LAGI

art + energy

TOOLKIT

for students ages 12–18

LAND ART
GENERATOR
RENEWABLE ENERGY CAN BE BEAUTIFUL

Welcome to the LAGI Toolkit.

This Toolkit is designed to work alongside the **LAGI Design Guidelines Document for students ages 12–18*** and provide classrooms and individuals with educational activities that will provide the confidence and inspiration to imagine a land art generator design.

The activities in this document have been developed in collaboration with educators and follow the steps of the Design Process. You may choose whether to use some of the Toolkit or use all of the Toolkit as it meets the needs of your classroom or course.

In addition to this Toolkit, we are available to help you. Please reach out to us with any questions you may have.

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*You can find the **LAGI Design Guidelines Document for students ages 12–18** along with additional downloadable resources at **https://youth.landartgenerator.org**

What is the Land Art Generator?
The Land Art Generator Initiative (LAGI) helps design renewable energy infrastructures that are also beautiful places for people.

With a mission to advance a just and equitable energy transition in response to the climate crisis, LAGI helps design public places that share land use with distributed renewable energy generation. Works of art in civic space distribute clean energy and provide other sustainable services to buildings and the utility grid while beautifying the built environment.

Land Art Generator educational programming is a great example of STEM to STEAM and project-based learning. Through the process of designing their own land art generator, middle school and high school students show applied understanding of concepts like energy conversion efficiency, capacity factor, and become familiar with using kilowatt-hours. At the same time they are applying knowledge of form, shape, colour, and touching on aspects of urban planning and whole systems design. These are exactly the kind of skills that researchers tell us are important for jobs in the twenty-first century.

What is a Land Art Generator?
A Land Art Generator artwork is a "regenerative artwork." It is a creative and active part of the solution to climate change. It incorporates technology as a medium for creative expression to generously contribute sustainable resources such as clean electricity or drinking water to meet existing needs. A Land Art Generator artwork may also assist in the regeneration of its surrounding landscape to increase groundcover and biodiversity. Any work of art that is conceived as sustainable infrastructure or as a means of environmental remediation or regeneration.

TABLE OF CONTENTS

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Suggested activities and downloads that will be most useful depending on how long you have to spend on the Challenge.

- Required (minimum time = 2 hours)
  This is the fastest you can expect to finish by skipping many steps and jumping right into design.
- Recommended (average time = 6 hours)
  This is the minimum recommended time and includes about half of the activities.
- Optional (maximum time = 12 hours)
  This is the most time it should take to complete all activities and dig deeper into the materials.

Design Process

Activity 1 (recommended)

ART OUTSIDE OF THE GALLERY

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TOOLS

- **DOWNLOAD** Art Outside of the Gallery Presentation
- Projector and/or computer screen

DESCRIPTION

Students learn about artists and artworks that were designed for outdoor spaces. Through this activity students are introduced to specific works of public art, land art, eco-art, and social practice art. Learning about how artists have created works of art in the landscape in the past will help you to imagine what is possible at Weston-super-Mare Beach.

GOALS

1. Develop visual literacy skills
2. Identify art outside of the gallery
3. Comprehend new ways of communicating

TIME TO COMPLETE ACTIVITY

30–45 minutes

Definitions

ECO-ART

Eco-art is a contemporary art movement that addresses local and global environmental issues. Some eco-art is functional, striving to reclaim or restore damaged environments.

LAND ART

Land art, also known as earth art, is art in which the landscape or natural elements often form the basis for the artwork. Artists may create artworks directly in the landscape, utilizing their natural surroundings and integrating the landscape itself into their work.

PUBLIC ART

Any work of art that an artist has created to be displayed, heard, or performed in a public space can be referred to as public art (also sometimes referred to as civic art).

SOCIAL PRACTICE ART

Social practice art includes a wide variety of strategies and techniques in which social interaction and exchange are the means for creating the artwork. Social practice art may involve community interactions, performance, interactivity, and much more!

INTRODUCTION

Sometimes artists feel that the walls of a gallery are too limiting to their creative expression. These artists have often sought to make works of art outside of the gallery—in open spaces, public parks, desert landscapes, polluted industrial brownfields, or even on and in bodies of water.

STEP-BY-STEP INSTRUCTIONS

Step 1

Instructor shows page one and two of the Art Outside of the Gallery Presentation. Group discussion about the points on slide two (copied below) is encouraged:

> **ART OUTSIDE OF THE GALLERY**
> Connects Communities.
> Tells Stories.
> Invites Dialogue.
> Asks Questions.
> Provides Solutions.

Step 2

Continue to view the remaining slides in the presentation. At each slide, have one person read aloud the paragraph about the artist and the artwork. Take a moment to think about what the artwork is doing and how it engages people. How many of the points on page two of the presentation are relevant to each artwork?

Step 3

As a group, come up with some answers to the question at the bottom of each slide.

Idea

Think about how you can create your own work of art from things you find outside. Some artists who have done this include: Andy Goldsworthy (land artist), Chris Drury (land artist), and Noah Purifoy (assemblage sculptor).

If you create something like this please take a photo, share it with your group, and email it to us. We would love to share your ideas with the world!

Activity 2 (recommended)

INTRODUCTION TO LAGI

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TOOLS

- **DOWNLOAD** Introduction to LAGI Presentation

DESCRIPTION

Students learn about the goals of the Land Art Generator Initiative. The group is introduced to several renewable energy technologies and LAGI submissions that have been entered into the LAGI open-call design competitions. Students discuss the submitted designs and talk about what makes a successful Land Art Generator.

GOALS

1. Understand the importance of narrative, experience, and storytelling for art in public space.
2. Begin to recognise terminology of renewable energy technologies, such as megawatt-hour (MWh).
3. Demonstrate understandings of design decisions.

TIME TO COMPLETE ACTIVITY

20–30 minutes

Definitions

A LAND ART GENERATOR IS

A Land Art Generator artwork is any work of art in the landscape that helps to power a building or the city by integrating renewable energy technology into the artwork. Some larger Land Art Generator artworks can provide clean energy to thousands of homes!

WHY IS LAGI IMPORTANT?

People can sometimes be resistant to change and to the introduction of new technology. That is why it is important that the new technologies evolve and respond to the aesthetic needs of the community (everyone who will be living with the new technologies in their daily lives).

RENEWABLE ENERGY

Refers to any usable form of energy such as electricity that is generated from natural sources that are rapidly replenished such as sun, wind, or water. Energy derived from fossil fuels or from uranium is not renewable, since these resources, once mined or extracted cannot be replenished.

PUBLIC ART

Any work of art that an artist has created to be displayed, heard, or performed in a public space can be referred to as public art.

STEP-BY-STEP INSTRUCTIONS

Step 1
Instructor draws four large quadrants on the board, and writes the words "Art" and "Energy" in the upper two boxes. As a class, students answer the following questions: What is Art? What is Energy? Answers are written on the board in the respective boxes.

Step 2
Students are asked where energy comes from and how we use it in our daily lives. Answers are written on the board in the box below the "Energy" definition.

Students are asked where have they seen art and how does it make them feel. Answers are written on the board in the box below the "Art" definition.

Step 3
Instructor shows the Introduction to LAGI Presentation.

Students are asked the following question:
How else can renewable energy technologies be incorporated into public artwork?

Step 4
Instructor asks each student to identify one LAGI design to discuss and then asks the following questions:

- Why do you think the artist chose the form/shape/technology/function for their artwork?
- What do you like about this piece?
- How much electricity does the artwork generate each year in MWh? (Annual Capacity)
- According to Ofgem, Great Britain's independent energy regulator, the average UK household consumes about 2.9 MWh (2,920 kWh) of electricity each year.
  Given that number, how many average UK households can the artwork power?

Dig Deeper

Download the LAGI "Art+Energy Flash Cards" set and "A Field Guide to Renewable Energy Technologies" to learn more about Land Art Generator public artworks and energy science.

Activity 3 (recommended)

DISCOVER DESIGN I

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TOOLS

- Drawing supplies
- **DOWNLOAD** LAGI Discover Design Presentation
- Projector and/or computer screen

DESCRIPTION

Students learn about elements and principles of design. Students experiment with quick 2D composition to better understand the application of composition terms in abstract drawings.

GOALS

1. Demonstrate understandings of basic design principles
2. Experiment freely with line and shape

TIME TO COMPLETE ACTIVITY

30–45 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1

Instructor draws four quadrants on the board. In each one, the instructor makes a simple shape or line. Four students are each given a slip of paper with a keyword. Inspired by their keyword, they are then called up to complete each image (one student per quadrant) and return to their seats once they feel that their sketch is complete.

Keyword examples:
Mechanical, Organic, Purposeful, Playful, and Meandering. Feel free to pick others.

Step 2

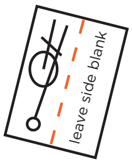
Instructor shows the LAGI Discover Design Presentation to the group.

Step 3

The instructor introduces some composition terms such as symmetry and balance, solid and void, vertical and horizontal, curved and linear. For each, the instructor can explain or demonstrate these terms by either referencing the sketches that are already on the board (if relevant) or with reference to the presentation slides.

Step 4 (10 minutes)
In pairs, students pick up sheets of A4 paper and fold them in half three times, creating a creased grid of eight boxes. Then they mimic the example on the board by taking turns drawing lines in a box, trading with their partner to complete each image in a different way. Students should be thinking about each of the composition terms from the presentation and incorporating them into their drawings. Drawings can be figural or abstract.

Step 5 (5 minutes)
Each student pair takes a new sheet of A4 paper and folds it in half as shown below. They then pick one of their sketches to develop into a composition using this half-size sheet. The pair works on the composition collaboratively by taking turns using one drawing utensil. While one is drawing, the other should be watching and planning their next moves in response. The goal is to arrive at a cohesive composition. Keep it simple. You only have five minutes.



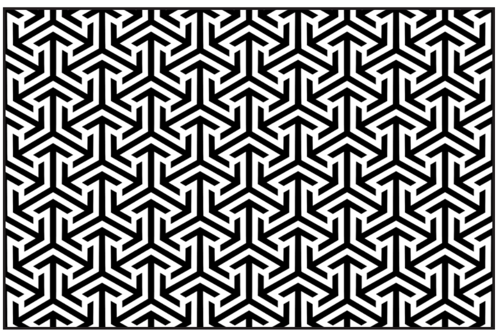
Fold paper in half as shown and keep folded.
Only draw on one half.

Step 6 (10 minutes)
The instructor leads the entire group in discussion about the results of the exercise. Students are asked to comment about what they like about each and what elements or principles of design they see in their sketch. Students are also asked to reflect on their collaboration and how the result may differ from a drawing that they would have made on their own.

Next Step
After a break or on another day, continue with Discover Design II. The sketches that were produced in Step 5 above will be used in the next activity, so don't lose them!

Idea

Make a pattern by creating a design and then repeating it in the box to the right. What is being repeated in the below pattern?



Activity 4 (recommended)

DISCOVER DESIGN II

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TOOLS

- Drawing supplies
- Sculpting and modelling materials
- **DOWNLOAD** Discover Design Site Plan (print full-size on A3 paper)
- Projector and/or computer screen

DESCRIPTION

Students learn about elements and principles of design. Students experiment with quick 3D composition and then imagine the forms that they have derived placed into a scale and site context.

GOALS

1. Demonstrate understandings of basic design principles
2. Experiment freely with form
3. Imagine and construct sculptural objects in space with consideration to how they relate to an existing outdoor context and people

TIME TO COMPLETE ACTIVITY

30–45 minutes

STEP-BY-STEP INSTRUCTIONS

Previous Steps

This activity should follow Discover Design I. In Step 5 of that activity students created sketches showing their understandings of design principles. If those sketches are lost, you can repeat Step 5 in Discover Design I before continuing below.

Step 1

Students form the same pairs that they had in Discover Design I.
Instructor may review the LAGI Discover Design Presentation.

Step 2

Using sculpting supplies (e.g. modelling clay, toothpicks, pipe cleaners, etc.), the student pair spends 10 minutes constructing a sculptural form that sits on top of the sketch they created in Step 5 of the previous activity. They should try again to incorporate the elements and principals of design into their sculpture. Make sure that their sculpture is not too fragile because it will soon be moved to a new location. It may be a good idea to make a cardboard base to place underneath the folded A4 sheet of paper.

Step 3
The instructor leads the entire group in discussion about the results of the form generation exercise. Students are asked to comment about what they like about each and what it makes them think of when they look at it. Students are encouraged to walk around the sculptures to see them from multiple angles.

Step 4
The instructor will have previously printed one copy of the Discover Design Site Plan.* Students are introduced to the site context and asked to place their previously constructed sculptures onto the site (use the guide lines on the Discover Design Site Plan). This activity is performed by the entire group with each sculpture placed one at a time onto the site.

Step 5
For each sculpture the students are asked to talk about how moving their sculpture to the site changes the way that they see the artwork. Students are asked to think about how people might interact or move around and through their sculpture. Note the sizes of people and cars on the beach. When considering the context within and around the site (the sand, the water, the street, the Tropicana building), how would you change your sculpture to better work with the surroundings and the way that people use and move through the spaces?

*Alternatively, the instructor may print out one copy of the site plan for each student pair and have them construct their model onto the site.

Idea

Scavenger Hunt

Find design elements and principles in the objects around you.

Step 1
Write down one element and one principle of your choice on the lines to the right.

Step 2
Take 5–10 minutes to search around your classroom, neighbourhood, or home to find an example of an object or picture that uses both your element and principle.

Step 3
Sketch it in the box. →

____
Design Element

____
Design Principle

Activity 5 (recommended)

ENERGY FUNDAMENTALS

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TOOLS

- Writing materials
- Calculators
- **DOWNLOAD** A Field Guide to Renewable Energy Technologies
- **DOWNLOAD** Energy Output Worksheet
- **DOWNLOAD** Art+Energy Flash Cards

DESCRIPTION

Students learn about how energy is harnessed to create electricity and how it is consumed. Students study renewable energy technologies in the context of Land Art Generator artworks and learn to estimate the annual output of each installation.

GOALS

1. Recognise where energy comes from, how it is harnessed, and how it is consumed
2. Interpret how renewable technologies function
3. Predict the energy output for different types of technologies
4. Demonstrate understanding of energy conversion efficiency and capacity factor

TIME TO COMPLETE ACTIVITY

30–45 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1

Introduction questions:
What are some forms of energy? (e.g. electrical, heat, chemical, kinetic, gravitational, etc.)
How do humans harness energy from renewable sources and generate electricity?

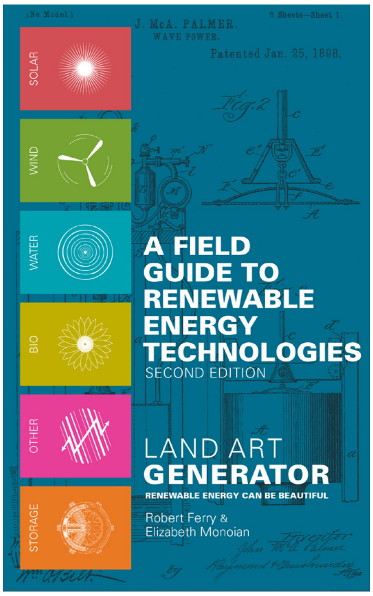
Step 2

Using *A Field Guide to Renewable Energy Technologies* PDF, and the introduction (pages 2-8) of the *Art+Energy Flash Cards* PDF, students are introduced to examples of clean energy technology with explanations of how they work. The concept of "conservation of energy" is explained, emphasising that energy changes forms, but cannot be created or destroyed. This point is explained through the example of a very efficient solar panel that converts sunlight into electricity and heat. Up to 25% of the available solar energy is converted into useful electricity. The other 75% is lost to heat energy, reflected, or otherwise unused. 25% is therefore the conversion efficiency of the solar power technology.

Step 3
The Energy Output Worksheet is distributed to each student. The instructor leads the class through the first pages that explain conversion efficiency. Instructor explains the idea of capacity factor by asking the students to think about the same 25% efficient solar panel as it operates over an entire year and explains that every energy technology has a capacity factor.

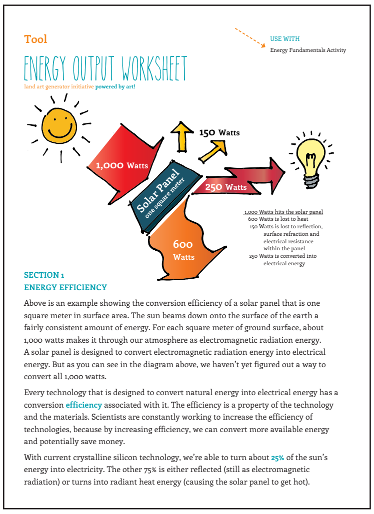
Step 4
The class goes through the first two questions at the end of the Worksheet together. Students are given five minutes to work on questions three and four.

Step 5
Students form groups, pick up three LAGI Art+Energy Flash Cards, and complete the last section of the Worksheet together by answering the math question on each card in the space provided on the Worksheet.



A Field Guide to Renewable Energy Technologies

Energy Output Worksheet


Tool

USE WITH
Energy Fundamentals Activity

ENERGY OUTPUT WORKSHEET
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SECTION 1
ENERGY EFFICIENCY

Above is an example showing the conversion efficiency of a solar panel that is one square meter in surface area. The sun beams down onto the surface of the earth a fairly consistent amount of energy. For each square meter of ground surface, about 1,000 watts makes it through our atmosphere as electromagnetic radiation energy. A solar panel is designed to convert electromagnetic radiation energy into electrical energy. But as you can see in the diagram above, we haven't yet figured out a way to convert all 1,000 watts.

Every technology that is designed to convert natural energy into electrical energy has a conversion efficiency associated with it. The efficiency is a property of the technology and the materials. Scientists are constantly working to increase the efficiency of technologies, because by increasing efficiency, we can convert more available energy and potentially save money.

With current crystalline silicon technology, we're able to turn about 25% of the sun's energy into electricity. The other 75% is either reflected (still as electromagnetic radiation) or turns into radiant heat energy (causing the solar panel to get hot).

LAGI Art+Energy Flash Cards

Activity 6 (optional)

IMAGINING ENERGY

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TOOLS

- Sculpting supplies
- Energy Half Cards (on following pages)

DESCRIPTION

Students expand on their knowledge of energy generation by building a sculptural form that imagines these technologies in action. Testing their knowledge, students use their models to explain to others how the technology works.

GOALS

1. Demonstrate understandings of renewable energy technologies
2. Illustrate how function influences the physical form that energy installations take

TIME TO COMPLETE ACTIVITY

20–30 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1

Instructor sets out labels at four stations according to renewable energy technology categories (Solar, Wind, Water, Bio) along with sculpting materials. Instructor prints the Energy Half Cards (found on the following pages) and cuts them along the dashed line.

Step 2

The students are divided into two groups.

Step 3

Energy Half Cards are handed out to each group. One group receives cards with images of technology (top half). The other group receives cards with text information about technologies (bottom half).

Step 4

Students have 3 minutes to find their matching card partner.

Step 5

Student pairs move to the station that corresponds to the technology on their cards.

An example of a student model of a vertical axis wind turbine (Savonius type) made using a clear plastic cup, a toothpick, and some paper.

Step 6
At each station students use the materials set out for them and begin creating expressive models of one or more of the technologies at their station.

