WHY DESIGN NOW?
National Design Triennial

Smithsonian
Cooper-Hewitt, National Design Museum
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New York
There is now scientific and political consensus that global greenhouse-gas emissions pose a critical threat to the earth’s climate, and that this environmental warming is produced by the burning of fossil fuels—by human actions. As about 86% of energy used globally is generated from the use of oil and coal, which produces greenhouse gases, responsive action must be taken through significant cooperation at an international level, balancing the responsibilities of advanced as well as rapidly developing industrial economies. For the United States, which imports about 70% of the oil it consumes and has among the highest carbon-dioxide emissions per capita in the world, the goal must be to make decisive policy, technological, and social changes. Designers, both in this country and elsewhere, can be important contributors to this urgent assignment.

One of the fastest, easiest, and least expensive ways to slow climate change is to use less energy. But efficiency can only take us so far. To achieve more substantial reductions in the production of greenhouse gases, we must replace our current energy supply with clean, renewable energy—a shift which presents countless design opportunities. Fortunately, designers the world over, often in collaboration with scientists and engineers, are innovating solutions that harness such clean energy.
energy sources. Many of the products are at the small, domes-
tic, even microscopic scale, while others are still too expensive,
complex, or experimental to be implemented immediately.

Sunlight is the world’s largest source of renewable energy.
The pressing dilemma is in finding inexpensive ways to store
solar energy, for there is no sunlight at night and its output
during the day depends on the weather. Vast amounts of afford-
able storage are needed: one expert calculates that an array of
photovoltaic solar panels spread across more than half the land
area of California would be needed to meet the daily energy
needs of the United States; at present, all panels built to date
cover barely ten square miles. Greater efficiency and cost
reduction are being achieved by Zenith Solar in Israel, whose
Z-10 system concentrates and intensifies sunlight to create
heat through the use of simple mirrors and tracking devices; a
design inspired by sunflowers (fig. 1). Breakthroughs in nano-
technology are also making solar panels more affordable and
efficient, and are alleviating the storage problem by capturing
energy in small, decentralized fuel cells. Thin, flexible plastic
solar panels resembling rolls of film offer “portable” electricity
that can be unfurled and wrapped around structures. One
advocate suggests that solar power is doubling every two years;
that we are only eight doublings away from meeting 100% of
the world’s energy needs; and that we have 10,000 times more
sunlight than we need to do this.1

Wind is another viable source of clean energy. It is growing
in popularity primarily through the use of larger and highly
engineered terrestrial turbines, especially in Northern and
Western European countries, where giant offshore wind farms
are becoming common in the North Sea. Wind power requires
less land footprint than any other option,2 but, similar to
other forms of renewable energy, conventional wind energy
is subject to fluctuations in weather and limitations imposed
by the availability of electrical transmission. Alternatively,
high altitudes promise to provide more consistent energy
from the powerful and more dependable winds aloft, with
fewer transmission problems because high-altitude winds
are relatively independent geographically. This is spurring
designers to experiment with various aerial structures
to harness high-altitude winds, such as the wing-shaped kites
designed by Makani Power in California (fig. 2).

Ocean wave and tidal power can also be captured to
produce electricity, and, according to some scientists, it is the
largest unexplored source of renewable energy. It requires
no land and is more dependable than solar or wind power, as
tides rely on the gravitational forces of the sun, earth, and moon,
which are accurately and reliably calculated. However, rela-
tively little is known about the effects large power-generating
structures may have on marine life. Nevertheless, it has been
estimated that oceans could eventually supply about 10% of the
electricity consumed in the United States.3 Among the designs
currently being tested to harness the kinetic energy of ocean
turbulence is the bioWAVE ocean-wave energy system, an enor-
mous underwater machine that mimics the swaying motion
of seaweed (fig. 3).

