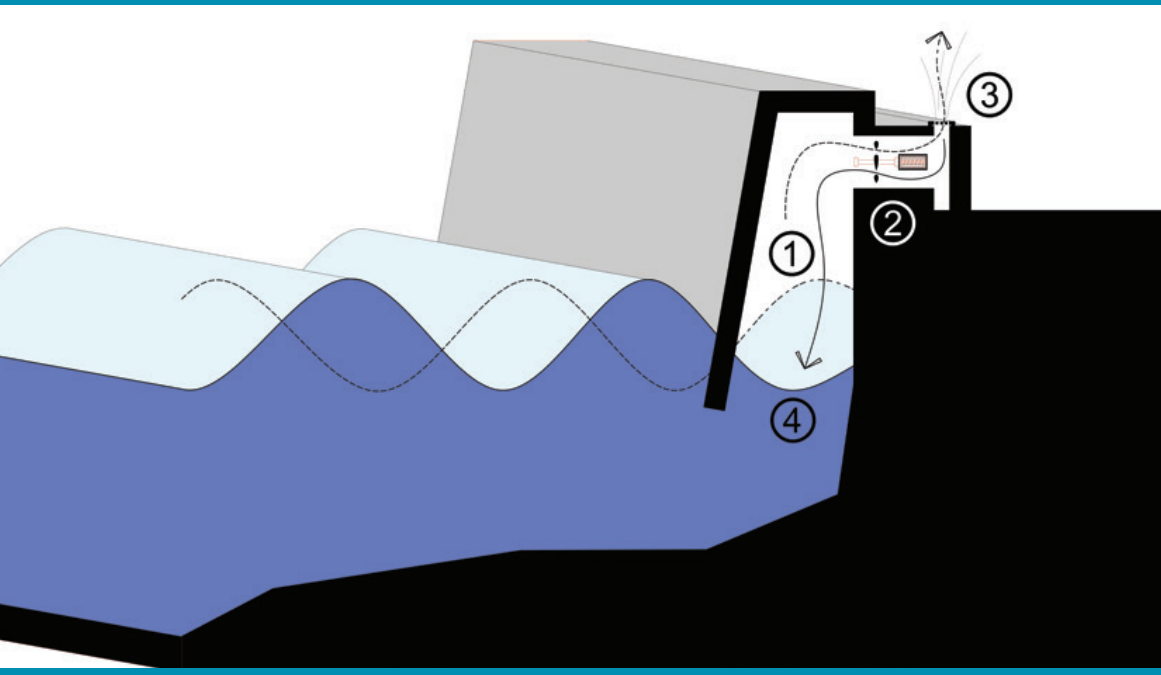


The fully transparent solar cells are installed on the top of the sphere.

TECH

WAVE ENERGY CONVERTER

OSCILLATING WATER COLUMN



An oscillating water column wave energy converter harnesses the continuous energy of the waves as they flow into and out of a large air chamber along the shoreline. When the wave rushes in ①, the air in the chamber is compressed and when it rushes out ④, the air becomes very low pressure. As air rushes into and out of the chamber ③ to equalize the air pressure in the chamber, a special type of turbine—a Wells turbine ②—spins continuously in one direction to generate electricity at a relatively constant rate.

CHARACTERISTICS
crashing, loud, air, water, edge, spinning

THIS CARD WORKS WITH
The Clear Orb

ART

FOLLIES AND FOG

ENERGY TECHNOLOGY
wave energy converter (point absorber)

2,600 HOUSES
can be powered by this artwork (13,000 MWh per year)