Step 7
Students are asked by the instructor to think about how large their model would be in real life and how many houses it might be able to power. Consider showing what size a person would be in the model.

Step 8
One student remains at the station while the other students are free to move to one of the other three stations. It is the job of the student who remained behind to explain to the others how their model functions and what technologies it incorporates.

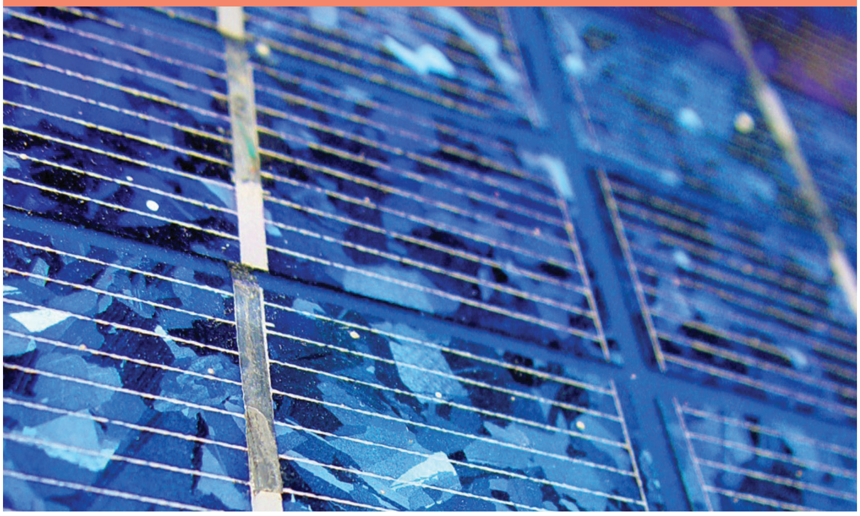
Silicon is the most common metalloid found in nature. It is typically found as silica (SiO_2) in sands rather than in its pure elemental form. Silicon makes up 27.7% of the earth's crust by mass.

solar

PHOTOVOLTAIC

CRYSTALLINE SILICON WAFER

$$\text{CONVERSION EFFICIENCY} = \frac{\text{energy output}}{\text{energy input}} = 18\%\text{–}23\%$$



POLYCRYSTALLINE SILICON SOLAR PANEL
Photo by Scott Robinson.

Silicon (Si) is a semiconductor material that displays the photovoltaic effect. It was the first material to be employed in solar cells and is still the most prevalent. It can be applied for use in either a crystalline (wafer) form, or in a non-crystalline (amorphous) form.

There are two types of crystalline silicon (c-Si): monocrystalline and polycrystalline (aka multicrystalline).

Monocrystalline is expensive to manufacture (because it requires cutting slices from cylindrical ingots of silicon crystals that are grown with the Czochralski process) but it is the most efficient crystalline silicon technology in terms of energy conversion.

Polycrystalline is easier to manufacture and can be cut into square shaped slices, but has slightly lower efficiency (approximately -5%). It is comprised of small crystals or crystallites.

As of 2018, there was 5,500 MW of installed capacity of CSP (concentrated solar power) plants in operation around the world supplying power to nearly 2 million households.

solar

THERMAL CONCENTRATED (CSP)

PARABOLIC TROUGH

$$\text{CONVERSION EFFICIENCY} = \frac{\text{energy output}}{\text{energy input}} = 25\%$$

SEGS POWER PLANT AT KRAMER JUNCTION IN THE MOJAVE DESERT
Owned and operated by FPL Energy. Image via Desertec-UK.

The concentrated parabolic trough design is one of the most common types of solar power systems in application for utility-scale electricity generation. It 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.

A heat transfer fluid (typically an oil) runs through the tube and is heated to approximately 400°C to provide the thermal energy required to run a steam turbine.

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.

Highly polished metals are often used as the reflector material since parabolic curved mirrors can be complex to manufacture.

Organic thin film functions well under low light conditions and at non-perpendicular angles to the sun such as vertical walls.

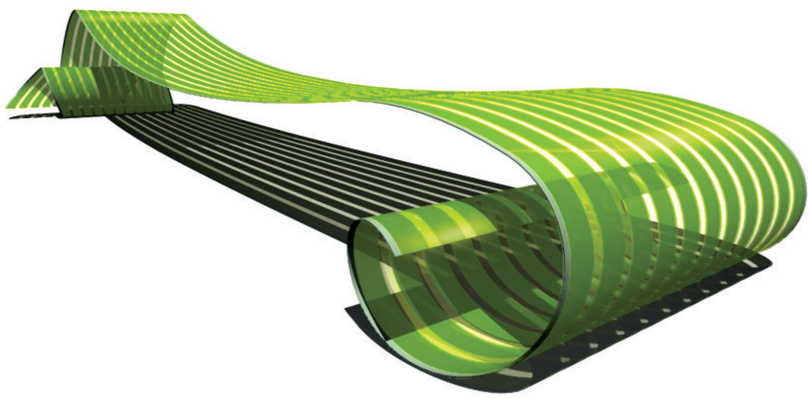
Its translucency means that it can also be applied to windows and other light transmitting surfaces.

solar

PHOTOVOLTAIC

THIN FILM ORGANIC PHOTOVOLTAIC CELL (OPVC) OR POLYMER SOLAR CELL

$$\text{CONVERSION EFFICIENCY} = \frac{\text{energy output}}{\text{energy input}} = 5\%\text{–}10\%$$



ORGANIC PHOTOVOLTAIC PLASTIC SHEET
Similar to that produced by Heliatek, Solarmer, Eight19, and Disasolar.

OPVC (or 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. They can be produced at a very low cost in comparison to other PV technologies because they can take advantage of roll-to-roll production techniques in which the organic photovoltaic system is “printed” onto a continuous sheet of substrate material. Current OPVC technology has a conversion efficiency of up to 10%. Its low cost of production, its flexibility, and its good performance in lower level and indirect light make it an attractive option for some applications.

Examples of small-scale uses for OPVC can be seen sewn into fabric such as in backpacks, laptop cases, tents, and jackets. The energy generated by a backpack utilising this technology, for example, is sufficient to charge portable electronic devices and to provide power to one or two lights. OPV is finding interesting applications in developing countries. A great example is the IndiGo 2.5KW system by Eight19 that is being provided to off-grid communities, financed via mobile phone SMS credit codes. Larger-scale applications, such as building integrated OPV in façade systems are also being implemented.

The earliest recorded use of wind power is with vertical axis wind turbines used to mill grains as long ago as 200 BCE. They were very common in 7th century Persia.

wind

VERTICAL AXIS WIND TURBINE (VAWT)

CONVERSION EFFICIENCY $= \frac{\text{energy output}}{\text{energy input}} =$ Varies with wind speed typically up to 40%

REVOLUTIONAIR WT1KW (GHT TYPE DESIGN)
Image courtesy of PRAMAC. Design by Philippe Starck.

Vertical axis wind turbines 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 (invented by Professor Alexander M. Gorlov of Northeastern University in the 1990s).

Typically 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 than can HAWTs.

Another advantage of VAWTs is that they can be located in closer proximity to each other than can HAWTs. Some studies have shown that dense configurations can actually increase efficiency of the overall installation with turbines picking up wake energy from the rotations of adjacent turbines.

HAWTs must be placed far apart from one another in order to minimise the shadow effect of air wake disturbance on the efficient operation of downwind turbines.

wind

HORIZONTAL AXIS WIND TURBINE (HAWT) OFFSHORE

CONVERSION EFFICIENCY = energy output / energy input = Varies with wind speed typically up to 40% wind speed is more consistent offshore = greater overall output

NYSTED WINDFARM (72 WINDMILLS, 165.6MW CAPACITY)
Image courtesy of Siemens AG, Munich/Berlin.

There are two types of off-shore turbines—those mounted on pylons in shallow waters and those that are designed to float in deep water. Both types typically employ variations on the standard three-blade designs for the turbine itself.

Floating models can be designed to use this feature as a method of rotation to follow the wind direction. Also, floating models can take advantage of higher and more consistent wind speeds in the open ocean.

Floating HAWTs deal with the issue of aesthetics in that their location more than 12 miles from land makes them completely disappear beyond the horizon as viewed from shore.

Pylon-mounted shallow water turbines are less expensive and easier to maintain. Their power transmission lines are also shorter.

It is important to consider all possible impacts that offshore turbines can have on marine ecosystems.

Some run-of-the-river hydro power installations consist of a simple water turbine in a strong current area of a river without any damming or piping. This type of installation has the most minimal ecological impact because the river can continue to flow around it.

water

HYDROELECTRICITY

RUN-OF-THE-RIVER (DAMLESS HYDRO)

CONVERSION EFFICIENCY = $\frac{\text{energy output}}{\text{energy input}}$ = 80%–95% Turbine efficiency (limited by the amount of water that is diverted)

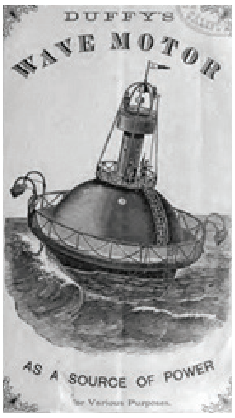
FISH LADDER AT THE COLUMBIA RIVER JOHN DAY DAM
Image courtesy of the Army Corps of Engineers.

While not entirely without ecological side effects, run-of-the-river type hydroelectricity plants offer an alternative to large flooding reservoirs. In these installations, only a portion of the river is diverted to the generators and the rest of the river is left to flow naturally.

Since no land is flooded, existing forests and natural habitats are not adversely affected.

Since there is very little storage capacity, this technology requires a river with a constant flow rate. While conventional hydro facilities can generate in the 10,000 MW capacity and above, run-of-the-river type plants typically are limited to around a 1,000 MW range or below.

There have been attempts made to harness wave energy since the late 18th century.



water

OCEAN WAVE (HYDROKINETIC)

BUOY OR POINT ABSORBER

CONVERSION EFFICIENCY $= \frac{\text{energy output}}{\text{energy input}} =$ 80%
Limited wave surface area

BUOY TYPE WEC OFF THE COAST OF HAWAII
Image courtesy of Ocean Power Technologies, Inc.

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

Some types installed in more shallow conditions use a piston that extends to the sea floor to drive a hydraulic motor, a linear generator, or to fill compressed air chambers that run small internal air turbines.

Deeper water provides longer period waves and more regular wave energy without as much potential for damage to equipment from cresting waves. But the logistics of electrical transmission and equipment maintenance must be weighed against this.

Limestone scrubbers can greatly reduce the emission of harmful chemicals from incineration, and while there is some CO_2 released, the net greenhouse gas effect is less than the methane that is released by landfills.

bio

BIOMASS

WASTE TO ENERGY (WTE)

Conversion efficiency is determined by the method used to convert the biofuel into mechanical or electrical energy

TREZZO SULL'ADDA 3 WASTE TO ENERGY PLANT IN MILAN, ITALY
Image courtesy of Falck Renewables SpA.

WtE is the use of non-recyclable waste for combustion (incineration) to generate electricity, or (in a small number of cases) for processing into methane or similar fuel.

There are some emerging WtE technologies which do not require incineration (some of which have been discussed above):

Gasification (produces hydrogen, synthetic fuels)
Thermal depolymerisation (produces synthetic crude oil)
Pyrolysis (produces combustible tar, bio-oil, and biochars)
Plasma arc gasification, PGP (produces syngas)

Non-thermal technologies:

Anaerobic digestion (biogas rich in methane)
Fermentation production (ethanol, lactic acid, hydrogen)
Mechanical biological treatment (MBT)

Biomass is considered a sustainable energy resource because it is a product of organic processes which naturally regenerate at a rapid cycle (as opposed to fossil fuel energy sources which take millions of years to form naturally).

bio

BIOMASS

BIOGAS AND LANDFILL GAS

Conversion efficiency is determined by the method used to convert the biofuel into mechanical or electrical energy

LANDFILL GAS INFRASTRUCTURE AT FRESHKILLS PARK, THE FORMER FRESH KILLS LANDFILL, NEW YORK CITY
Photo by Robert Ferry.

Biogas is created through the breakdown of any organic material (biomass) in an oxygen-poor environment. The resulting gas by-product is mostly methane and carbon dioxide. Biogas is similar in composition to conventional natural gas and as such can be compressed or fed into a municipal gas grid. It can be used for many different purposes including cooking, heating, lighting, transportation, and electricity production.

It can be either tapped from the underground activity in a landfill site, or it can be produced in specially constructed anaerobic digester tanks.

Farms with such tanks can process manure into biogas reducing the amount of nitrous dioxide and methane that would otherwise enter the atmosphere. These two gases have a far greater atmospheric warming effect than does carbon dioxide (nitrous dioxide = 310 times greater, and methane = 21 times greater).

Activity 7 (recommended)

LAGI IDEA GENERATOR

land art generator initiative powered by art!

TOOLS

- Scissors
- Paper
- Tape
- Dice templates (see page 28)
- Pencil

How would you harness energy from nature in a creative way to power the world around you?

What if you could create a piece of public artwork that could create electricity for all of those places that people go every day to play, relax, socialize, or work?

Can you imagine making electricity from the wind to power your stereo?

What about a sculpture that captures sunlight to power a garden watering system?

Can you conceive of a playground that generates energy for streetlights when people play on it?

Start designing your own Land Art Generator! Below is "Energy Duck," designed by Hareth Pochee, Adam Khan, Louis Leger, and Patrick Fryer for LAGI 2012 and could power around 50 homes in the United States.

Imagine making your own work of public art. What would it look like? Would it have a message or meaning for your community? Remember that it will be something that people will see, hear, and interact with every day, so you will want to make it interesting—something that people will want to experience more than once. It can be as large as a building or as small as a park bench.

By playing this game you will begin imagining renewable energy technologies in everyday places—housed in creative forms—and begin to design your own land art generators that could live in your backyard, neighborhood, or city center.

Renewable energy can be beautiful, fun, and anything that you can imagine!

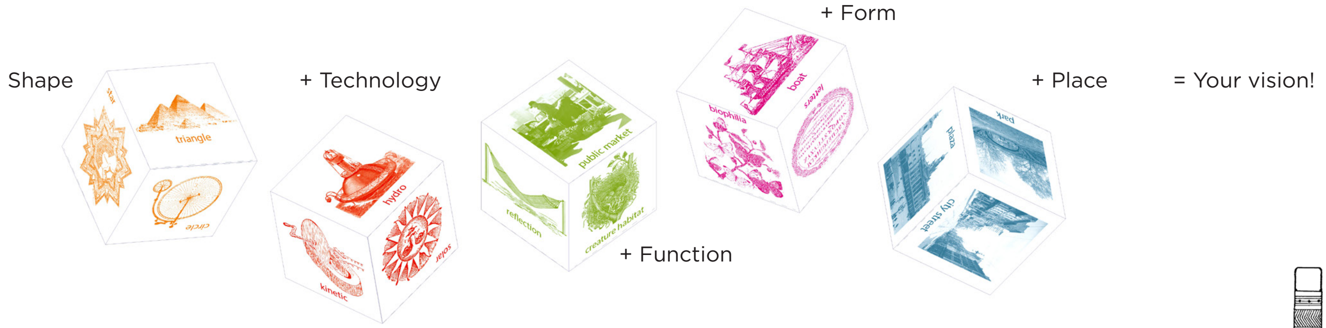
Help to shape the future of our clean energy landscape by playing this game and exercising collaborative imagination.

Introduction

There are five dice categories. Look through example images of each category to get a clear understanding of what each one means. Use all five, or leave one or more categories to your imagination by reducing the number of dice.

You'll notice that each category has a Wild Side, which allows you to make something up within the theme of the cube.

This game can be played in groups or individually. If you play in groups, roll your dice once, write down your combination in the worksheet, and pass the dice to the next player!



HOW TO PLAY

Step 1

Make your first combination of choices by tossing the dice. Write down this combination in the Worksheet.

The dice will answer these five questions:

- What type of place (site) would you like to see your land art generator in?
- What kind of technology will it harness?
- What purpose will it serve to the public (in addition to electricity generation)?
- What form will it take?
- What kind of shapes will it incorporate?

Step 2

Toss again (or pass the dice to the next person for their toss) and write down the next combination. Do this a total of 3–5 times and imagine land art generators from the combination of icons that appear. If you don't like a combination, roll again!

Step 3

On the Worksheet sketch your own land art generator ideas based on the combinations that you rolled.

Sketching gets ideas out of your head and onto paper. It's an important step towards realising any project.

Sketches can be raw, messy, and quick (just a few seconds!). You don't have to be an artist. This is just about getting ideas out of your head. Create stick figures if you aren't yet comfortable with your drawing skills!

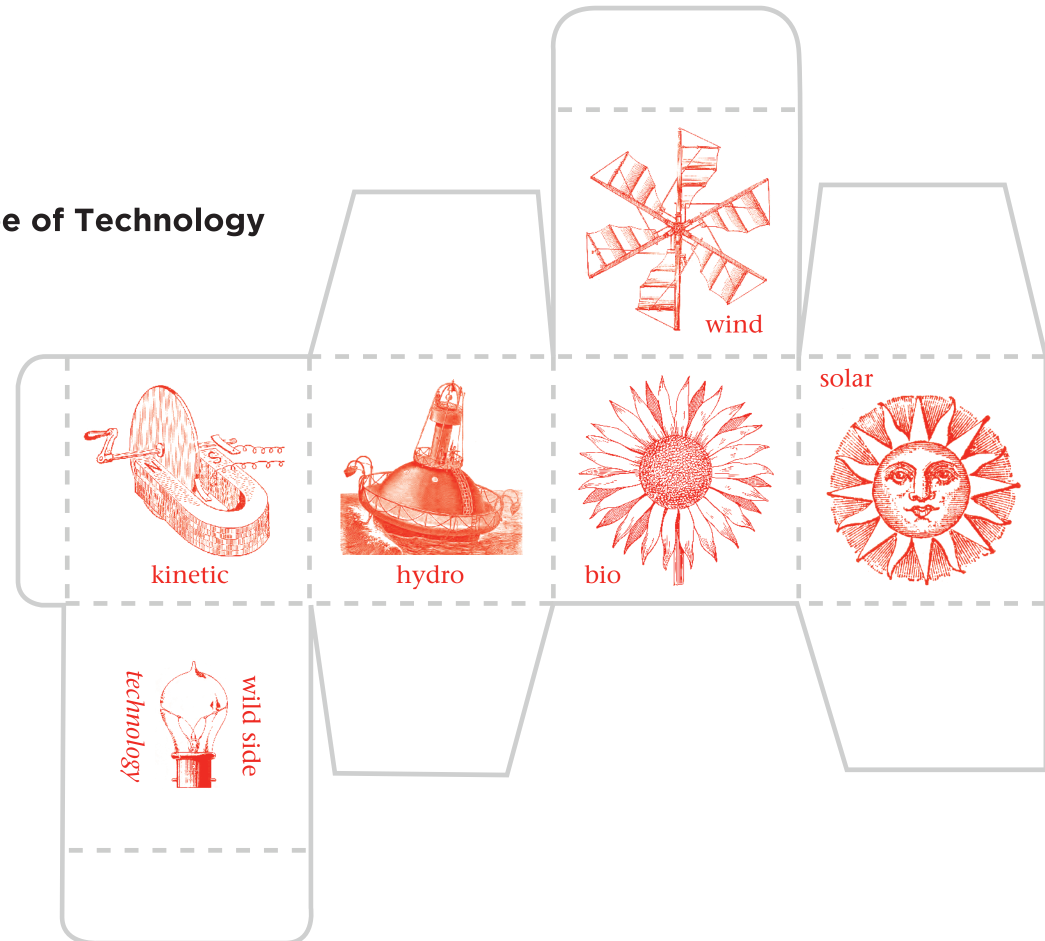
Sometimes your first idea is not the strongest, so create multiple sketches.