The solution to the problems of storage and intermittent
clean-energy sources and their integration from geographically
dispersed sources lies in the creation of smart power grids.
These intelligent networks are energy superhighways that pro-
mote optimal electricity distribution and use, similar to what
the Internet did for computing. They can connect and combine
diverse systems and measure and monitor quantities of
data to improve reliability and efficiency and to reduce costs.
They can even regulate thermostats, meters, and appliances
as well as inform consumers about high peaks of energy use.
A number of products entering the market, such as the Energy
Aware clock or the Power Aware cord, provide real-time ways
for consumers to instantly visualize their electricity consump-
tion (figs. 4, 5). At the global scale, an intelligent international
grid could help relieve energy shortages throughout the world.
Today, one in four people does not have electricity in his or her
home, and many of those who do have only a sporadic supply.
Designing systems to conduct our existing business more
efficiently and economically must be an adjunct to the organi-
zation of new energy sources. The United States is responsible
for roughly 50% of the world’s carbon-dioxide emissions,
and our buildings produce the largest share of this.4 Tougher
building codes are inspiring changes in construction, includ-
ing more efficient windows, roofing materials, lighting, and
heating and cooling systems; proper building orientation and
insulation; recyclable materials; and the inclusion of renew-
able power sources. Green roofs keep buildings warmer in
winter and cooler in summer, and they absorb rainfall, slowing
the rate of run-off into the city’s water system. In addition, they
reduce urban heat islands, which absorb heat and radiate it
back into the air. The plant-covered, contoured roof designed
by Renzo Piano for the California Academy of Sciences is
a key component of the building’s overall ecological system;
making it one of the most sustainable new buildings today
(fig. 6).
The average house in America is 45% larger than it was thirty years ago, and requires a commensurately larger amount of energy to run. Designers are countering the increase by creating appliances that consume less energy: for example, most water heaters—the second largest power consumer in the home—are already operating at half the energy consumption of earlier models. Designers can also find ways to make products work together, such as harnessing the heat generated from a clothes dryer, which now goes to waste. **Lightbulbs are undergoing major changes and improvements** (fig. 7), and an expanded use of low-energy, LED technology not only promises improved color quality and cost-efficiency, but entirely new lighting forms previously unimagined. Design at a much larger scale is also undergoing reconsideration. **Using solar energy to light city streets, resulting in significant savings, is being studied in projects such as Jongoh Lee’s Invisible Streetlight** (fig. 8). The new desert city, Masdar, in the United Arab Emirates, is among the current experiments in which comprehensive changes to urban technologies, policies, and user behavior are being attempted. Designers will hopefully be able to apply lessons learned from this colossal project to many parallel conditions in existing cities.

What is clear is that the current path of industrial societies as inefficient users of energy and producers of intolerable and ugly waste can no longer be sustained. For designers, creating circumstances in which renewable energy is technically and economically feasible, in which resources are cultivated rather than wasted, in which the human environment is enhanced rather than degraded, is both a profound responsibility and a significant intellectual challenge.

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3 Steinhilber, pp. 55–57.
8 Ibid.

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The recently completed California Academy of Sciences in San Francisco, designed by architect Renzo Piano, is a vibrant expression of the Academy’s mission to explore, explain, and protect the natural world. At over 400,000 square feet, it is the largest public building ever to obtain a LEED (Leadership in Energy and Environmental Design) Platinum rating for its environmental performance. This natural-history museum is organized around a central atrium which leads to three architectural elements retained from the previous museum; and two new ninety-foot-high spheres, one housing a planetarium, the other a rain forest. The atrium is covered by two layers of tensile nets which hold sun, acoustic, and rain shades. Surrounding the building is a solar canopy embedded with 60,000 photovoltaic cells, which produces between 5 and 10% of the building’s power and casts a vibrating light shadow on the space below. The steel used for the structure is recycled; parts of the former demolished museum have been reused in a nearby freeway; excavated sand has restored the nearby coastal dunes; a large part of the building’s insulation is from recycled denim (San Francisco is home to Levi’s jeans); and water from the nearby Pacific Ocean is filtered and piped directly into the museum’s aquarium, which features the world’s deepest live coral-reef exhibit.

Another distinguishing feature is the museum’s 2.5-acre roof, landscaped with seven verdant mounds covered by nine indigenous plant species that provide habitat for butterflies, bees, hummingbirds, and other creatures. The roof’s eco-friendly design is a living environment and outdoor laboratory for students and scientists. The green roof also helps regulate temperatures throughout the building and absorbs 98% of all storm water, thus lowering its impact on San Francisco’s sewage system. The roof plants are carried in specially designed bio-trays made from coconut-husk fiber, lined with fungi to supply nutrients; the trays disintegrate within three years.
Energy Aware Clock

Electricity is invisible, and for many of us, it is something we take for granted. To provide people with better knowledge of, and control over, their energy consumption, designers are conceiving of in-home solutions that are more appealing than electricity meters. The Energy Aware clock, designed by Loove Broms and Karin Ehrnberger, in collaboration with Sara Ildstedt Hjelm, Erika Lundell, and Jin Moon for the Interactive Institute in Sweden, is intended to resemble an ordinary kitchen clock in form and use, drawing a parallel between the rhythms of energy and of time. The clock shows electricity use in real time: if the dishwasher is turned on, the energy surge appears immediately on the clock’s display. It also tracks energy consumption over a twenty-four-hour period and compares usage over several days through overlaid graphic visualizations. Energy Aware also functions as an ordinary clock. It is wirelessly connected to an energy meter and can be integrated into portable objects, serving as an ambient display.