DESIGN TEAM
Nik Klahre, Brooke Campbell-Johnston

INFO

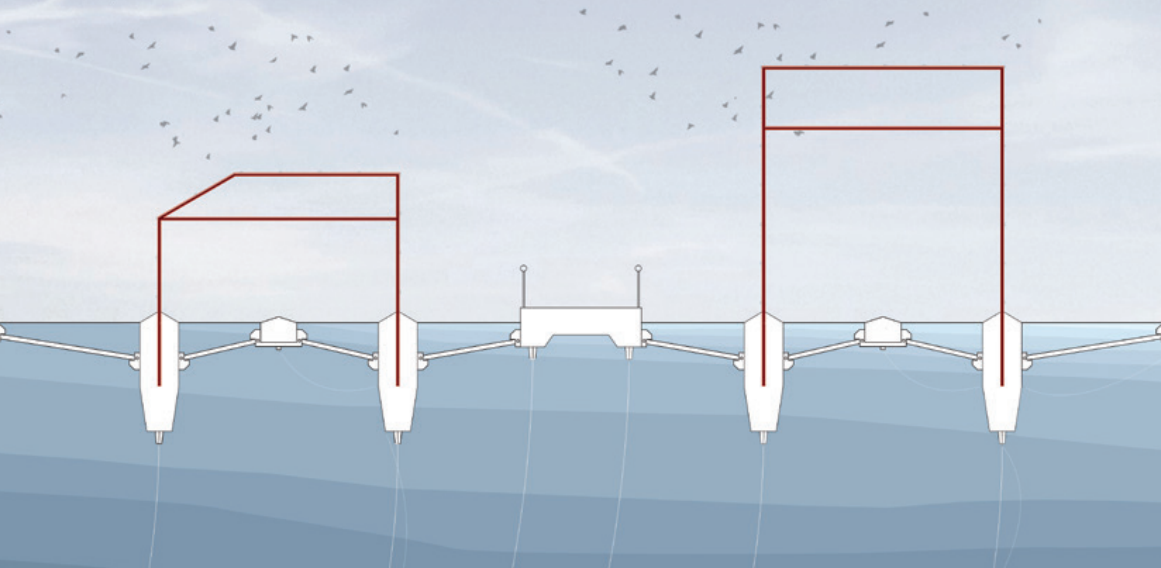
FOLLIES AND FOG

ENERGY TECHNOLOGY
wave energy converter (point absorber)

The artwork makes visible the hidden activity of wave energy production. Connected to a floating grid of buoy-type wave energy converters are 128 follies. As the amount of energy generation nears peak productivity during periods of intense wave activity, an artificial fog engulfs the artwork in a cloud of mist. As the waves become less powerful, the viewer is able to again see the artwork from the shore as the cloud of artificial fog begins to disburse.

LAGI 2016 SANTA MONICA

This section through the follies shows the point absorber wave energy devices, their interconnections to pedestrian walkways, and their anchoring to the seabed.



TECH

WAVE ENERGY CONVERTER
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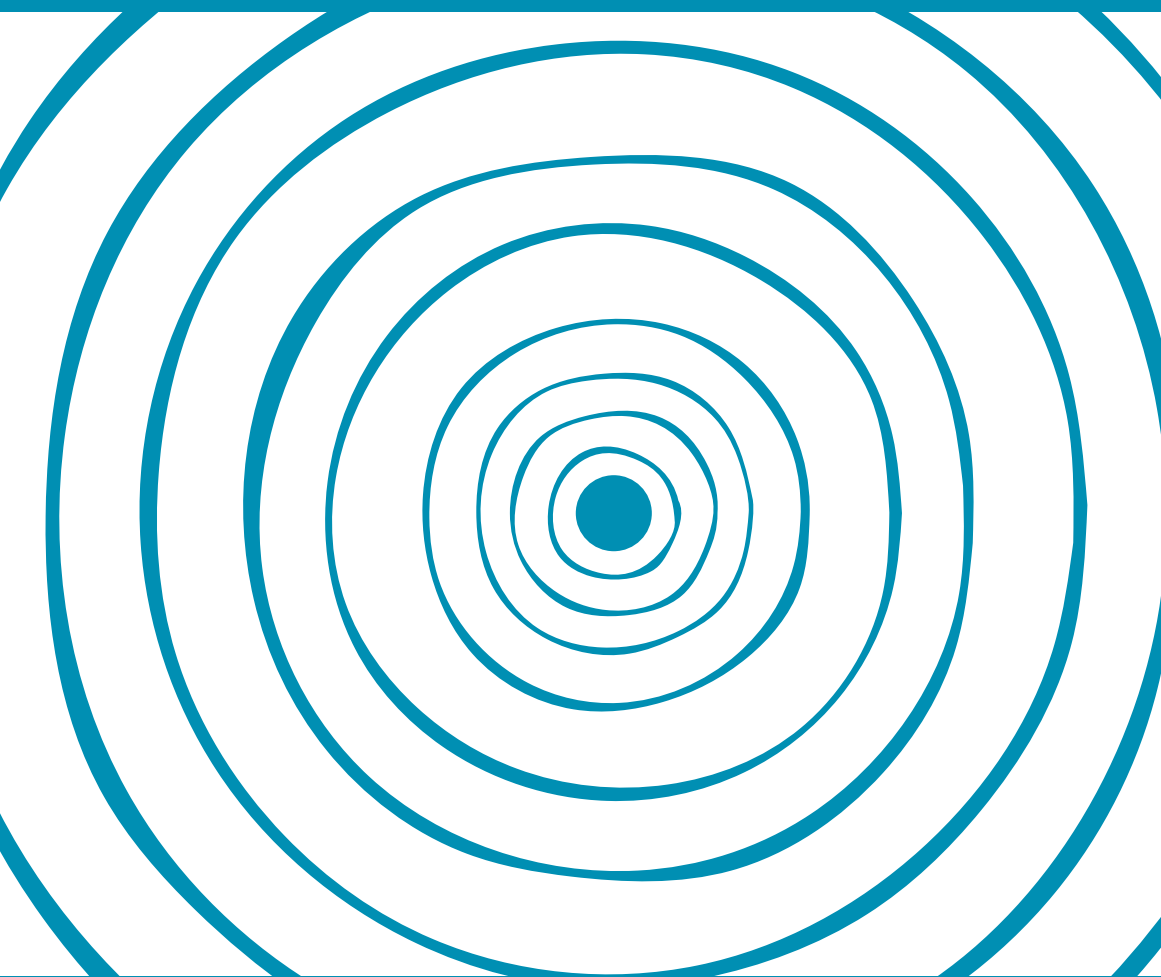
IMAGE ABOVE
Image courtesy of Ocean Power Technologies, Inc.