Idea

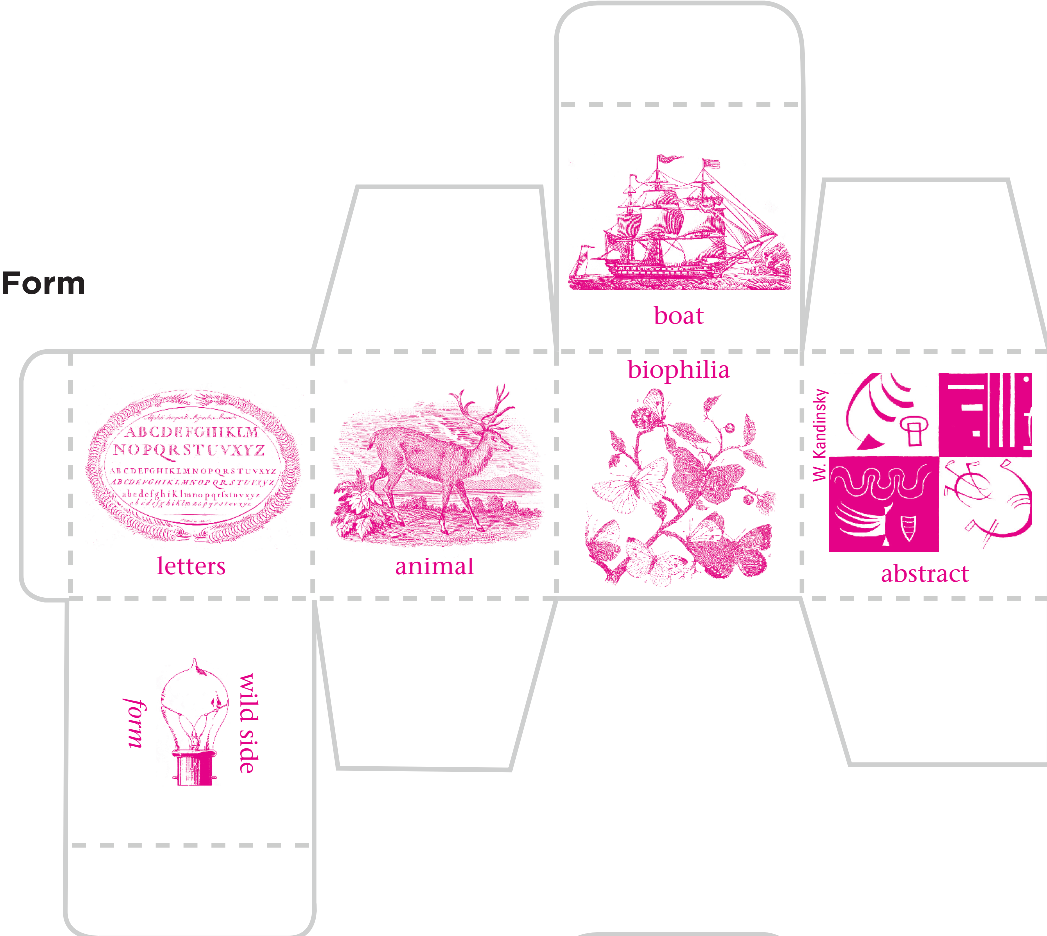
Have your friends give a title to your artwork after you are done sketching.

CUT OUT THE TEMPLATES AND FOLD INTO DICE FORM.

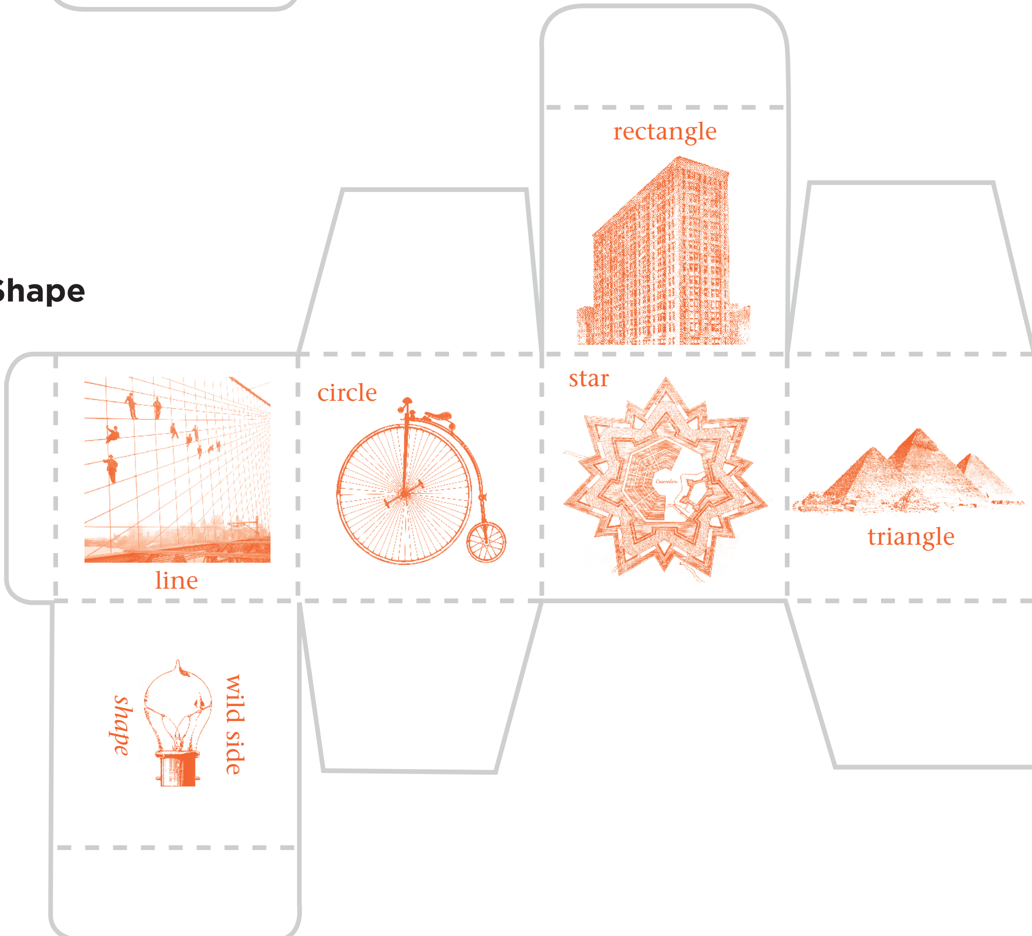
Type of Technology



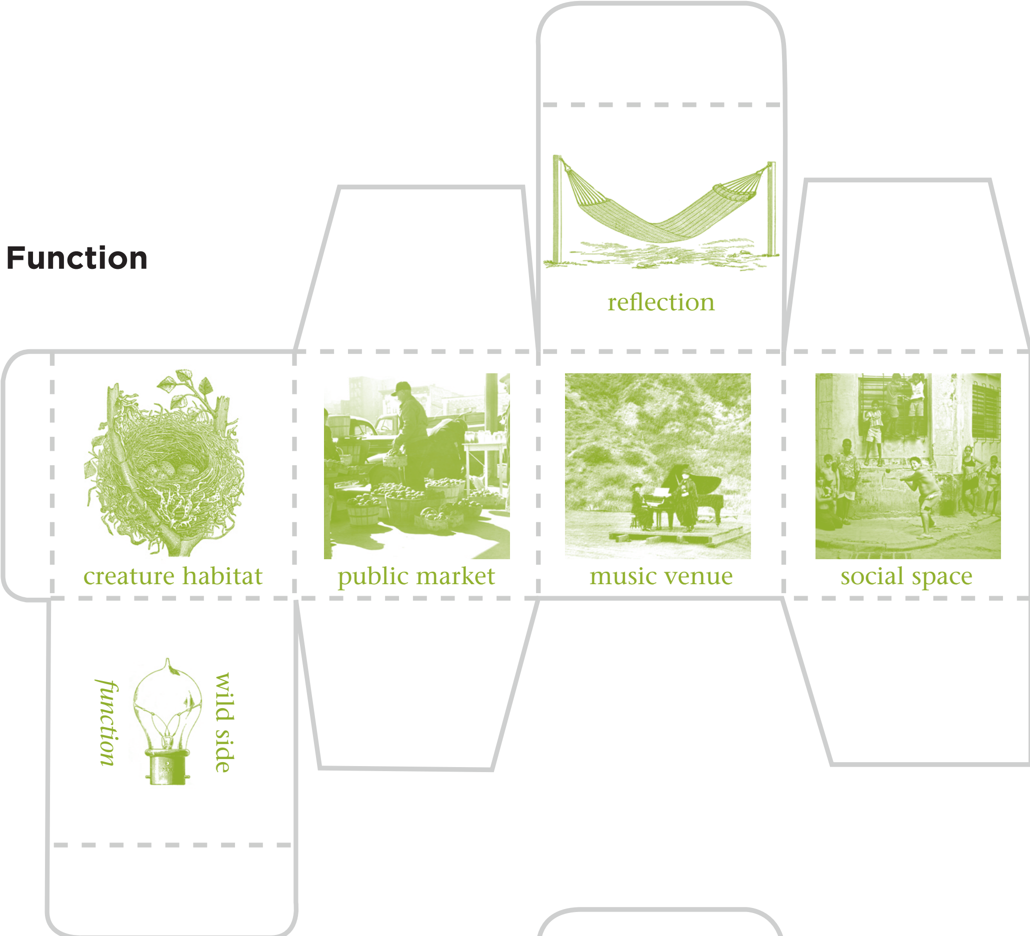
Form


boat
biophilia
letters
animal
W. Kandinsky
abstract
form
wild side

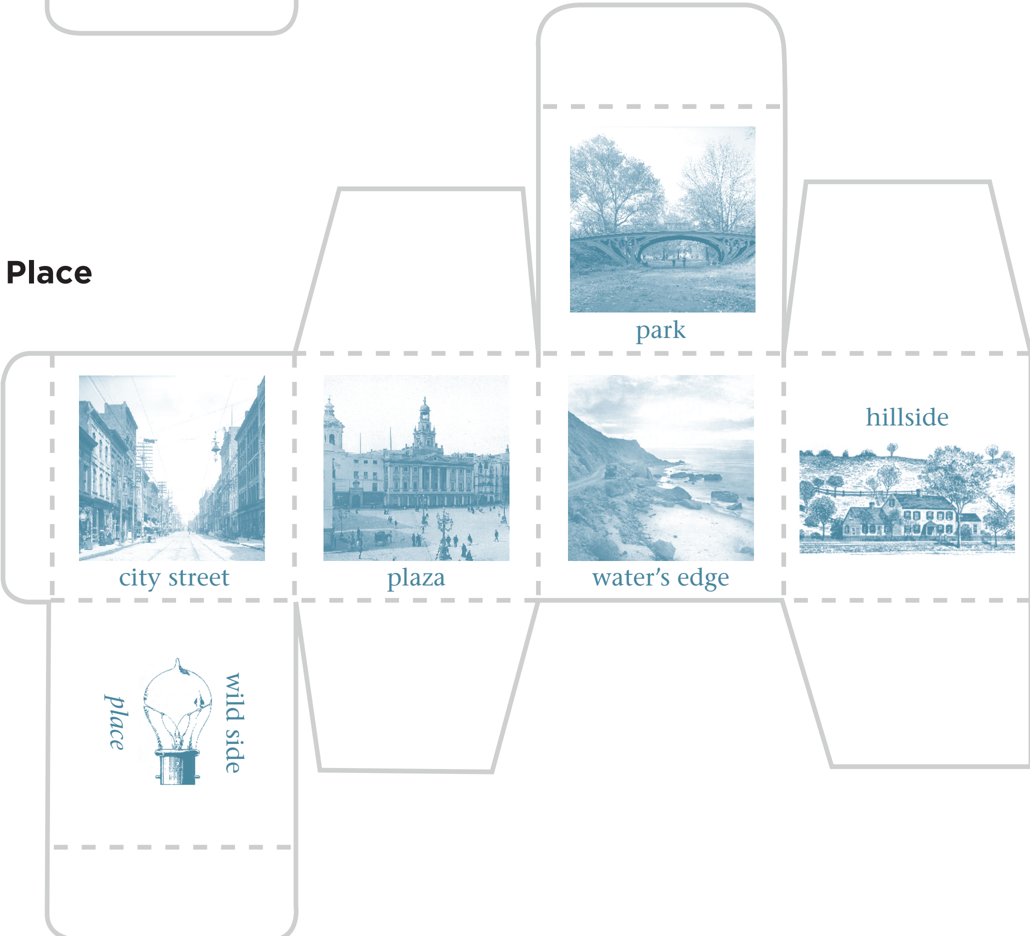
Shape


rectangle
circle
star
line
triangle
shape
wild side

Function



Place



What will you roll?

Combination examples in the form of Land Art Generators

Below you will find examples from the Land Art Generator Initiative portfolio of projects. You'll see the combination of dice rolls that might have led the designer to arrive at each of the ideas.

Bio (Technology) + Park (Place) + Reflection (Function) + Circle (Shape) = **Golden Roots**

Kinetic (Technology) + Park (Place) + Abstract (Form) + Social Space (Function) = **Power Play!**

Solar (Technology) + Hillside (Place) + Circle (Shape) Creature Habitat (Function) = **Heliofield**

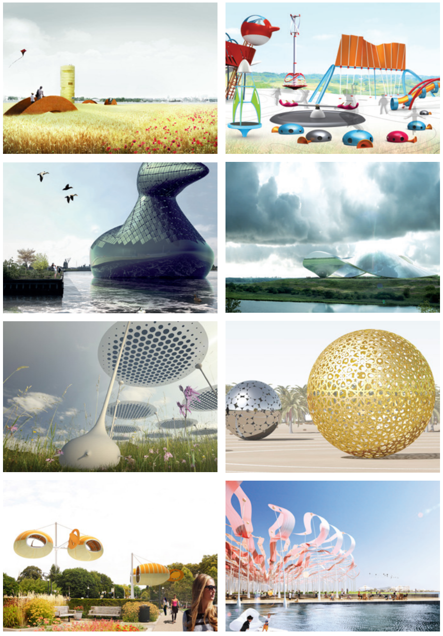
Solar (Technology) + Park (Place) + Abstract (Form) + Music Venue (Function) = **Solar Loop**

Solar (Technology) + Water's Edge (Place) + Animal (Form) = **Energy Duck**

Wind (Technology) + Plaza (Place) + Social Space (Function) = **WindNest**

Solar (Technology) + Park (Place) + Circle & Star (Shape) + Reflection (Function) = **Solar Eco System**

Solar (Technology) + Line (Shape) + Water's Edge (Place) + Social Space (Function) = **Beyond the Wave**



You will notice that these artworks were designed by groups of people. Some of these teams have artists, architects, engineers, and scientists all working together. This is the power of the collaborative process!

Artwork Information (left to right)

Golden Roots
TEAM Ronny Zschörper, Franziska Adler
TECHNOLOGY biomass
ANNUAL CAPACITY 52 MWh (could power about 6 homes)

Power Play!
TEAM Trygve Faste, Aubrey Ament, Michael Bartell, Bryce Burgess, Kevin Do, Yasunori Fujikawa, Elizabeth Hampton, Heidi Hollingsworth, Isamu Jarman, Stephanie McCuaig, Lauren Mikami, Daniel Nicholson, Nathan Schultze, Claire Stewart, Joel Swenson, Rebecca Swofford
TECHNOLOGY wind turbines, solar panels, kinetic harvesting
ANNUAL CAPACITY 100 MWh (could power about 12 homes)

Energy Duck
TEAM Hareth Pochee, Adam Khan, Louis Leger, Patrick Fryer
TECHNOLOGY solar panels
ANNUAL CAPACITY 400 MWh (could power about 50 homes)

Solar Loop
TEAM Paolo Venturella, Alessandro Balducci, Gilberto Bonelli, Rocco Valantines, Mario Emanuele Salini, Pietro Bodria
TECHNOLOGY solar panels
ANNUAL CAPACITY 10,000 MWh (could power about 1,150 homes)

Heliofield
TEAM Michael Chaveriat, Yikyu Choe, Myung Kweon Park
TECHNOLOGY solar panels
ANNUAL CAPACITY 15,000 MWh (could power about 1,730 homes)

Solar Eco System
TEAM Antonio Maccà and Flavio Masi
TECHNOLOGY tinted and translucent solar panels
ANNUAL CAPACITY 1,000 MWh (could power about 116 homes)

WindNest
TEAM Trevor Lee, Suprafutures
TECHNOLOGY wind turbines, flexible thin film solar panels
ANNUAL CAPACITY 30 MWh (powers one carousel)

Beyond the Wave
TEAM Jaesik Lim, Ahyoung Lee, Sunpil Choi, Dohyoung Kim, Hoeyoung Jung, Jaeyeol Kim, Hansaem Kim (Heerim Architects & Planners)
TECHNOLOGY flexible thin film solar panels, kinetic harvesting
ANNUAL CAPACITY 4,230 MWh (could power about 488 homes)

Worksheet

____

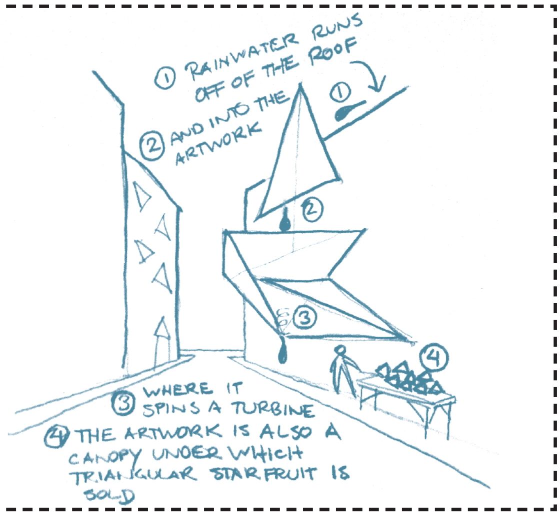
Creator's Name

Write down your combinations here (one toss in each column).

	Example	1	2	3	4	5
Technology	hydro					
Shape	triangle					
Form	boat					
Function	public market					
Place	street					

In the boxes below, sketch what the combinations you wrote down on the previous page might look like as an artwork. Use another piece of paper if you need more space.

example



first toss (column 1 from previous page)

second toss (column 2 from previous page)

third toss (column 3 from previous page)

fourth toss (column 4 from previous page)

fifth toss (column 5 from previous page)

Activity 8 (optional)

SKETCHING IN CONTEXT

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TOOLS

- Drawing materials
- **DOWNLOAD** Design Site Background
- **DOWNLOAD** Design Site Context
- **DOWNLOAD** Design Site Perspective

DESCRIPTION

Students begin sketching ideas for a Land Art Generator on the design site boundary. Sketches of your idea can function as your final concept!