GreenPix Zero-energy Media Wall and SolPix

Using building façades as canvases for advertising or public art is not new, but today, LED lighting can be embedded into glass curtain walls, transforming them into interactive, programmable spectacles. New York–based architect Simone Giostra pushes this technology in his site-specific installation, SolPix, an animated media wall that runs on solar energy. This project is based on Zero-energy Media Wall, a carbon-neutral LED display he created for the Xicui Entertainment Complex in Beijing. Referred to in Beijing as GreenPix, it consists of 2,292 energy-efficient lights distributed across the massive 24,000-square-foot façade, making it the largest color LED display in the world. For the first time, polycrystalline photovoltaic cells were placed with varying density in the building’s skin, laminated within the entire glass envelope of the building. Since there are windows in the building, the cells were clustered in patterns that allow natural light to penetrate where needed. In addition to the digital displays, the wall also serves as a type of weather report: sensors placed between the glass panels register variations in wind pressure and solar exposure, and use embedded software to create real-time interactive animations that transform the building façade into a responsive environment. These sustainable digital-media spaces offer many new possibilities for integrating media, art, and architecture in an urban context.

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greenpix zero-energy media wall, beijing, china. simone giostra, simone giostra and partners. lighting design and facade engineering: ove arup. manufactured by suntech and thorn lighting. client: qiaoya corporation. designed united states and united kingdom, manufactured and installed china, 2005–8

energy aware clock, prototype. loove broms and karin ehrnberger, with sara ildstedt hjelm, erika lundell, and jin moon, interactive institute ab, sweden, 2007. epoxy, polyamide, acrylic, electronic components.
HydroNet: San Francisco 2108

San Francisco–based designers IwamotoScott created HydroNet as an experimental project in response to the design challenge of conceiving the city one hundred years in the future. Predicated on the belief that future circulation networks in cities will be more connected but also more self-sufficient, the project proposes a citywide, multi-scale transportation network that collects, distributes, and stores fresh water, geothermal energy, and hydrogen fuel. For areas along the San Francisco Bay impacted by a five-meter water level rise predicted as a result of global climate change, algae ponds occupy a new aquaculture zone that provides the raw material for the production of hydrogen fuel. The HydroNet's tunnels form an underground circulation infrastructure that stores and distributes the fuel for hydrogen-powered hover cars, which reduce the number of cars on the streets. High-density housing coexists with the aquaculture zone as a forest of sinuous “algae towers.” The network taps the vast underground reserves of water and power from freshwater aquifers and underground geothermal energy stores below San Francisco. HydroNet also links to an array of “fog flowers” that harvest fresh water. The entire network forms a super-system that resembles seaweed and chanterelle mushrooms in form, while allowing much of the character of above-ground San Francisco to be preserved and to evolve organically.

Hope Solar Tower

Solar towers are among the more ambitious attempts being made to capture solar energy more effectively than through photovoltaic panels. The Australian company EnviroMission is currently commercializing solar-tower technology, originally conceptualized by the German structural engineering firm Schlaich Bergermann and Partner. The Hope solar tower operates by collecting the sun’s radiation to heat a large body of air under an expansive collector zone, which acts as a giant greenhouse. Based on the principle that heat rises, this air flows towards the center of the collector through electricity-generating turbines and up and out of the tower, like a chimney. A single 200-megawatt solar tower is estimated to produce enough electricity to power approximately half a million households, preventing more than one million tons of greenhouse gases from entering the atmosphere. To offset the drop in energy production once the sun sets, heat-retention systems can be incorporated to store heat during the daytime and release it at night to power the tower’s turbines.
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Wind is a promising source of renewable energy. California-based Makani Power Inc. was founded with the goal of producing low-cost, renewable energy using tethered airfoils, or kites. The M10 kite-power system is a fundamentally new way of harnessing the energy of the wind, using a tethered wing to fly at altitudes where the wind is both stronger and more consistent. At these altitudes, the wing sweeps through a vast amount of area, accessing a tremendous amount of wind energy. The wing is similar in size to a single wind-turbine blade of the same power rating, but without the costly tower and nacelle of a wind turbine. Small turbines on the wing extract power from the wind as it rushes across, converting it into electrical power. Because the kite is moving many times faster than the wind, these turbines capture the same amount of power as a full-size wind turbine. The tether carries the traction force of the wing and transmits electrical power to the ground, where special conditioning hardware connects the system to a power grid. Successful development of the Makani technology would enable large-scale wind energy generation over 80% of the United States’ land surface, as well as deployment in offshore locations, allowing wind to be developed closer to demand centers.