THIS CARD WORKS WITH
Catching the Wave, Follies and Fog

TECH

WILD CARD

Play this card with any hydro **ART** or **INFO** card.



DESIGN INNOVATION

Innovation happens when you dare to think creatively about problems. The next decade promises to be an exciting time for new energy products and solutions, both in clean generation and in energy storage. Biomimetic designs—inspired by the way that fish, eels, and cephalopods move through water—are advancing our ability to draw energy from flowing water without harming wildlife.

TECH

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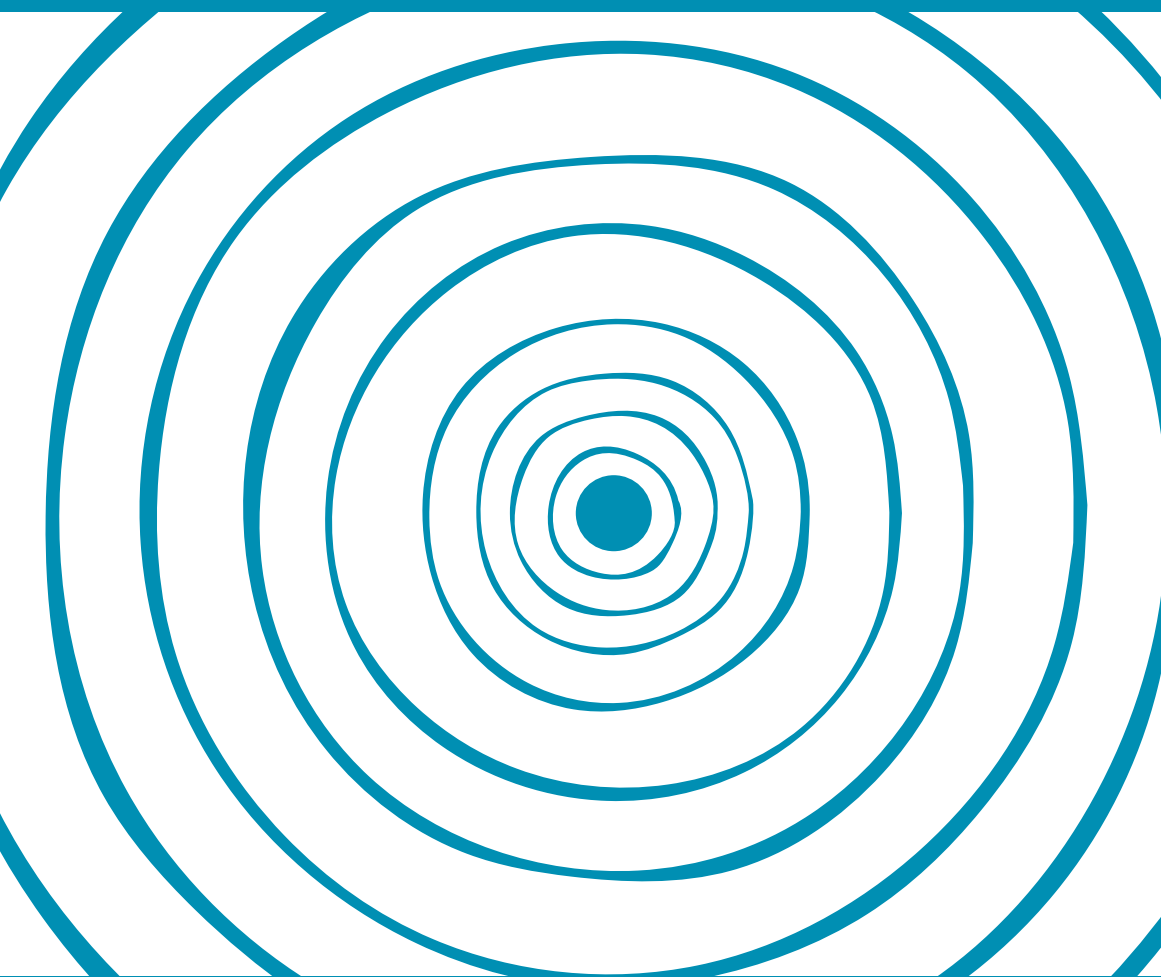