GOALS

1. Sketch forms in perspective
2. Design a public artwork for site-specific context
3. Reflect on decisions made early in the design process

TIME TO COMPLETE ACTIVITY

20–30 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1

Spend some time looking at the LAGI sketches on pages 38–41. The images show examples of early sketches by professional LAGI design teams when they were coming up with their ideas, along with computer renderings of the finished design concept.

Step 2

Students are provided with printouts of the design site and asked to think about what technology they would use to generate electricity there and how people would circulate through and interact with the space.

Step 3

Using a wide marker or charcoal pencil, students individually sketch ideas within the dashed lines of the design site. The dashed lines are called the "site boundary."
Consider giving 10 minutes to this exercise. Limit sketching time at the beginning to 30 second sessions, and then increase the time given to the last sketch up to 5–7 minutes.

Step 4

After completing the last sketch, students spend time answering the questions on the next page.

Step 5

The class then divides into groups (ideally groups are made up of 3–5 individuals).
Each student shows one of their sketches to the group and talks about their answers to the questions.

The LAGI SEE MONSTER Art + Energy Design Challenge Design Site

Q. What renewable energy technology did you use with this design? Why?

A.

Q. Is there anything surrounding the design site that influenced your sketch?

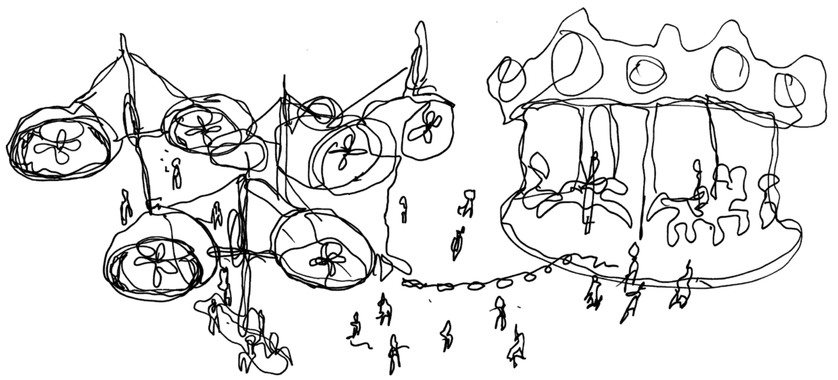
A.

Q. Have you considered the impact that your design has on the environment?

A.

EXAMPLE SKETCHES

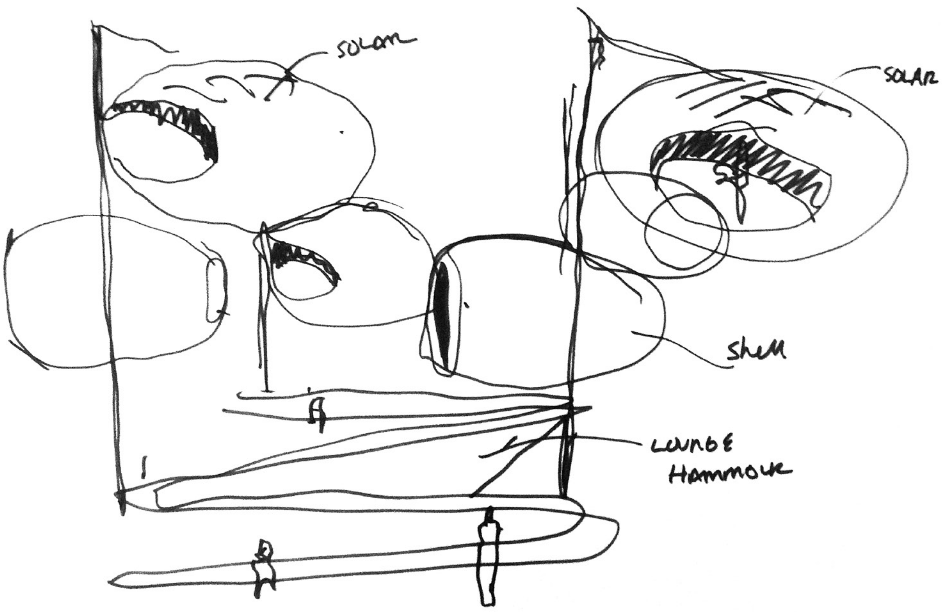
The following sketches were done by professionals as a part of their LAGI design process. Below their sketches you'll see their final computer rendering of the design.

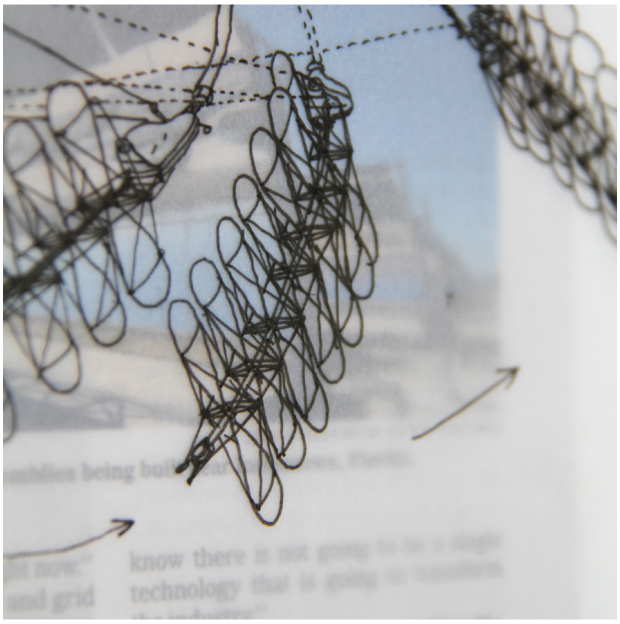


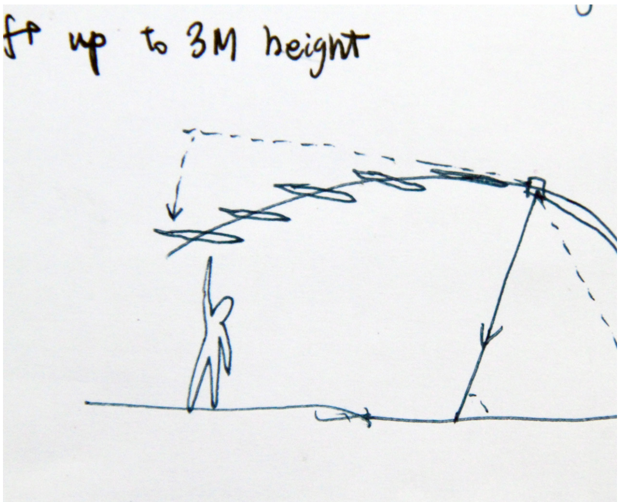
TITLE **WindNest**

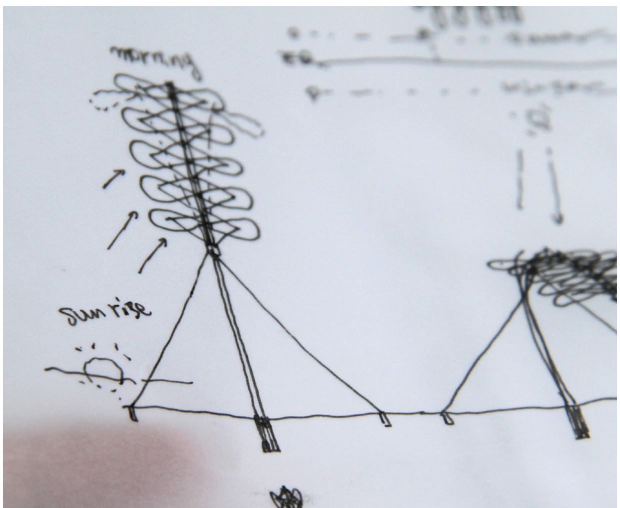
ARTIST Trevor Lee

TECHNOLOGY horizontal axis wind turbines set in compact acceleration ducts, and organic photovoltaic thin film (OPV)

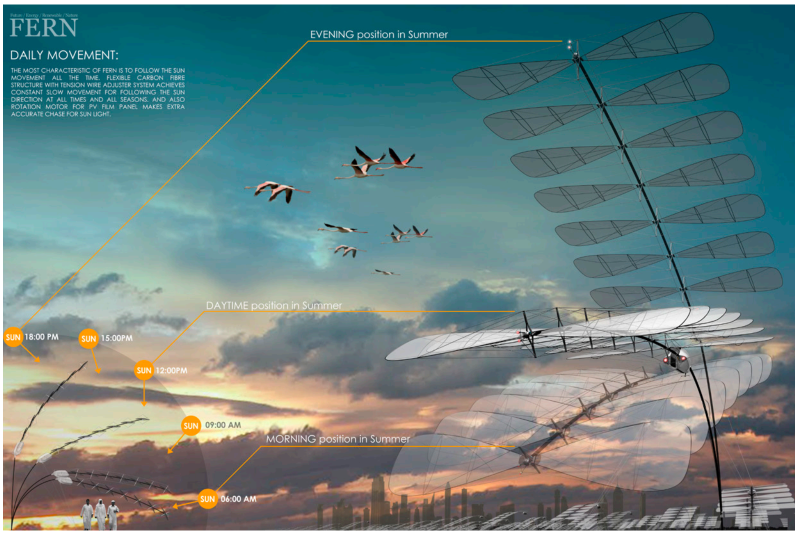








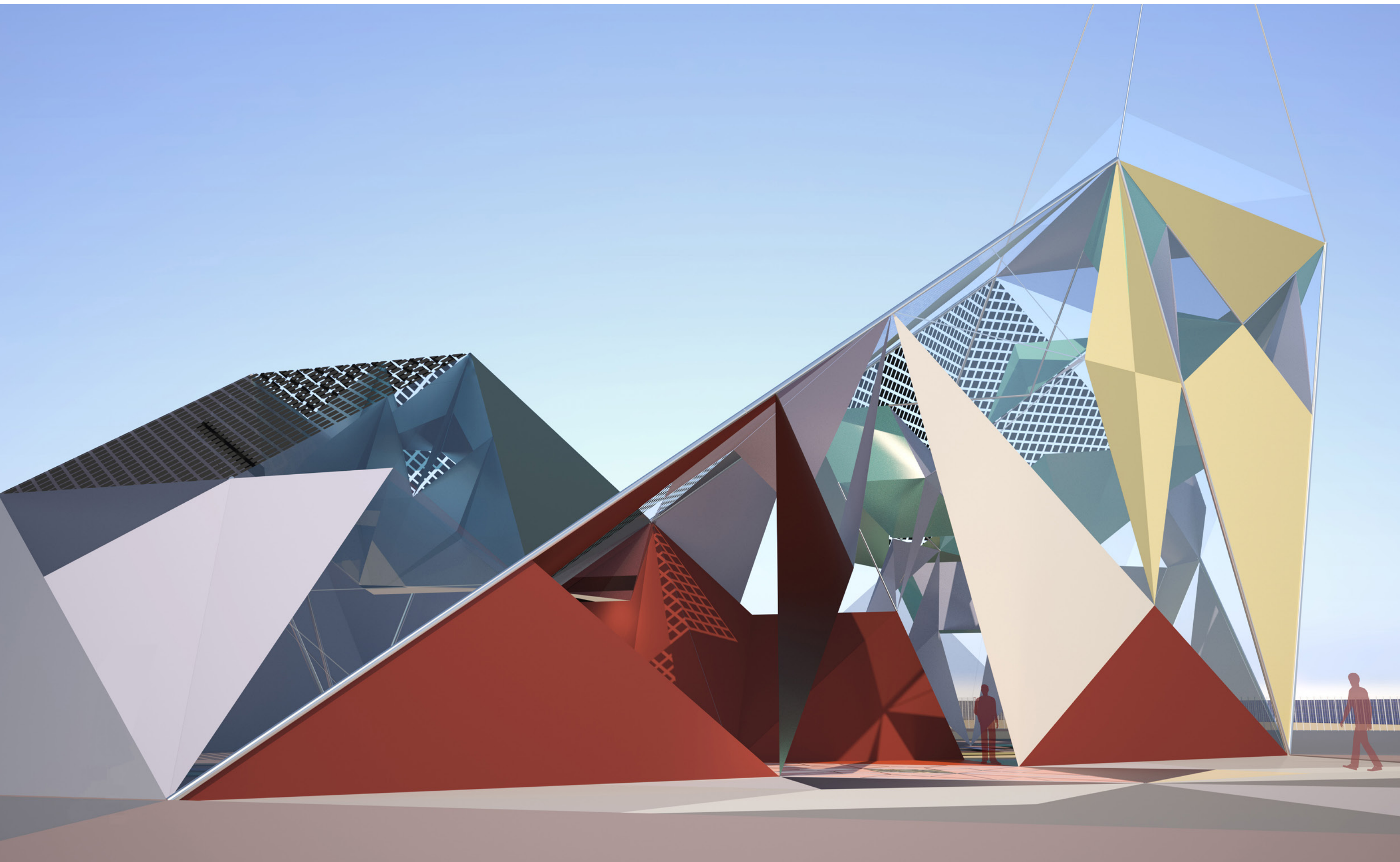
TITLE **FERN**
ARTIST Takuya Onishi
TECHNOLOGY thin film solar and solar tracking mechanism



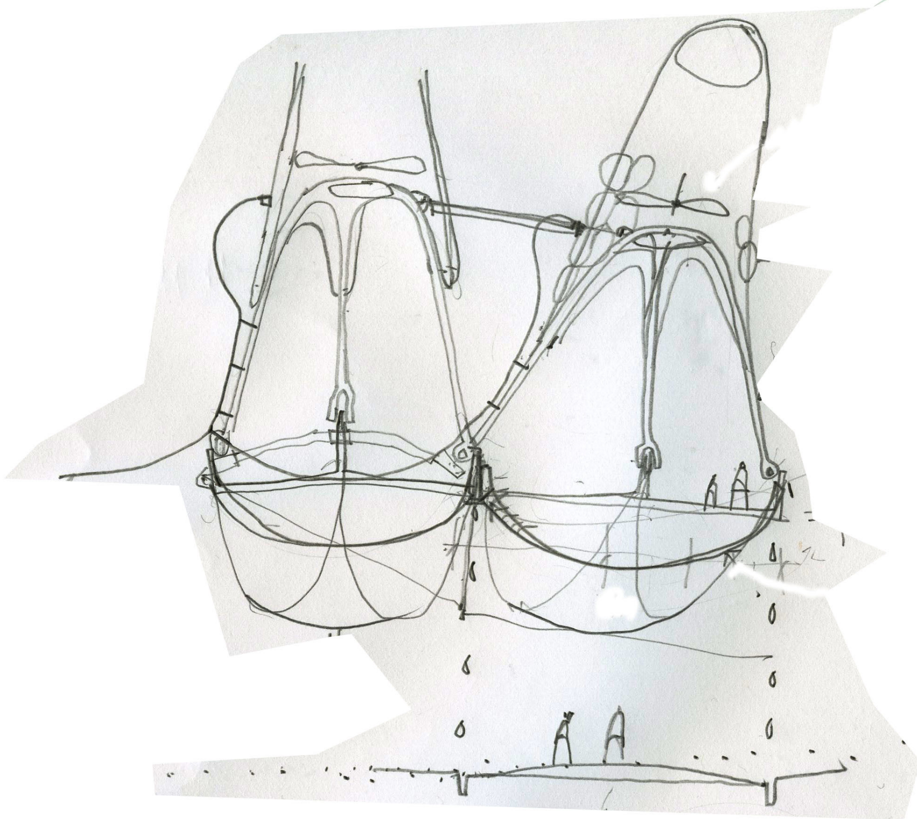
TITLE **Tetras**

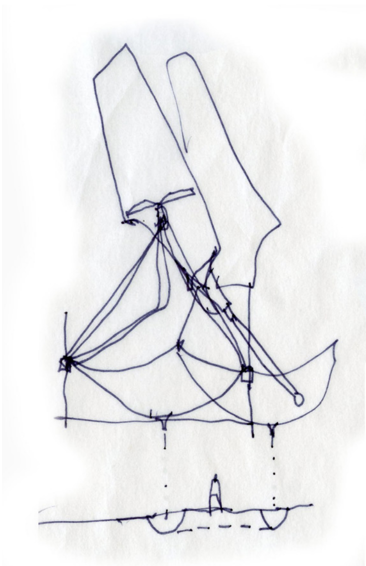
ARTISTS Ann Preston and Roger White

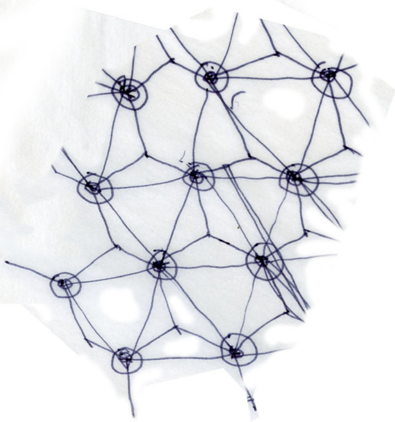
TECHNOLOGY thin film solar

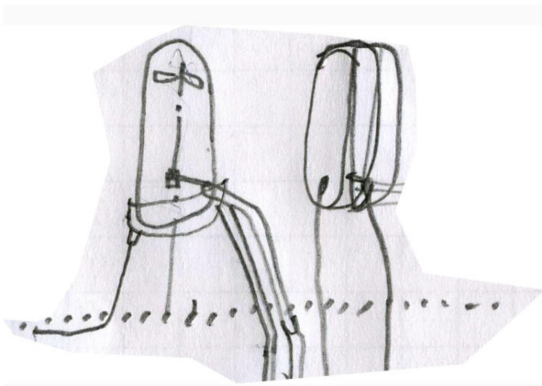


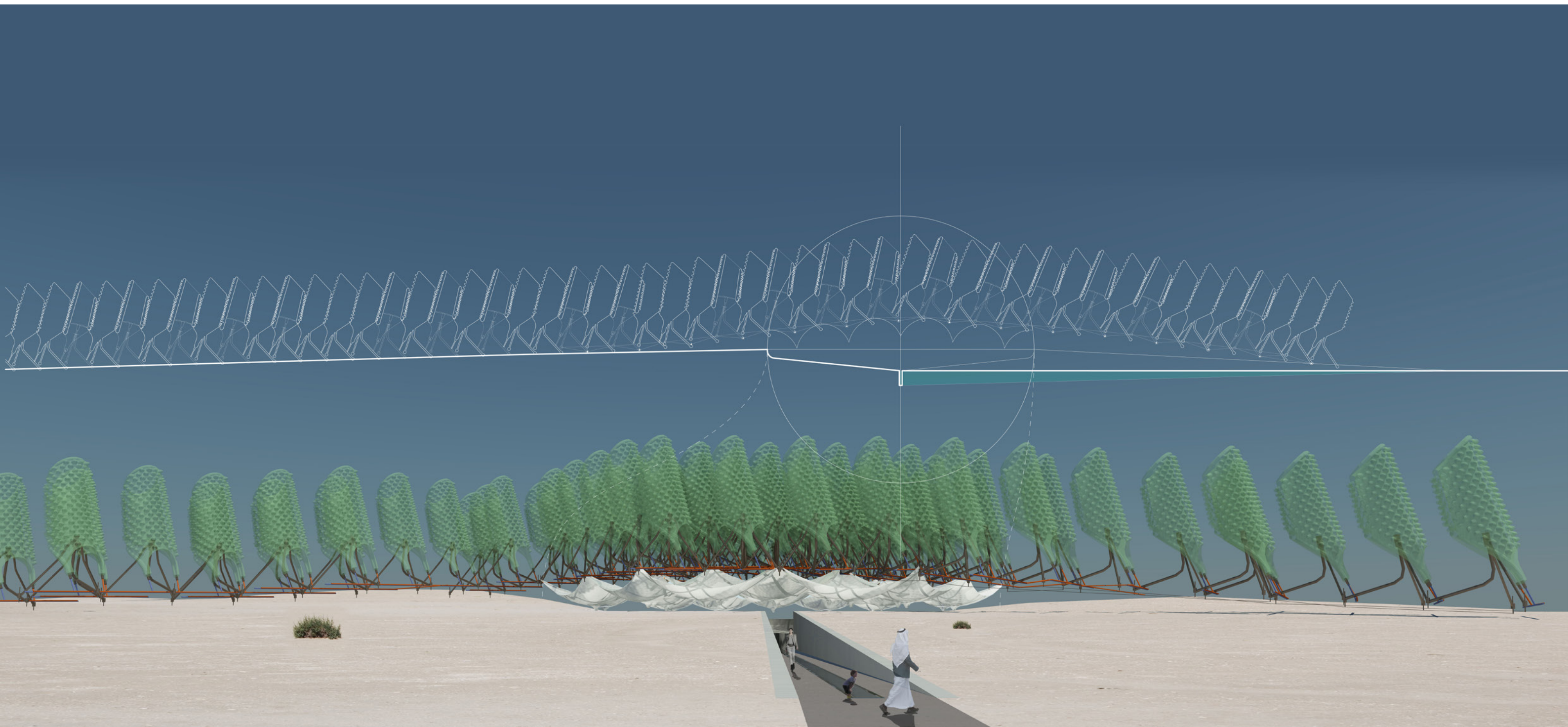
TITLE **Dew Electric**
ARTISTS Joshua Brevoort, Lisa Chun, Ian Campbell, and Jennifer Dixon
TECHNOLOGY solar updraft micro-turbine and water harvesting material











Activity 9 (optional)

MAKE A PROTOTYPE

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DESCRIPTION

Students form their design team for the Challenge. Together the team sketches their first collaborative design concept, then builds a prototype of their design with models placed on top of the design site plan. Photos of this prototype can function as your final concept!