Invisible Streetlight

Imagine walking through a forest at night and seeing small bursts of light, like fireflies, magically scintillating among the branches. Such is the concept behind Korean designer Jongoh Lee’s Invisible Streetlight: artificial leaves that can be wrapped around tree branches and other natural surroundings. During the day, these thin, delicate leaf structures, invisible as they mingle with the tree’s natural leaves, harness and store sunlight. At night, they provide a poetic alternative to most streetlights, which are strictly functional and designed for fixed, predetermined heights.

The body of Invisible Streetlight is made by the double injection of silicon and aluminum. These lightweight materials ensure flexible movement. Silicon’s high thermal conductivity protects the leaves from water, and its semi-transparency diffuses the fixture’s LED light as it shines in the dark. Using a “photo-capacitor” that converts solar energy into electricity, which is then stored in a nano-wire battery, the Invisible Streetlight is able to utilize indirect sunlight on cloudy or rainy days and release electricity at any time.

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M10 Kite-power System

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Masdar Development

Masdar is a brand-new, self-contained, sustainable city of forty thousand residents currently being built on the desert outskirts of Abu Dhabi, in the United Arab Emirates. A vast experiment, its design pushes ideas of alternative energy, aiming to be the world’s first car-free, carbon-neutral, zero-waste city powered by renewable energy sources. To achieve this, its master planner, the London-based firm of Foster + Partners, is applying new approaches to architecture and engineering on an urban scale. The project is expected to be completed by 2018. The Masdar headquarters building, designed by Adrian Smith and Gordon Gill, will be completed by the end of 2010.

With global warming and rising temperatures, people will be living increasingly in interiors. Buildings will be just seven to twelve meters apart—close enough to shade each other—with thick insulation to reduce the need for air conditioning and electric light. The only source of water will be produced through a solar-powered desalination process in which sea water is converted to fresh water. Water usage will be reduced from a national daily average of 143 to about 21 gallons per person by recycling waste-water and by using low-flow fixtures, waterless urinals, and a leak-detection system. The sun will be the primary source of energy, captured in thin-film solar panels in the largest solar plant in the Middle East; and supplemented by wind turbines and waste-to-power plants, which use garbage retrieved from a garbage-collection network as fuel.
According to designers Rachel Wingfield and Mathias Gmachl of Loop pH, MetaboliCity is “biomimetic architecture modeled on molecular structures and metabolism in living cells.” The project was inspired by their collaboration with Nobel Prize–winning scientist Sir John E. Walker, whose work has greatly contributed to the understanding of energy conversion in the living world. For Loop pH, the convergence of design and science and, ultimately, the emulation of nature can serve to address some of today’s most urgent problems by promoting energy independence, human nutrition, and “metabolic thinking.”

MetaboliCity

MetaboliCity is an urban ecosystem that supports modular farming systems. A lightweight textile structure, whose form is based on non-Euclidean geometry and molecular biology, is woven from millimeter-thick fiberglass rods and serves as the scaffold on which plants are grown. Organic, dye-sensitized solar cells, made from the dye of berries by researchers at the National Laboratory for Sustainable Energy in Denmark, are clad to the woven structures to harvest the sun’s energy, powering a pump system that monitors and feeds the plants as well as micro LEDs for ambient light at night. These energy-harvesting canopies mimic the process of photosynthesis, wherein the dye, replacing chlorophyll, absorbs energy from sunlight to produce an electrical current in the solar cells.

—Andrea Lipps
**Ninety Light**

The recent introduction of small LED lights to replace the ubiquitous and highly inefficient incandescent bulb has provided designers with the opportunity to create new lamp designs. The versatility of LEDs has alleviated the size and shape constraints of traditional bulbs and inspired designers to reenvision the lamp, as exemplified by the Ninety Light task lamp. Designed by American Shawn Littrell for the Norwegian lighting company Luxo, it is a contemporary successor to the firm’s classic L-1 task light. The Ninety Light uses four high-power, 1.5-watt LEDs, which consume a total of only 6 watts to distribute twice as much light as the 60-watt incandescent bulb. It is estimated that more than 425 million such bulbs are sold every year in the United States alone—about 50% of the domestic market. The LED replacement would save enough electricity in one year to power the lights of 17.4 million American households, and would avoid 5.6 million metric tons of annual carbon emissions.