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2–5 players
Ages 13 +

INSTRUCTIONS & GAME RULES

HOW TO MATCH

Match an **ART** card with its corresponding **INFO** card for a two-card match.

EXAMPLE
Sun Ray **ART** ①
Sun Ray **INFO** ②

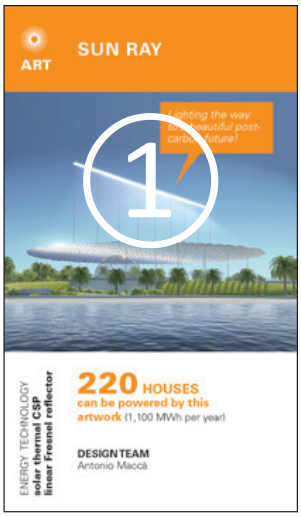
OR Match an **ART** or **INFO** card to the **TECH** card that it works with.

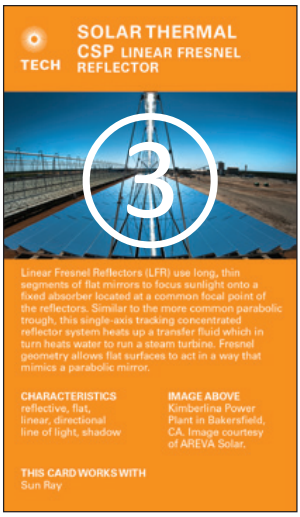
EXAMPLE
Sun Ray **ART** ① or **INFO** ②
Solar Thermal CSP *Linear Fresnel Reflector* **TECH** ③

OR Match a full set of **ART, INFO,** and **TECH** cards.

EXAMPLE
All three cards together as shown below

A **WILD CARD** can take the place of any **TECH** card in its category (solar, wind, bio, hydro).





2–5 players
Ages 13 +

INSTRUCTIONS & GAME RULES

BEGIN

Each player is dealt five (5) cards.

The remaining cards are placed in a draw pile, face-down.

The first player is the one to the left of the dealer.

Gameplay is in a clockwise direction.

Set a timer for 7-minutes.

If you can't transition to renewable energy quickly enough, you risk the whole table losing to a massive climate feedback loop.

PLAY

1. The first player looks at their hand to see if they can make any matches. If they can, they place one match (either a set of two or a full set of three) face-up on the table. Players can only place one match per turn.

If they cannot make any matches, the same player asks the table if anyone has a **TECH** card that could help them make a match.

2. If another player has the requested **TECH** card, that person is obligated to hand that card over and replace it with a card from the draw pile.

2–5 players
Ages 13 +

INSTRUCTIONS & GAME RULES

Players may only ask the table for a **TECH** card. If the player does not need a **TECH** card, they will skip this step. If successful in seeking a match with a **TECH** card, the player places their match face-up on the table and ends their turn.

3. If no player has the requested **TECH** card—or the player still cannot make a match—they draw one card. If the card drawn allows them to make a match, they may do so and place it face-up on the table. If throughout their turn the player is unable to make a match, their hand grows by one card. Players can place only one match per turn on the table.