TOOLS

- Sculpting and modelling materials
- **DOWNLOAD** Design Site Perspective
- **DOWNLOAD** Design Site Background Plan

GOALS

1. Adapt 2D sketches into 3D models
2. Employ understanding of scale in a design context
3. Demonstrate craft and attention to detail

TIME TO COMPLETE ACTIVITY

45–60 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1

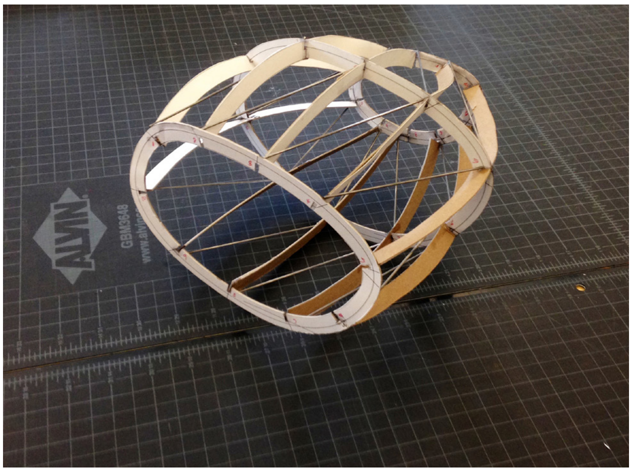
By now you will have read the Design Guidelines Document and understand the context and the design problem. In the previous activity in the Toolkit, Sketching in Context, you will have generated ideas based on your understanding of renewable energy and design. At the end of the Sketching in Context activity, groups of 3–5 were formed and you shared your ideas within your group. This group might now be your official LAGI design team.

As a group, think about what you would like to design together. Are there some ideas in your group that can be combined? Read through the design brief as a group and talk about what it is asking. How would you work together in your group to design a solution that is the very best it can be? What story will you tell with your artwork?

Step 2

Using the Design Site Background or Design Site Perspective drawings, take 15–20 minutes to arrive at a group sketch. Remember the Sketching in Context activity. Start with a bunch of quick sketches and then spend more time on the later sketches. Think through how your design would appear on each of the drawings (Plan, Elevation, and Perspective).

This group sketch is your first group design concept. Now you will work together to test your idea.



Above: Photographs of the prototype made by artist Trevor Lee when designing the **WindNest** project for a site in Pittsburgh. The lower image is a computer rendering of what it would look like in Schenley Plaza.

The final artwork has wind turbines inside of the cloud like forms. Each set rotates 360 degrees to face the wind direction at any given time. The orange stripes that you see on top are thin film photovoltaic material.

Step 3

Review the prototype examples on this page and the following pages. Notice that each artist team chose different materials for their models. Each time you model your idea in three dimensions, it will allow you and your design team to experiment and reflect on how the idea will actually work in the world. In every design process there is discovery along the way—sometimes it doesn't work the way you thought it would. For what reason?

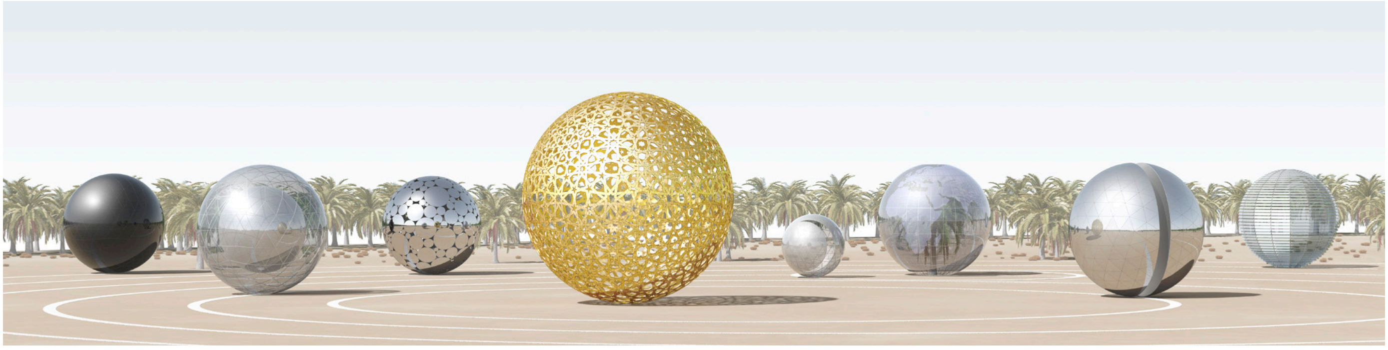
You'll see on the next page that the **Blossomings** team uses the simplicity of folded paper to demonstrated their design! The most beautiful designs are sometimes those that discover the simplest solution to a problem or question. Often the simplicity of the finished form conceals a complex process that led to its creation.

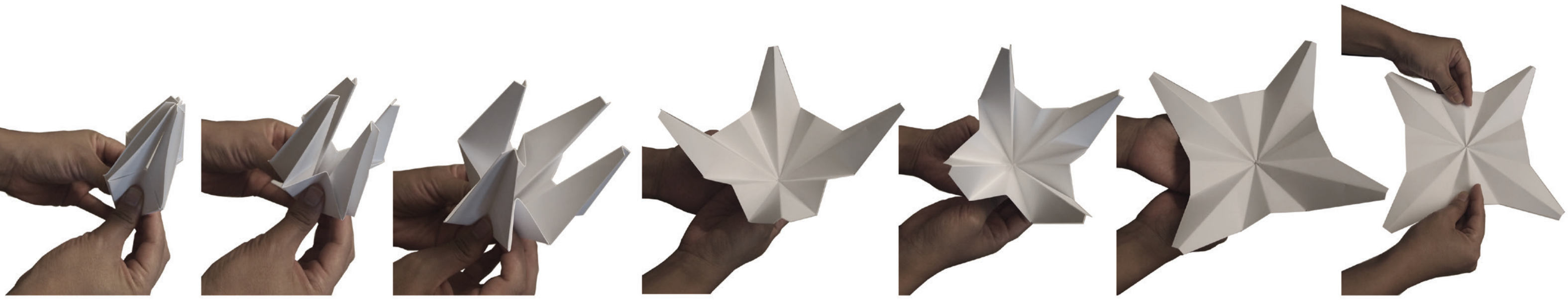
Step 4
On top of the Design Site Background Plan drawing (printed at full scale on A1 size paper) each group works together to build a model of your idea in three dimensions. Use clay, straws, sticks, pipe cleaners, wire, toothpicks, folded and twisted paper, or anything you can get your hands on for sculpting materials. Make sure to use caution with glue guns, scissors, or other tools.

How are you modelling your renewable energy technologies? Are you making a turbine? If so, what is in the path of the blades when they spin? Are you using solar panels? Are they straight or curved? Do they face towards the sunshine at noon, or in the morning or evening?

Antonio Maccà's prototype model above of **Solar ECO System** and his computer rendering below for his LAGI 2010 proposal. The prototype explores the concept of the abstraction of the solar system and relative scale.

The final artwork uses photovoltaic panels that have been custom fabricated into shapes fitted into patterned spheres.





Above is a prototype model of **Blossomings** by Inki Hong, Solim Choi, and Walter Sueldo (Architecture i.S). It's made out of paper. Below are their computer renderings for their LAGI 2012 proposal. The final artwork (images below) is a modular unit that uses a folding geometry to expose solar panels to the sun during the day, and closes at night to become a vertical axis wind turbine.

Activity 10 (optional)

LAGI YOUTH JURY

land art generator initiative powered by art!

DESCRIPTION

Students analyse LAGI artworks through a guided exercise. After gaining a deeper understanding of the concepts behind the artworks they are asked to assess each submission based on the LAGI Jury Criteria.

TOOLS

- Projector or computer screen
- **DOWNLOAD** LAGI Jury Example Presentation

GOALS

1. Apply visual literacy and analytical skills
2. Effectively compare and rank designs based on selection criteria
3. Practise skills in collaboration

TIME TO COMPLETE ACTIVITY

50 minutes

STEP-BY-STEP INSTRUCTIONS

Step 1 (10 minutes)

Instructor shows the LAGI Jury Example Presentation to the entire group.
It demonstrates how the LAGI jury criteria was applied to the winner of the 2014 LAGI design competition for Copenhagen. Have a group discussion about the selection process.

Step 2 (5 minutes for each: total 20 minutes)

Together study the four LAGI artwork designs in the pages that follow. Discuss the details including the title, the technology, its annual electrical output capacity, and the artist's written description.

Step 3 (10 minutes)

It's your turn to assess! Follow the criteria and assign the points using the worksheet on the next page. Rate each of the four designs based on all of the LAGI Jury Criteria. Give 1–5 points for each criteria and total the points in the box at the bottom.

Step 4 (10 minutes)

Sum up all of the scores using the totals from each individual juror (consider going around the room with each student sharing their scores) and present the winner. Have a group discussion about the winning submission.

Students get into groups and rate each design they looked at based on the LAGI Jury Criteria. They can give 1–5 points for each criteria. The project with the most points wins!

	Beyond the Wave	WindNest	Energy Duck	Solar Eco System
Criteria 1 Points (1-5)				
Criteria 2 Points (1-5)				
Criteria 3 Points (1-5)				
Criteria 4 Points (1-5)				
Criteria 5 Points (1-5)				
TOTAL POINTS				

Name

LAGI Jurors assess artwork proposals based on the five sets of questions below (called criteria). Each question leads you to make an assessment with your answer. It could be a “yes” or a “no.”. Or it could be “very much” or “very little”. If you answer “yes” or “very much” you’ll give more points; “no” or “very little” would mean fewer points. There are no right answers, but do your best to be honest and helpful to the artist with the points you assign. Using criteria is a way to make your assessment fair and constructive.

Criteria 1.
How does the artwork fit into its surroundings? Is the design responding to elements around it such as buildings, landscape, or human culture?

Criteria 2.
Is the design sensitive to nature? Can you think of any ways in which it might be harmful or beneficial to animals or to the environment?

Criteria 3.
How much clean electricity can be produced by the artwork? (refer back to the Energy Fundamentals activity)

Criteria 4.
How does the artwork address the public? How can people interact with it? Do you think it would be a nice addition to the community?

Criteria 5.
What does the artwork make you think about? Does it provide meaning or ask important questions? Is it beautiful? Poetic?

BEYOND THE WAVE

ARTIST TEAM
Jaesik Lim, Ahyoung Lee, Sunpil Choi, Dohyoung Kim, Hoeyoung Jung, and Jaeyoul Kim

ENERGY TECHNOLOGIES
organic photovoltaic (OPV), kinetic harvesting (piezoelectric)

ANNUAL CAPACITY
4,230 MWh (4,500 MWh minus 200 MWh for lighting and 70 MWh for soil cleansing)

ARTIST'S WRITTEN DESCRIPTION
Inspired by the kinetic sculptures of artist Len Lye, **Beyond the Wave** creates visual movement and dynamic expression with ribbons attached to flexible poles. The way the poles and ribbons are placed is based on the way that the wind blows across the site and also on the type of soil in the ground. Some of the electricity produced is used to light the artwork, and some is used to clean the soil through a process called Electrokinetic Remediation. The rest is distributed to the city grid.

The ribbon that interconnects the poles symbolically becomes a "wave," representing the encounter between the water and the wind. The system utilises the power of the sun while also harnessing the forces within the support structures to produce additional energy with piezoelectric disks. The poles to allow the ground to be open for various park-like activities. A display panel in the lower part of the pole indicates the amount of energy generated.

WINDNEST

ARTIST TEAM
Trevor Lee

ENERGY TECHNOLOGIES
compact wind acceleration turbines and flexible organic photovoltaic solar film

ANNUAL CAPACITY
30 MWh

ARTIST’S WRITTEN DESCRIPTION
WindNest is a unique renewable energy installation designed as a safe and educational public amenity for visitors. The installation demonstrates the potential for our sustainable infrastructures to be joyful contributions to creative placemaking. Walking through **WindNest**, visitors will 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 at that very moment generating clean electricity with a mix of wind and solar technologies. Perhaps they’ll take a moment to sit on the wood bench and charge their phone with the energy that the artwork is generating. From there they will see an interpretive display showing how much electricity is being generated at that very moment from wind and solar, and how much has been generated since its installation.

ENERGY DUCK

ARTIST TEAM
Hareth Pochee, Adam Khan, Louis Leger, and Patrick Fryer

ENERGY TECHNOLOGIES
Photovoltaic Panels

ANNUAL CAPACITY
400 MWh

ARTIST'S WRITTEN DESCRIPTION
So much more than just a duck, **Energy Duck** is an entertaining and iconic sculpture.

The common eider duck is resident in great numbers in Copenhagen, however its breeding habitat is at risk from the effects of climate change. **Energy Duck** takes the form of the eider to act both as a solar collector and a buoyant energy battery.

Solar radiation is converted to electricity using low cost, off the shelf PV panels. Some of the solar electricity is stored in the form of gravitational potential energy via water pressure. At night, when there is no solar radiation the water pressure can be released through hydro turbines within the duck's belly providing renewable electricity at all times. The floating height of the duck is an indicator of the amount of city wide energy use relative to the renewable generation.

SOLAR ECO SYSTEM

ARTIST TEAM
Antonio Maccà and Flavio Masi

ENERGY TECHNOLOGIES
various types of photovoltaic panels of differing reflective hues

ANNUAL CAPACITY
1,000 MWh

ARTIST'S WRITTEN DESCRIPTION
The project is an artistic interpretation of the Solar System and marks the position of the planets corresponding to the configuration of the Solar System on December 2nd 1971, the day in which the United Arab Emirates was founded. The environmental installation is a metaphor of the Seven Emirates, represented in the form of a Sun with six planets. The artwork is also meant to create a new iconic sun for the City of Abu Dhabi: the astronomic Sun radiating energy to the new photovoltaic sun, which will generate light and electricity for the city.

The PV sun works as the attracting element and symbolises the unity and infinity of the cosmos. The endless geometrical pattern of the golden surface, with its timeless perfection and purity, represents the starry sky and creates a spherical motif of both light and shade. The spheres are all different, varying in structure, dimension, colour, transparency, and photovoltaic technology.

Activity 11 (optional)

GOOD IDEAS GET BETTER

land art generator initiative **powered by art!**

DESCRIPTION

Student teams analyse their designs and seek guidance from others. Through the process, they will learn how to give comments constructively. The format of this activity is similar to a design review meeting that might be conducted with a client on a real project.

TOOLS

Student sketches and models that were made in previous activities

GOALS

1. Evaluate design effectiveness
2. Consider and propose alternatives
3. Collaborate with others to improve
4. Provide feedback to peers in a constructive manner

TIME TO COMPLETE ACTIVITY

30–45 minutes

By now you will have established your design teams. You will have also generated your first collaborative sketch and your first prototype. Now it's time to share your idea with other teams and seek external feedback. If you are using this Toolkit as an individual (outside of a classroom or after-school club), consider seeking advice from family members and friends.

Self and group reflection is a critical part of the creative process. Professional designers go through it every day, providing and receiving comments in frequent design reviews in an effort to make their good ideas better. It's important to let yourself be open to the feedback of others. Sometimes they can help you see things in a way you may otherwise overlook. You can decide to change your design in response to their feedback, or you can explain in more detail the reasons that you think your way is still better.

STEP-BY-STEP INSTRUCTIONS

Step 1

Find another group of students, perhaps another group working on their own LAGI design (or it could be any group).

Step 2

Provide one copy of the worksheet to each student and let everyone read the instructions at the top.

Step 3 (5–10 minutes)
Presentation: The first group picks one team member to lead their presentation. In about 5 minutes they explain the ideas behind their group's design, why the artwork looks the way it does, what renewable energy technologies they used, and how it works.

Explain how people will experience the artwork when they approach it for the first time. How much electricity do you estimate it will produce? What is the electricity used for?

Step 4 (5–10 minutes)
Question and Answer: Pay attention during the presentation and do not write. Once the presentation is over, feel free to ask questions of the presenting team.

Step 5 (10 minutes)
Design Review: Using the worksheet, each student on the reviewing team writes down at least three comments that come to mind. Think about what will be most helpful for the presenting team as they continue to work on their design. Is there something that they have not answered? Details they should focus on?

While the reviewing team is writing their comments, the presenting team talks about how they can improve their presentation.

Step 6
Switch! Repeat Steps 3–5 with the other team presenting.

Step 7
Reflection: Based on the feedback that has been provided about your artwork, write down five things that you plan to do that will make your design stronger. You can use the back of the worksheet that was provided to you by your reviewers.

Consider going back to the Making a Prototype activity, incorporating the lessons that you learned in this activity. Designing is an iterative process that repeats for as long as it takes to arrive at what you think is the most perfect outcome!

Professional projects often hire a design review consultant who can make an informed and unbiased assessment of the success of a project. This person or team is referred to as a "third-party" because they are not the owner or the designer. Instead they are paid to be completely objective. This is the role you should take on as the reviewer in this activity.