Philips, a Dutch electronics corporation, asserts that its products are made “to reproduce the equivalent amount and color of light made by the 60-watt incandescent bulb, using only 10 watts of power. The competition also requires that the new bulb last for more than 25,000 hours—about twenty-five times longer than the standard incandescent light bulb—and that at least 75% percent of the bulb be manufactured in the United States.” One of the great advantages to Philips’s design is that it fits into the same socket as incandescent bulbs, which means people will not need to replace their current light fixtures. Philips claims that eventually it can reduce the price of the LED light bulb to between $20 and $25.

**Philips LED Replacement for the Common Lightbulb**


**Soil Lamp**

A number of designers today are integrating objects with alternative means of clean power to create self-contained, self-sustaining systems. For Dutch designer Mariëlle Staps, the power source is mud. Her Soil Lamp makes use of the metabolism of biological life in dirt to produce enough energy to power a small LED light. The soil, enclosed in cells containing zinc and copper, acts as an electrolyte—an electrically conductive medium—and requires only a simple splash of water to keep it from drying out. The more cells there are, the more electricity can be generated. Staps’s design and naming of the Soil Lamp celebrates the transparency and simplicity of its process: the earth battery is housed in a clear bulbous base, with power carried along a thin conductor leading to a bare bulb. Exposing the possibilities of another source of abundant, renewable energy, the lamp serves to invigorate future innovation for small, contained power systems.

—Andrea Lipp
**Solar Rechargeable Battery Lanterns**

Industrial societies take electricity and lighting for granted, but in most rural areas of the developing world, people rely on inefficient fuels such as kerosene that are both dangerous and pose serious health problems. Designed by Nishan Diasnayake from Sri Lanka and Simon Henschel and Egbert Gerber from Germany for Sunlabob Renewable Energy, a Laotian energy firm, the solar rechargeable battery lantern provides a safe, competitive electrical lighting alternative to the conventional use of kerosene by reducing greenhouse gases and offsetting fossil fuels, while providing a service-oriented solution for rural electrification.

Villagers rent these portable, rechargeable lanterns from a solar charging station set up in the center of the village. There are microeconomic opportunities as well. The stations are rented by village entrepreneurs, who receive technical assistance and training from Sunlabob but undertake the operation and management, empowering communities and fostering a sense of ownership.

Each lantern has an embedded microprocessor, an “identification” tag that monitors and safeguards its battery. During recharging, the central station collects data on the use and status of the lantern; the data are analyzed to ensure high efficiency of all equipment and for reliable carbon trading. The lanterns are also being used in Afghanistan and Uganda.

**Solar Lilies**

Nature continues to be an inspiration for designers seeking optimized, sustainable solutions for harvesting energy. Solar Lilies, designed by the Scottish firm ZM Architecture, are biomimetic solar collectors whose form is modeled on the plant that inspires their name. Initially conceptualized for the River Clyde in Glasgow, the solar lily pads take advantage of open and underused space along waterways to convert solar energy to grid electricity. Circular discs made from steel and recycled rubber float on rivers. The discs are mounted with motorized solar arrays that rotate to track the sun throughout the day, angling themselves for maximum exposure to gather the sunlight that is intensified by the water. The giant Solar Lilies range in diameter from fifteen to forty-five feet, with “stems” tethered to the river bed for easy maneuverability.

—Andrea Lipps
Z-10 Concentrated Solar-power System

In order for solar power to compete with fossil fuels and become a more widespread alternative, the mechanisms that capture the energy must be more affordable and efficient. One recent solution is the Z-10 concentrated solar-power system, designed by Ezri Tarazi and Ori Levin from Tarazi Studio, for the Israeli firm ZenithSolar. What distinguishes this solar technology is its use of simple mirrors to gather and focus diffused light onto a small, fifteen-square-inch “generator” that converts sunlight into electrical and thermal energy. The overall system is a parabolic optical dish, which serves as a tracker, following the sun from dawn until dusk, much like a sunflower. Moreover, the Z-10 harnesses 70% of the solar energy that hits the dish, making it five times more efficient than conventional flat photovoltaic panels. This solar collector serves a dual purpose by capturing heat from the generator to provide hot water. In April 2009, the first field of thirty-two concentrated solar dishes was installed in Kibbutz Yavne, a community of 1,100 inhabitants near Tel Aviv, where it is expected to generate one-third of the kibbutz’s electricity needs and all of its hot water. This innovative technology is already being considered for use in India and several other countries due to its efficiency and affordability. Its relatively simple materials are easy to assemble—1,200 flat mirrors mounted to a curved, plastic surface—and, compared to conventional flat panels, the Z-10 system uses only a limited amount of polysilicon and Germanium, which are expensive and in relatively short supply globally.