Play moves to the next person, who follows the same steps.

As soon as there are matches on the table, players may choose to finish a 2-card set by laying the matching card in their hand next to that set, making a full set of three.

Play continues until one person has "played to zero" exhausting the cards in their hand and thus saving the planet, or until the timer goes off.

POWER

landartgenerator.org

Why play to ZERO?

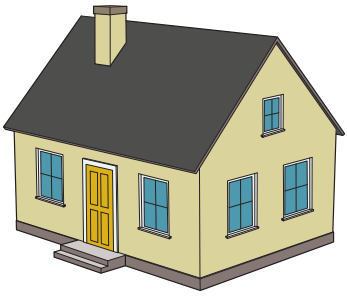
A prosperous world that produces ZERO greenhouse gas emissions from the burning of fossil fuels will allow our planet to avoid a tipping point of runaway global warming. We can get there, but we have a long way to go. In 2017 we pumped 32.5 billion metric tons of carbon emissions into our very thin atmosphere and the number keeps rising every year. We must turn this around immediately and bring carbon emissions all the way to ZERO by the middle of the 21st century or we are risking the lives of millions of people.

The good news is that we live in a world of plenty and we already have the technology needed to bring about a prosperous and equitable net-ZERO world. If we design it, we can pass along to our children a global "circular economy" powered by the energy of the sun, wind, and water.

A circular economy is one in which we do not pollute our precious environment. Instead we use 100% biodegradable materials and reduce our waste streams to ZERO.

POWER

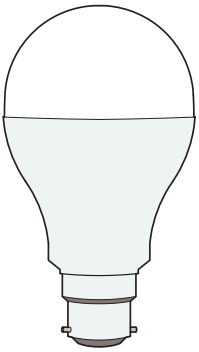
landartgenerator.org



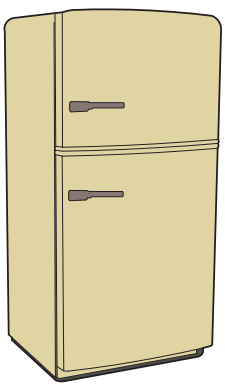
How many Homes?

A large and inefficient single family house—poorly insulated with the lights and air conditioning on all the time—will use about 10 MWh per year. That is how much the average home uses in the United States for example.

More efficient single family homes use far less—about 5 MWh per year—which happens to be the average in Australia.



5 MWh per year is the number that we have used in this game on the **ART** cards.



Smaller homes and apartments can use even less than that. The very best home, of course, is the one that uses the least energy or even ZERO energy!

POWER

landartgenerator.org

MWh: A mega what?

A watt is a unit of measure of electrical *power* equivalent to 1/746 horsepower.

A watt-hour is the measure of electrical *energy* equivalent to one watt of power used or produced consistently over one hour of time.

A kilowatt-hour (kWh) is 1,000 watt-hours, or one kW output or consumption of power over a one hour period of time.

A megawatt-hour (MWh) is one million watts delivered continuously over one hour (or 1,000 watts delivered continuously over 1,000 hours).

One solar module can generate 300 watts of power when facing the optimal direction on a bright sunny day. Over the course of a year that power accumulates to between 315 kWh–525 kWh of energy per year depending on the climate.

To meet the yearly consumption of a 5 MWh per year home, you can install 10 solar modules if you live in a sunny climate or 16 solar modules if you live in a cloudy climate.

POWER

landartgenerator.org

About LAGI

The great energy transition will have an impact on our built environment and our cherished landscapes like no other technical advance since the automobile. Our cities and countrysides will look different in 2040 than they do today. At less than 2% share of our energy portfolio, the expanding presence of wind and solar infrastructure has already sparked intense debates about land use and real estate values.

But what if clean energy installations were designed as elegant solutions, appealing to the human need for aesthetics and beauty, for art and high design? What if we could spark the imagination of the world, inspiring the public about the beauty and cultural richness of our post-carbon cities?

The Land Art Generator Initiative (LAGI) is doing that by engaging interdisciplinary creative teams to innovate and collaborate —to design our new energy landscapes as playful works of art in public space.

POWER

landartgenerator.org

CREDITS
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AVAILABILITY
This Land Art Generator card game is available for free download in pdf format at **www.landartgenerator.org**

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