Worksheet

The questions in the left column represent the jury criteria. If this challenge were being judged for a winner, these would be the things the jurors would be measuring against. As you listen to the presentation by the other group and as they explain their design ideas, write down some comments in the column on the right that you think will help their design get better.

____
Name of team being reviewed

____
Name of reviewer (your name)

Write your design review comments for your friends in the empty column below.

1. How does the artwork fit into its surroundings? Is the design responding to elements around it such as buildings, landscape, or human culture? **2.** Is the design sensitive to nature? Can you think of any ways in which it might be harmful or beneficial to animals or to the environment? **3.** How much clean electricity can be produced by the artwork? (refer back to the Energy Fundamentals activity) **4.** How does the artwork address the public? How can people interact with it? Do you think it would be a nice addition to the community? **5.** What does the artwork make you think about? Does it provide meaning or ask important questions? Is it beautiful? Poetic?	

Activity 12 (optional)

YOUR CREATIVE STATEMENT

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TOOLS

- Writing materials
- Dictionary
- Thesaurus
- Calculator

DESCRIPTION

Students reflect on the experience of designing their own Land Art Generator artworks and create a list of tips for future designers. Students then create their own creative statements, and calculate the energy output of their artwork. This is followed by an open work and documentation session.

GOALS

1. Reflect on the design process and workshop experience
2. Articulate aesthetic concepts
3. Demonstrate a link between language and design
4. Calculate energy output figures for regenerative artworks

TIME TO COMPLETE ACTIVITY

60 minutes

By the time you reach this activity, you and your team will have worked through much of the design process. You will have read and understood the Design Guidelines Document and the Design Brief within it, brainstormed some creative ideas, sketched your ideas, modeled them in three dimensions, and made changes to your design based on constructive feedback provided by others.

This activity is intended to help you start to package your design for presentation. You'll put together a narrative summary of your concept and you will arrive at an estimate of the amount of electricity that your artwork will produce in a typical year.

STEP-BY-STEP INSTRUCTIONS

Step 1 (5 minutes)

Instructor leads with the following or similar questions to the entire group:
What did you find to be most challenging about designing your Land Art Generator artwork?
What came the easiest to you? Why?

Step 2 (10 minutes)

Consider referring back to the LAGI Jury Example Presentation and reading the creative statement that Santiago Muros Cortés wrote about his artwork, **The Solar Hourglass**.

Step 3

Students split into their design teams and one person on each team is selected to be the creative writer. This person will collect the thoughts of the group on paper or on the computer during the remainder of this activity.

Note: It's perfectly fine if you are working on your own. You can just ignore all of the references to the team and group. After completing each activity, consider sharing your work with someone (either an adult mentor or a friend) who can provide continuous feedback along the way.

Step 4 (20 minutes)

Instructor provides each team with a copy of the Creative Statement Generator Worksheet (on the following page). Working as a team, students fill in the worksheet questions, reflecting on the process that they went through to arrive at their solution. Teams should consider what the best way will be to convey to others the ideas contained within their design and the way they hope people will experience it when they visit the artwork.

Step 5 (15 minutes)

Reflect back on the Energy Output Worksheet that was used in the Energy Fundamentals activity. In that activity students used energy conversion efficiency and capacity factor to estimate the annual output of four different energy installations.
Now teams will examine their own art installations using the same process.

Teams work on the Adding Up Electrons worksheet. It's a good idea to check each other's math because it's easy to make mistakes.

Step 6 (10 minutes)

Together, each team writes their final written narrative statement using the answers that have been generated with the two worksheets. This will be the document that will be emailed with your drawings.

Title of Artwork

Worksheet

CREATIVE STATEMENT GENERATOR

Pictures and models are very important, but it's also important to provide a narrative statement that helps others to understand why you made the decisions that you made.

What is the best way for you to talk to others about your design? Perhaps you would like to explain how you derived the form of your artwork or why you chose to focus on one part of the site over another. How do you want people to experience your artwork when they visit it? Maybe the best way to talk about it is to tell a short story, or to make reference to the writing of others (if so, make sure to provide a proper citation).

Be poetic and get creative!

Using a separate sheet of paper, answer the six questions below.

1. Think back to when you were just beginning to research and come up with your first ideas. What was your biggest inspiration?

2. What are the first five words that come to mind when you think about your artwork?

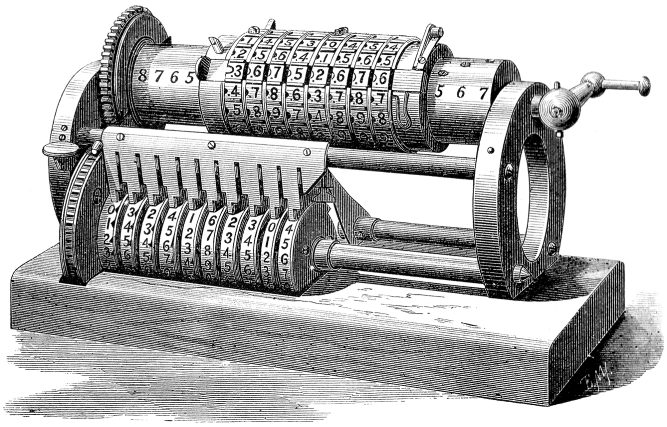
3. Using the five words that you listed above, write a short paragraph that tells the story of your artwork. In the paragraph, explain how your concept relates to the context of the site.

4. Write three sentences that best describe what people will experience when they visit your artwork.

5. What renewable energy technologies does your artwork include? How are they integrated? Does their function rely on interaction with people? With nature?

6. Think of three ways in which your artwork will have an impact on the natural environment. Are you digging foundations in the sand to provide a structure for your artwork? What is living in the sand? Does your artwork extend out into the water? What is living there? For each of the three impacts, write a sentence about how you could minimise the effect on the environment and what regular maintenance might be required to counteract any negative effects.

Title of Artwork



Once your design is complete (or beforehand if you want to check things along the way), you'll need to take careful measurements of the dimensions of your energy technologies. Make use of the graphic scale on the Site Plan Drawing.

If you need to convert to or from metric units:
1.0 meter = 3.28084 feet
1.0 square meter (m^2) = 10.7639 square feet (ft^2)
1.0 foot = 0.3048 meters
1.0 square foot = 0.092903 square meters

Do you have solar panels in your artwork? If so, what is the surface area? If you have wind turbines, you can measure the swept area that the wind passes through. Similar rules will apply to other technologies. Once you have your dimensions, all you need in order to estimate the annual production of your artwork is the nameplate capacity and the capacity factor for each technology.

Step 1
See the list on the following page. Check the blue box next to each technology that you use in your artwork. It's OK if you only use one (simplicity is good). Be sure to separate out the different types of solar PV installations within your design (the capacity factor varies greatly depending on the orientation of your panels). If you aren't sure about the distinctions between technology types, please download and look through A Field Guide to Renewable Energy Technologies.

Step 2
See the box below. Do a separate calculation for each type of technology and then add your answers together to arrive at a total output for your artwork.

Surface Area #1 **x** nameplate capacity **x** capacity factor **x** 8,760 hours/year **=** annual output

[m^2] [Wp] [%] [Wh]

+ Surface Area #2 **x** nameplate capacity **x** capacity factor **x** 8,760 hours/year **=** annual output

[m^2] [Wp] [%] [Wh]

+ (repeat for each technology) Total Annual Electrical Output **=** [Wh]

	nameplate (peak) Wp	capacity factor	type of technology
❑	200 Wp/m^2	25%	Solar PV—Heliostatic (dual-axis sun tracking)
❑	200 Wp/m^2	20%	Solar PV—Angled (south-facing 15–60 degrees from horizontal)
❑	200 Wp/m^2	12%	Solar PV—Vertical (south facing > 60 degrees from horizontal)
❑	200 Wp/m^2	17%	Solar PV—Horizontal (or < 15 degrees from horizontal)
❑	200 Wp/m^2	10%	Solar PV—Facing East or West
❑	200 Wp/m^2	4%	Solar PV—Facing North
❑	100 Wp/m^2	see above	Flexible Solar Films (see PV angles above for capacity factor)
❑	300 Wp/m^2	30%	Solar - CPV (heliostatic concentrated photovoltaic)
❑	250 Wp/m^2	30%	Solar Thermal CSP (concentrated solar power) **See Note 1**
❑	250 Wp/m^2	55%	Solar Thermal CSP with thermal storage
❑	100 Wp/m^2	25%	Solar Pond with Rankine Turbine
❑	**see Note 2**	40%	Horizontal Axis Wind Turbine
❑	**see Note 2**	48%	Compact Wind Acceleration Turbine (ducted turbine)
❑	**see Note 2**	30%	Vertical Axis Wind Turbine
❑	**see Note 3**	60%	High Altitude Wind (kites, airborne turbines, gliders, etc.)
❑	1 Wp/m	30%	Wind Belts (measure the total length of belts)
❑	**see Note 4**	30%	Ocean Tide (assumes axial type with underwater blades)
❑	10 kWp/unit	25%	Wave Power—Buoy or Point Absorber
❑	500 kWp/unit	10%	Wave Power—Surface Following or Oscillating
❑	100 Wp/m^2	5%	Biofuel (assumes fuel cell conversion to electricity) **See Note 5**

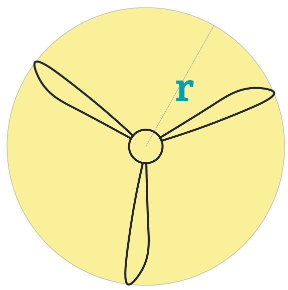
Notes on Calculating Surface Area and Nameplate

Note 1 Includes the following CSP technologies: parabolic trough, linear Fresnel reflector, Stirling dish, and solar power tower.

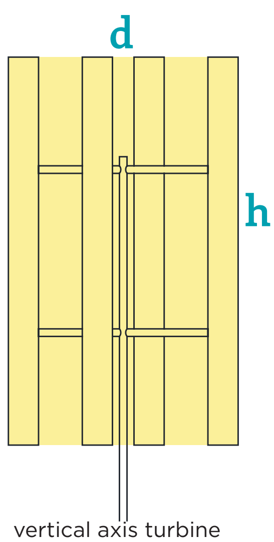
Note 2 Estimate the nameplate capacity for your wind turbine by multiplying the Swept Area by 68. The result is the nameplate capacity of your turbine in watts (_____Wp). See the diagram to the right for help in determining the Swept Area (in yellow). For horizontal axis turbines use the area formula for a circle (πr^2). For vertical axis turbines, multiply the height by the diameter. This is a simplified version of the formula derived by Albert Betz in 1919. The complete formula is:

Power = 0.5 x Swept Area x Air Density x Velocity^3

In the simplified version we have included an air density (1.23 kg/m^3) and average wind velocity (4.8 m/s) at the design site, so the only thing you need to add to the equation is the area swept by your turbine blades.



horizontal axis turbine



vertical axis turbine

Note 3 For kites and gliders, calculate the area within the pattern that the kite or glider makes in the air.

Note 4 Similar to the formula for wind turbines but multiply the Swept Area by 500 instead of 68.

Note 5 Calculate the surface area of algae or biofuel crops that you are exposing to the sun.

Activity 13 (recommended)

TELL THE WORLD

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DESCRIPTION

Students learn how to illustrate and graphically present their ideas in a clear and precise manner. The activity includes lessons on hierarchy of information, simplicity of message, and clarity of communication.

TOOLS

- Drawing supplies
- Sculpting and modelling materials
- Tracing paper
- Computer graphics software (not required)
- **DOWNLOAD** Design Site Background Plan

GOALS

1. Apply visual literacy skills
2. Demonstrate attention to detail
3. Employ communications skills
4. Plan and produce design illustrations

TIME TO COMPLETE ACTIVITY

210 minutes

Now that you have successfully finished your design and your narrative statement, it's time to put it all together in a way that everyone can easily understand. Some people find this to be the most fun and exciting part of the entire design process.

This activity is completed as a team (unless you're working alone, which is also OK!) and will result in the images and text document that you will send to the LAGI SEE MONSTER Art & Energy Challenge by email to lagi@landartgenerator.org.

STEP-BY-STEP INSTRUCTIONS

Step 1 (10 minutes)

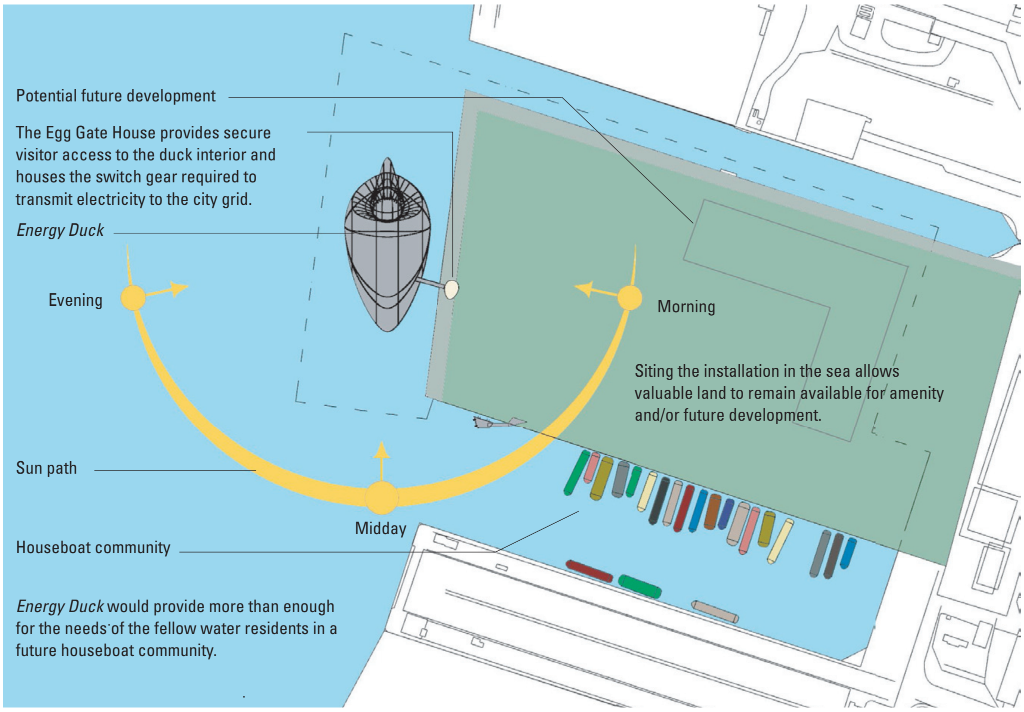
Write down the title of your artwork. Write a few sentences about how you arrived at that particular title. After reading those sentences aloud, write down a sentence (ideally no longer than eight words) that captures the essence of your idea and that people will be able to easily remember. This is your tagline.

An example is the **Energy Duck** project by Hareth Pochee, Adam Khan, Louis Leger, and Patrick Fryer (an entry to the LAGI 2014 Copenhagen professional competition). Their tagline "so much more than just a duck" is fun and intriguing. It makes you want to learn more about the project and discover in what ways this "duck" is really different.

Step 2 (30 minutes)

Plan Diagram

Using the Design Site Background Plan and with reference to your latest sketches and prototype model, draw a simple plan of your artwork as it would be seen from the sky looking down. Write labels directly on your plan that explain key parts of your artwork and the surrounding context. If you don't have enough space, sometimes it is better to write the words in a neat column on the side and draw arrows to the things or spaces you are describing (see the example from **Energy Duck** below). You can also number the important spaces and parts of your artwork and make a key reference somewhere on the paper.



Plan of **Energy Duck** showing the artwork and the surrounding context. The design site boundary from the LAGI 2014 professional competition in Copenhagen is shown as a dashed line. In plan drawings the convention is to align the drawing so that a north arrow would point to the top. If you align your drawing in another way, it is a good idea to include a north arrow to avoid confusion.

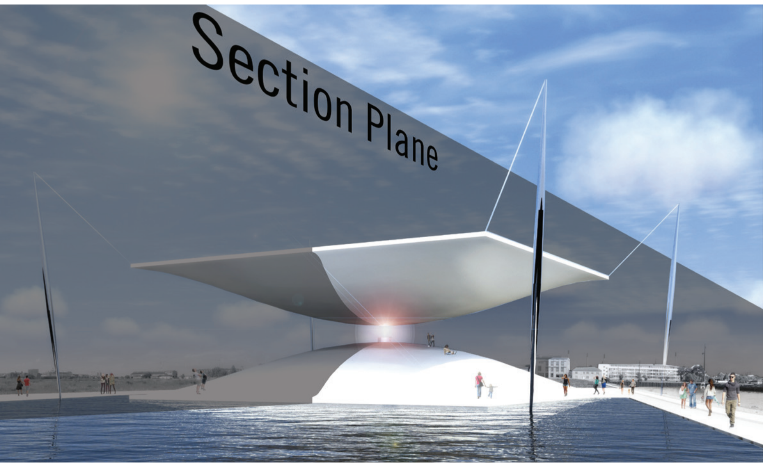
Step 3 (30 minutes)

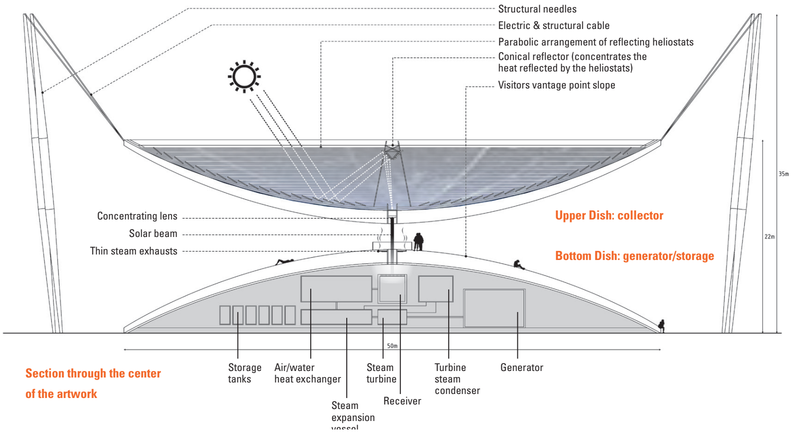
Section or Elevation diagram

How does your project work? Follow the path of energy from **1.** the source (the sun, the wind, or the waves, just to name three examples) to **2.** the technology contained within your artwork (solar panels, wind turbines, wave generators...) to **3.** the wires that carry the electricity from your artwork to the Tropicana to help power it.

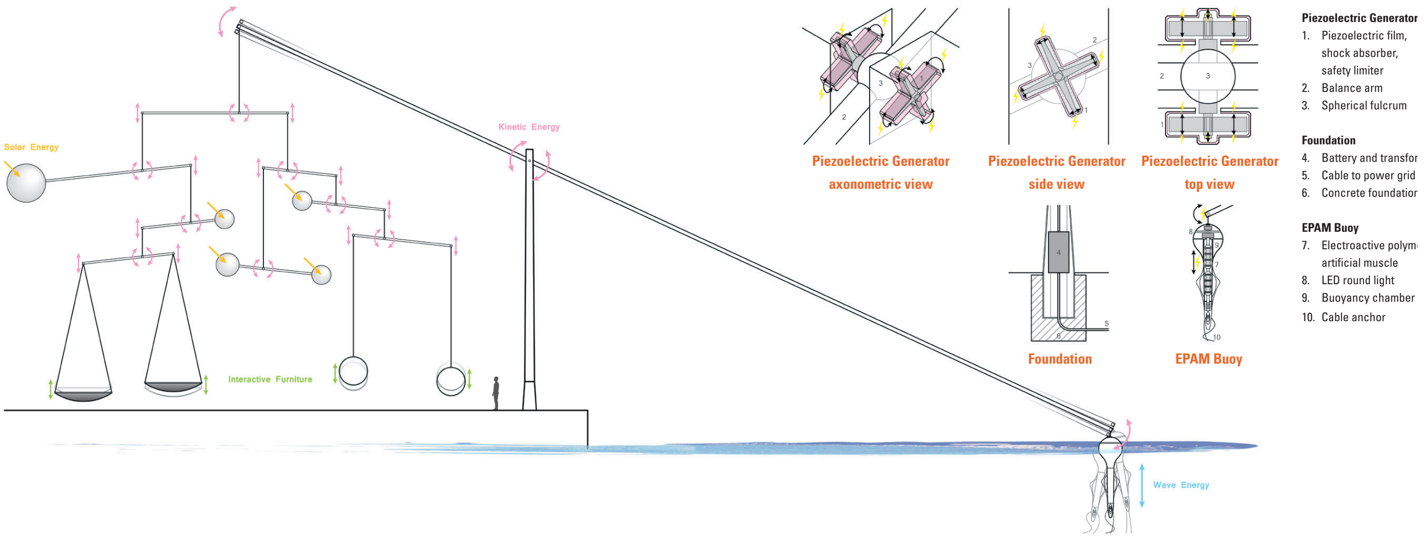
If someone other than you were to look at the photographs of your prototype model and the drawings or renderings that you have made, would they be able to very easily understand the flow of energy? Would they immediately understand how big your artwork is and how people would interact with it?

Some types of projects can be explained by using a section diagram. Imagine a flat plane cutting through your prototype and what it would look like to be able to look inside. Below is an example from **The Solar Hourglass** by Santiago Muros Cortés.





Other types of projects are best explained with an elevation. It's kind of like a section because it is looking from the side, but in an elevation the section plane doesn't actually cut through the project. You see all of the project. Below is an example from **Balance / Imbalance** by Hideaki Nishimura. In this case the artist has also included some detail diagrams on the right with a key reference.



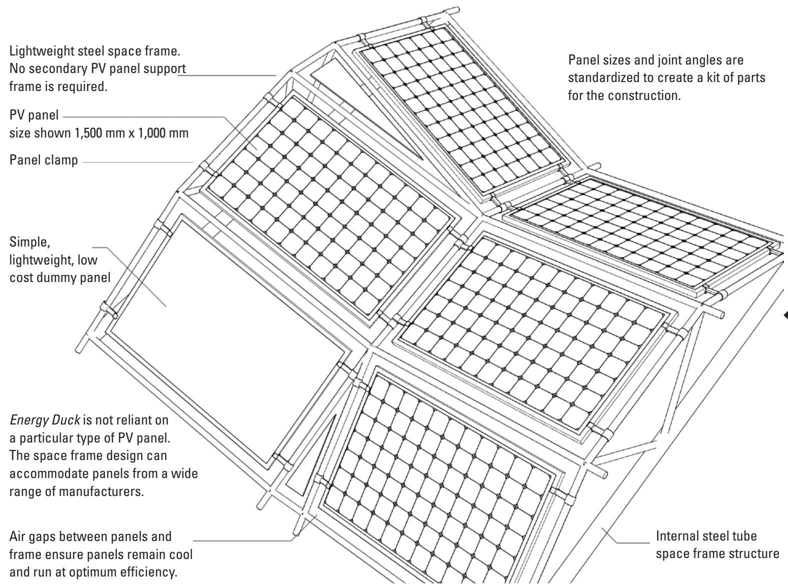
Next to the plan that you sketched in Step 2, draw a section or an elevation of your artwork. You can draw straight lines from your plan drawing to make sure that everything lines up accurately.

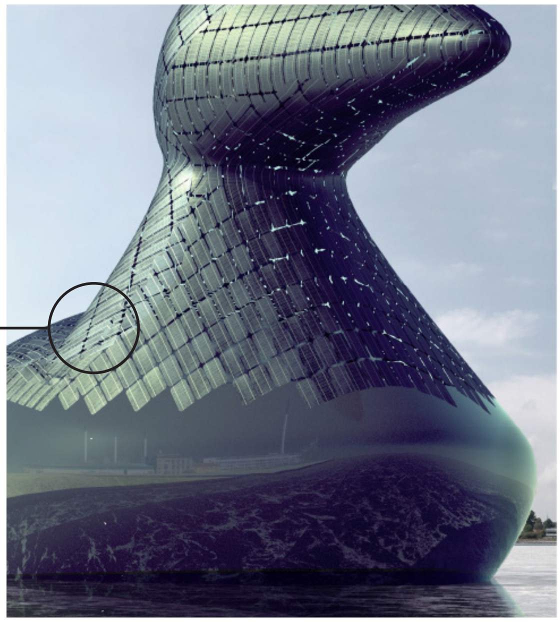
Step 4 (20 minutes)

Detail diagram

Is there some part of your project where many parts come together or that is really important to understand? Most designs have something that could be explained by using a detail of some sort. It could be drawn at a larger scale or at no particular scale, but it should be large enough so that someone who wanted to build your artwork would be able to do so without the need to ask you any questions. The diagram below shows how the solar panels are attached within a metal frame to make the curving shape of **Energy Duck**.

Draw at least one detail of your design and label the parts that is illustrates.





Step 5 (60 minutes)

Perspective

A great way to present your idea is to allow others to imagine what it would be like to experience it in reality. If you have access to 3D modelling software, like Sketchup or TinkerCAD (free online) then you can translate your physical prototype into a virtual model and render it in perspective with surface textures and lighting effects. If you don't have access to 3D modelling software, you can place a camera next to your prototype model and take photographs that do something very similar. Consider placing people at the correct scale in your perspective drawings.

Step 6 (60 minutes)
Graphic Design
Now that you have plans, sections, elevations, and perspectives that explain your design, it's time to put it all together!

The design guidelines document asks you to send three JPG images. Each image can be one drawing, photograph, or rendering. It can also be a graphic layout that includes a combination of images.

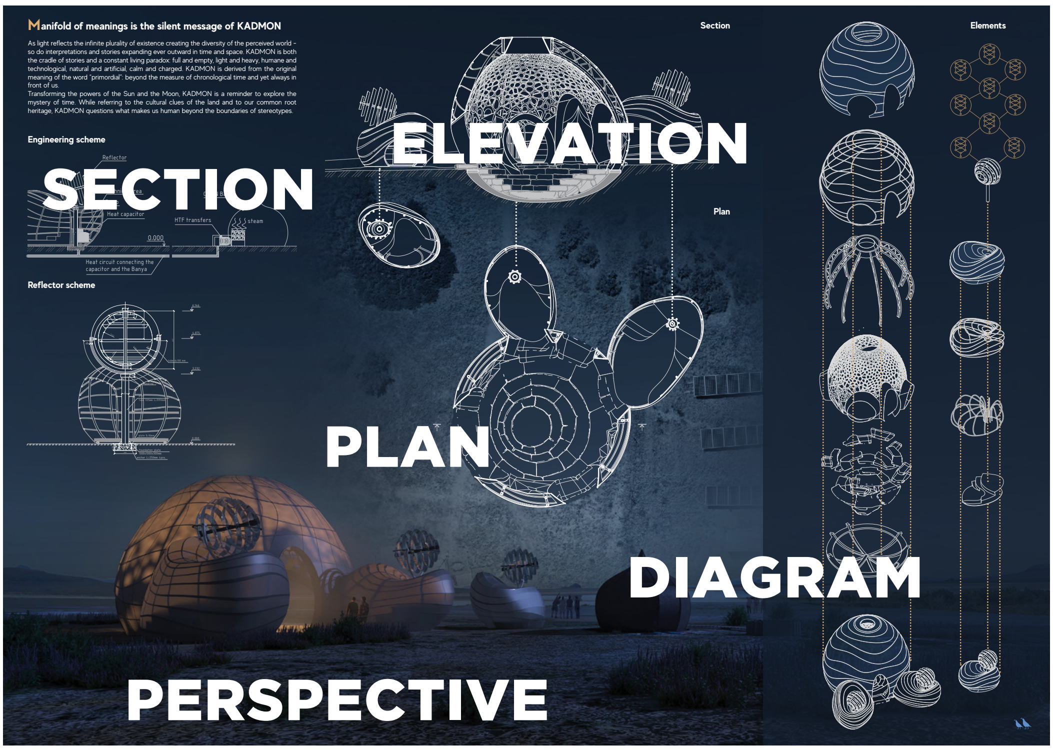
Sometimes a single image can be quite powerful, but often it helps to have some diagram or reference plan that helps to explain what the larger image represents. Below is one of the boards by the **KADMON** team that they entered into the LAGI 2020 Fly Ranch design challenge. You can see they have included plan, section, elevation, diagram, perspective, and explanatory text all together on one image.

It's important to keep things simple. Try not to put too many diagrams on one page and remember that white space can be important.

Remember the principles of design (balance, emphasis, movement, contrast, unity, etc.). These all are important for graphic design.

You can include text on your JPG images. This is often very important and helps to explain the various parts of diagrams, plans, elevations, and sections. But remember that you also get to email a written description DOC file.

The written description should include a lot of the text that you wrote in the Your Creative Statement activity. Try to limit the text in your JPG images as much as possible. There is no need to duplicate anything from your narrative file.



KADMON
by Boris Ryabov, Liya Ivanova, Kirill Ivanov, Sergey Ivanov, Olga Kritova, Laurent Rains, Ilyaz Khairov, and Michael Bogomolny

WHAT TO SEND TO lagi@landartgenerator.org

1. One JPG image that explains how your proposal works. This could be a plan, section, elevation, detail diagram, or a graphic layout that includes a combination of these.

Name the file:
<title-of-artwork>_<your-last-name>_001.jpg
For example, if your project was the Solar Hourglass and your name was Santiago Muros Cortés, then your first file name would be:
Solar-Hourglass_Cortes_001.jpg

2. One JPG rendering, perspective drawing, or photograph of your prototype that shows what it would be like to experience your proposal, either from a distance or from within the artwork.

Name the file:
<title-of-artwork>_<your-last-name>_002.jpg

3. One more JPG image of your choice. This could be another rendering, another diagram, or a graphic presentation combining multiple drawings.

Name the file:
<title-of-artwork>_<your-last-name>_003.jpg

4. One text description of your idea and artistic concept (around 300–500 words)

Name the file:
<title-of-artwork>_<your-last-name>.docx

JPG images should be between 3Mb and 15Mb.
Please do not exceed 20Mb for any one image.

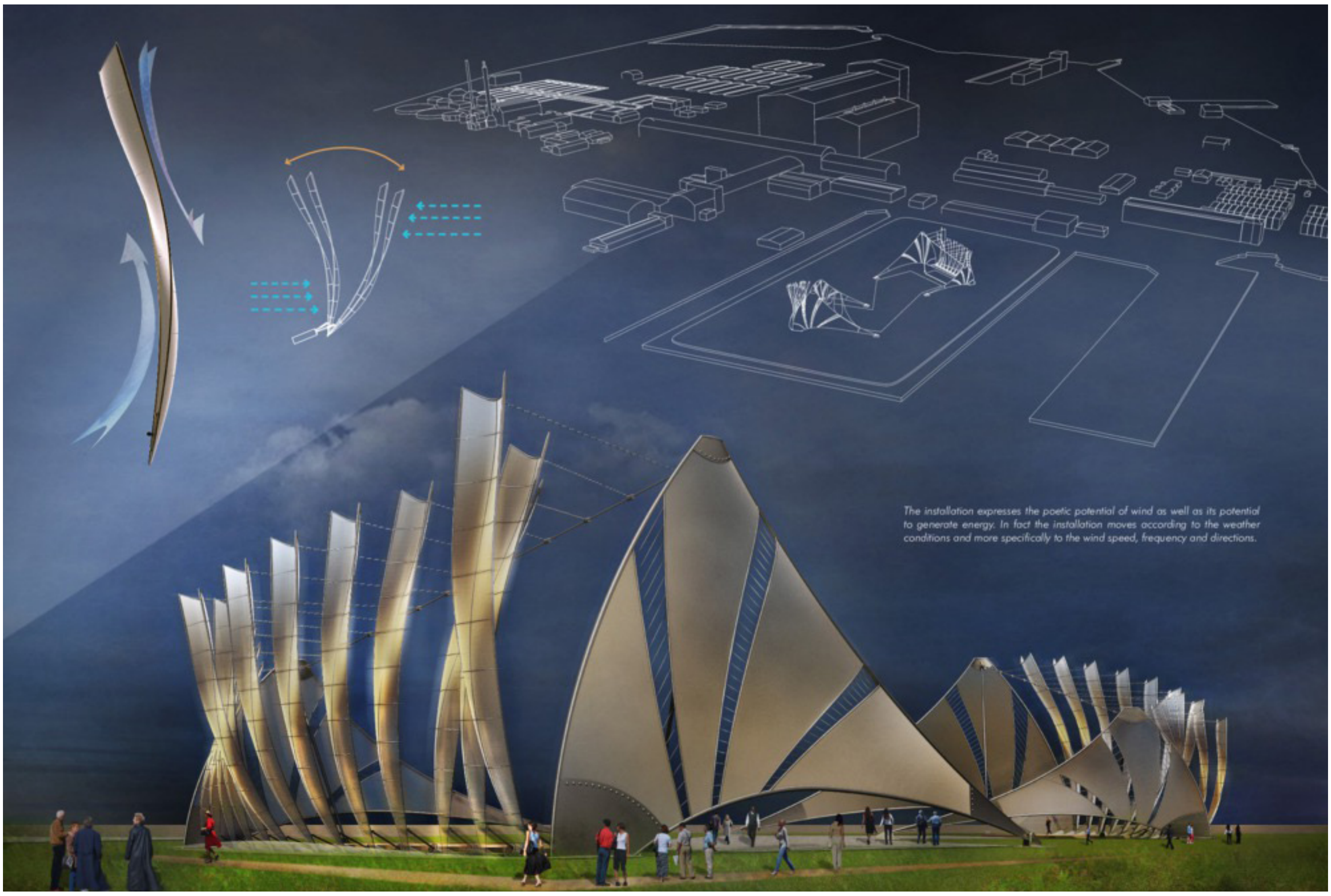
You can either attach your files and send in email directly to lagi@landartgenerator.org, or you can send your files to the same address through wetransfer.com or dropbox.com

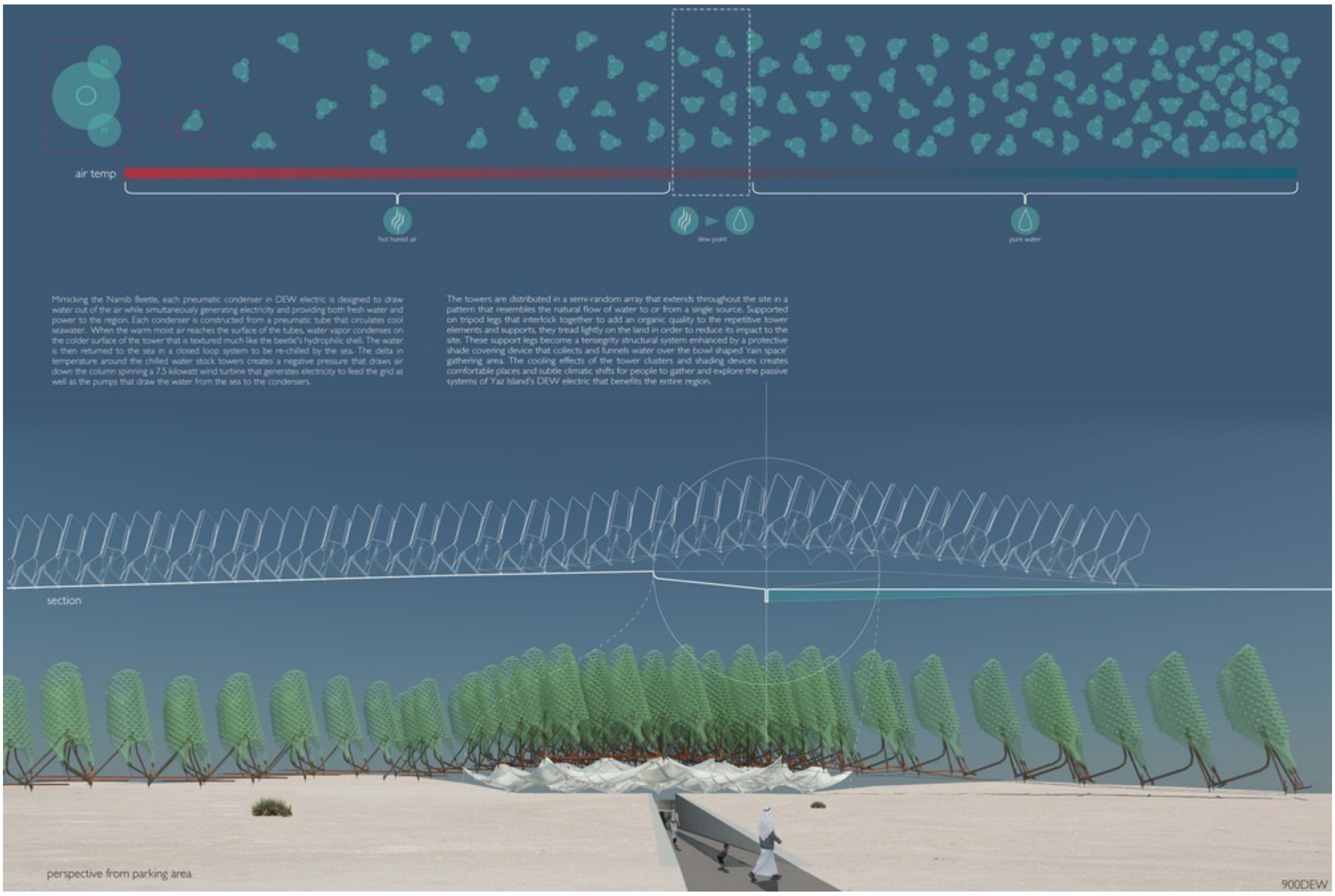
For dropbox you can use this link:
https://www.dropbox.com/request/vsz4xzH9ExBtmeIPtNsz

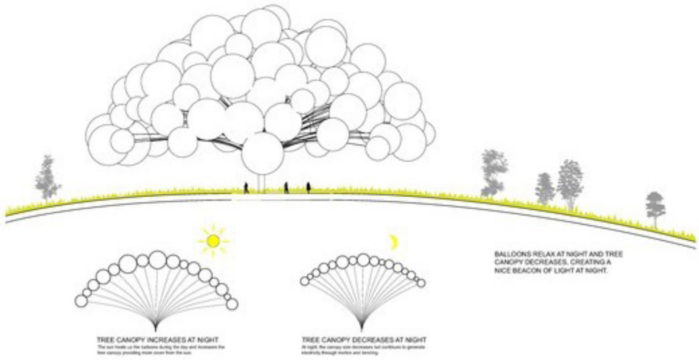
CONGRATULATIONS!

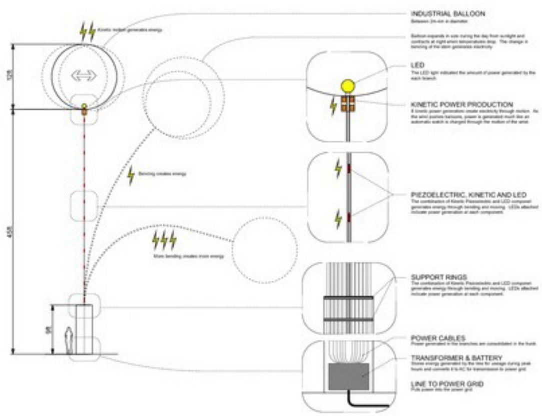
Example Design Boards

Below are some examples of design boards from past professional LAGI design competitions. We are showing them as examples here because they are very effective at explaining how the designs work and what it would be like to experience them. They are also good examples of graphic layout. Notice how there is not too much text, how there is a lot of open space, certain things are emphasised, and how there is a hierarchy of information.









algaescape_copenhagen

With our algaescape we provide an environmental connection on different levels.

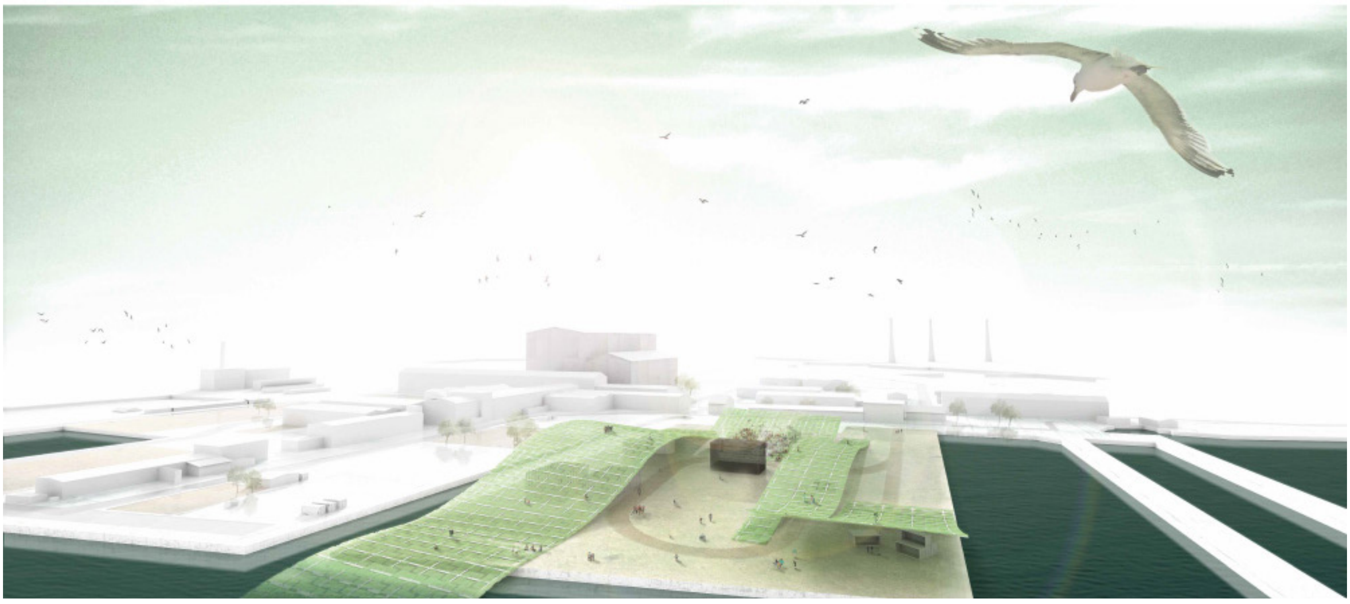
The first one is the technical production of energy by biomass. Here we are able to create a circular flow with the city and its infrastructur and the energy production. We gain carbon dioxide and nutrient-rich waste water and produce by photosynthesis algaebiomass and oxygen. The installation works like a filter for the city which clean the air and water. The algae can be processed for foodproduction, cosmetics and energieproduction in form of fuel or gas which again serve the city and its inhabitans.

The second level are the functions and variety of spaces and atmospheres we offer with our algaescape. These are for example an information and teaching point, an open air stage with a view over Copenhagen, a covered outdoor bar or café run by the surrounding restaurants, and several possibilities to do sports or outdoor activities all in direct impact of the algaeproduction.

In this way we connect the output of energy with the city and its inhabitans, and expose the potential of energy production by biomass with a everyday use of the algaescape and a matter of course of innercity energy production.

We started by analysing the process of energy production by algae. Out of this process we chose the part of the specific algae prodution, which requires the biggest amount of space, and transformed it into a both biomass producing and space providing form.

The algae containing tubes which are used in typical algaereactors where replaced by flexibel plastic sleeves and weaved to a textile. During the weavingprocess it is possible to imply different layers to the algaemesh, like a bearing structure and a suply and controlling system which is necessary for the algaegrowing. This textil is now able to form connect and affect spaces below and above it and is decisivly aligned to the algae production. Mayor effects are a varying transparency depending on the algae population and an slightly inclined shape towards the south. The textile is like a shaped cloth which allows communication between both sides of it.



GLOSSARY

ALGAE BIOFUEL
Algae can be grown and harvested (algaculture) as a feed stock for the production of alternatives to fossil fuels. Naturally occurring oils within algae (lipids) can be used directly (similar to straight vegetable oil), or they can be refined to burn more cleanly.

Different production methods can result in biodiesel, biobutanol, biogasoline, methane, ethanol, or even jet fuel. The uptake of CO_2 by the algae during cultivation offsets the CO_2 that is emitted during the combustion of the algae-generated fuel. Algae can produce up to 300 times more oil per acre than conventional crops such as jatropha, palm, rapeseed, or soybean, and it can be cultivated in locations where these types of crops are not viable.

ALTERNATING CURRENT (AC)
An electrical system in which the flow of electric charge periodically reverses direction (as opposed to direct current in which the flow is constant). AC was adopted early as the standard for electrical utility distribution due to the fact that transmission losses over great distances were less than with direct current (DC). Contemporary technology has made high voltage DC transmission (HVDC) the preferred solution for some long-distance distribution applications (lower transmission losses) but this requires changing the current from AC and back to AC on either end with expensive conversion equipment.

AMORPHOUS SILICON (A-SI)
The functioning semi-conductor material within a type of photovoltaic system (thin film) that is less expensive and more versatile in its application than crystalline silicon types. Conversion efficiency is generally less than crystalline silicone PV. See "monocrystalline silicon" for more information.

ART OUTSIDE OF THE GALLERY
Art practices that exist outside of the confines of the gallery have a long history that include genres such as land art, eco-art, public art, and social practice art.

BIOGAS AND BIOMASS
Biogas is created through the breakdown of any organic material (biomass) in an oxygen-poor environment. The resulting gas byproduct is mostly methane and carbon dioxide. Biogas is similar in composition to conventional natural gas and as such can be compressed or fed into a municipal gas grid. It can be used for many different purposes including cooking, heating, lighting, transportation, and electricity production. It can be either tapped from the underground activity in a landfill site, or it can be produced in specially constructed anaerobic digester tanks. Farms

with such tanks can process manure into biogas reducing the amount of nitrous dioxide and methane that would otherwise enter the atmosphere. These two gases have a far greater atmospheric warming effect than does carbon dioxide (nitrous dioxide = 310 times greater, and methane = 21 times greater). Biomass is considered a sustainable energy resource because it is a product of organic processes, which naturally regenerate at a rapid cycle (as opposed to fossil fuel energy sources which take millions of years to form naturally). 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).

BIOPHILIA

From the 1984 book, "Biophilia", by Edward O Wilson. An innate affinity for the natural world that is universally held by human beings. Biophilic design incorporates natural and organic forms (such as animal shapes and curling, branching lines) that appeal to this human feeling of oneness with and fondness for nature. Biomimicry or biomimetic design refers to design and engineering processes that learn from and are inspired by the workings of natural systems.

CAPACITY FACTOR

A multiplier used to calculate the average output of an energy-generating device over a certain period of time. This factor takes into account conditions that are less than ideal and which contribute to the device operating at below nameplate capacity during certain periods. See "nameplate capacity" for more information.

CARBON DIOXIDE (CO_2)

A naturally occurring chemical compound critical to life on earth, carbon dioxide also functions as a greenhouse gas (GHG) in the Earth's atmosphere. The emission of CO_2 through fossil fuel combustion by humans has, since modern industrialisation, created an increase of 35% in the parts per million (ppm) concentration of the gas in the Earth's atmosphere. Since 1960, its concentration has risen from 320ppm to 390ppm and further increases threaten rapid shifts upward in global temperature and sea levels. In order to avoid a temperature rise beyond 2° Celsius, between 2/3 and 4/5 of the known reserves of fossil fuel will need to remain unused until such time that proven methods of carbon capture and storage (CCS) can allow their safe combustion (no method of CCS has yet been proven suitable for long-term CO_2 storage). Increased atmospheric concentrations of CO_2 also have a secondary effect on the chemical composition of the oceans, as surface-level carbon dioxide dissolves forming other carbon compounds and leading to acidification.

COMPACT WIND ACCELERATION TURBINE (CWAT)

CWATs are a new acronym that encompasses the class of machines formerly known as DAWTs as they were known in the 1970s and 1980s. This type of horizontal axis wind turbine uses a cone or series of cones to concentrate the wind, increase the velocity of the wind as it passes through the rotor's swept area, and thus increase the efficiency of the overall system. They are also known as "ducted turbines" or "lens wind turbines."

CONCENTRATED SOLAR POWER
Describes a variety of systems that use mirrors or lenses to concentrate the power of the sun in order to create heat energy that can then be converted into electricity.

COPPER INDIUM GALLIUM SELENIDE (CIGS)
A semiconductor material alternative to silicon used in thin film photovoltaic.

CRADLE-TO-CRADLE
The goal in sustainable design and manufacturing of diverting 100% of the materials from landfill or other waste streams. All materials contained within a cradle-to-cradle product must be compostable, recyclable, or otherwise reusable. This is distinct from conventional design and manufacturing, which is referred to as “cradle-to-grave.”

DATA MONITORING
Real-time statistics of how much electricity is being produced. Monitoring can be either on site or remotely accessed and is displayed in an easy-to-understand graphical interface that often simulates analog dials and meters.

DIRECT CURRENT (DC)
An electrical system in which the flow of electric charge is constant (as opposed to alternating current in which the flow periodically reverses direction). See “alternating current” for more information.

DYE-SENSITISED SOLAR CELL (DSSC)
Techniques for creating dye-sensitised solar cells (DSSC) are simple and the materials are very low cost, but the conversion efficiency is also below that of solid-state semiconductor technologies (DSSC is the most efficient of the “third generation” thin films). This technique was invented in 1991 by Michael Grätzel and Brian O’Regan at EPFL. The DSSC solar cell is alternatively known as the Grätzel cell. They have the characteristic of being semi-transparent, flexible, and they are very durable. They also function comparatively better than other PV technologies in low light levels and indirect light. Because they are so inexpensive to produce they have one of the lowest price/performance ratios, and are therefore potentially competitive with conventional energy in terms of levelised cost ($ per kWh over the lifetime of the installation) despite their lower conversion efficiency.

ECO-ART
Eco-art is a contemporary art movement that addresses local and global environmental issues. In their work, eco-artists explore a variety of ideas and intentions, which may include environmental ethics, information about ecological systems and the use of natural forms and materials in art. Some eco-art is functional, striving to reclaim, restore or remediate damaged environments. Eco-art can re-envision ecological relationships and even propose new models for sustainability.

ELECTRODE
The electrical conductor that makes contact with a semiconductor or other non-metallic material. Electrodes can be labeled either anode or cathode depending on which direction the electrical charge is flowing.

ELEVATION

In design and architecture, an elevation is a parallel projection view (not in perspective) of an object or building as seen from the front, side, or rear.

EFFICIENCY (ENERGY CONVERSION EFFICIENCY TO ELECTRICITY)

The ratio between the electrical output of a device (such as a solar panel or a wind turbine) and the energy input to the device (the sun or the wind that strikes the device). The efficiency of any device determines its nameplate capacity. See "nameplate capacity" and "capacity factor" for more information.

FEEDSTOCK

In power generation this refers to the source of the energy as it exists in non-electrical form. This could be chemical energy (petroleum and biofuel), radiant or thermal energy (solar), or gravitational (hydro), or mechanical (wind and wave).

FUEL CELL

Any mechanical system that converts the energy stored within a fuel source (e.g. hydrogen, methanol) into electricity through an oxidation process. Fuel cells require the replenishment of the fuel source (reactant) to maintain electrical output. Fuel cell technology has the potential to replace the internal combustion engine for the conversion of fuel into energy for use in transportation and machinery.

HELIOTROPIC (HELIOSTATIC)

The ability to follow the location of the sun in the sky and maintain an object's consistent relationship to it throughout the diurnal and seasonal shift. In solar energy technology, heliostatic mechanisms can maintain a solar cell perpendicular to the sunlight for ideal absorption and conversion, or mirrors can maintain an angle-of-incidence relationship to the sun so as to consistently reflect sunlight to a central collector.

HIGH-ALTITUDE WIND POWER (HAWP)

The power of the wind at high altitudes is much stronger and more consistent than what is typically available nearer to the ground. However, getting access to this excellent source of energy and harnessing it for electrical use presents obvious challenges. HAWP has the potential to be a cheap and consistent source of energy. There are a wide number of technologies that are presently being developed. Many designs are derivative of kite and sailing technology. Other types of HAWP devices (airborne turbines, or AWT) use light-than-air balloons (aerostats) that rotate between two cables, or small glider-like machines that are designed to fly in a constant circle or figure-eight. In these technologies the conversion of energy to electricity is performed in the sky.

HYDROELECTRIC STORAGE

Excess capacity electricity is used to pump water temporarily into an upstream reservoir. The water can then later be released when there is demand for electricity and by the force of gravity drives hydraulic turbine electrical generators similarly to conventional hydroelectric dams which rely on natural precipitation cycles to provide the water source.

HYDRAULIC TURBINE
A rotary engine that is driven by the force of passing water.

KILOWATT (KW)
Equal to 1,000 watts. See “watt.”

KILOWATT-HOUR (kWh)
Equal to 1,000 watt-hours. See “watt-hour.”

KINETIC HARVESTING
Converting movement into electricity. This can be accomplished using piezoelectric actuators, linear alternators, wells turbines, or other means.

KITE WIND POWER OR WIND KITE
See high-altitude wind power (HAWP).

LAND ART
Land art, also known as earth art, is art in which the landscape or natural elements often form the basis for the artwork. Artists may create artworks directly in the landscape, utilising their natural surroundings and integrating the landscape itself into their work. Conversely, artists may also incorporate natural elements into works exhibited in gallery spaces. Land Art emerged in the southwestern United States during the late 1960s, and culminated in the mid-1970s. Since the 1970s, much Land Art has been absorbed into the broader realm of Environmental Art, as many artists began working in more urban and public spaces.

LED
Light-emitting diode, a semiconductor light source. OLED is an LED made from organic compounds.

LINEAR ALTERNATOR
A linear motor used as a power generator for alternating current. Linear motors do not rely on torque and rotation but rather on simple linear motion.

MEGAWATT (MW)
Equal to 1,000,000 watts. See “watt.”

MEGAWATT-HOUR (MWh)
Equal to 1,000,000 watt-hours. See “watt-hour.”

MONOCRYSTALLINE SILICON
Silicon (Si) is a semiconductor material that displays the photovoltaic effect. It was the first material to be employed in solar cells and is still the most prevalent. It can be applied for use in either a crystalline (wafer) form, or in a non-crystalline (amorphous) form.

There are two types of crystalline silicon: monocrystalline and polycrystalline (aka multicrystalline). Monocrystalline is very expensive to manufacture (because it requires cutting slices from cylindrical ingots of silicon crystals that are grown with the Czochralski process) but it is the most efficient crystalline silicon technology. Its conversion efficiency is around 23%.

NAMEPLATE CAPACITY

The standard and consistent power that an energy-generating device can output in an ideal environment.

OMNI-DIRECTIONAL PHOTOVOLTAIC

Able to convert sunlight into electricity at any angle in relation to the sun. Most PV technologies either require or work best at an angle perpendicular to the sun's positionin the sky.

ORGANIC PHOTOVOLTAIC

Organic PV can be manufactured in solutions that can be painted or rolled onto proper substrate materials. They can be produced at very low cost in comparison with other PV technologies because they can take advantage of roll-to-roll production techniques in which the organic photovoltaic system is "printed" onto a long continuous sheet of substrate material. Current OPV technology has a conversion efficiency of only around 8%. But its low cost of production (and its good performance in lower level and indirect light) makes it an increasingly attractive option in the marketplace.

PARABOLIC TROUGH

A type of concentrated solar power that uses a long mirrored surface with the cross-sectional shape of a parabola. Sunlight that hits the mirror surface (at an angle parallel to the central axis of the parabola) is directed to the focal point of the parabola thus providing energy to a heat transfer fluid that runs continuously along its length. The heated transfer fluid can be used to generate the steam required for turbine generators.

PERSPECTIVE

A rendering or view of an object or building as one might experience it with human sight. The laws of perspective (studied most famously by Filippo Brunelleschi in the 15th Century) allow artists to create photorealistic renderings of the world using one or more vanishing points, a horizon line, and a picture plane onto which the image is formed. A vanishing point exists wherever parallel lines appear to converge at a point in the infinite distance. A one-point perspective can be experienced by looking down a road or railroad track. A two-point perspective can be experienced at the intersection of two streets, and a three-point perspective can be experienced in a downtown intersection while looking up at tall buildings. A complex shape can have a great number of vanishing points. Artists often play with perspective to create a feeling of disorientation (Vincent's Bedroom in Arles by Van Gogh) or to reveal more than that which could be seen while adhering to strict rules of perspective (Print Gallery by M. C. Escher).

PLAN VIEW

In design and architecture, plan view is a parallel projection view (not in perspective) of an object or building as seen from above. Often a plan view assumes that a horizontal section plane has cut through an object or building to reveal the internal order within (such as floor plans that reveal what is underneath the roof at each lower level).

PEAK CAPACITY
The highest design output that an energy-generating device can manage under ideal conditions and newly installed components.

PHOTOVOLTAIC (PV)
The photovoltaic effect, first recognised by A. E. Becquerel in 1839, is the ability of a material to produce direct current electricity when exposed to solar radiation. It is related to the photoelectric effect, which is the ejection of an electron from a material substance (usually a more highly conductive metal as opposed to a semiconductor material) by electromagnetic radiation incident on that substance. However, in the photovoltaic effect, the electrons remain within the material (by the nature of the semiconductor material) creating positive and negative bands which can be harnessed by an electrical circuit.

PIEZOELECTRIC GENERATOR
A device that generates electrical power from pressure force. Common application of a piezoelectric device is as the ignition source for gas range and grill "push starters."

PUBLIC ART
Public Art encompasses any work of art that an artist has created to be displayed, heard or performed in a public space. Although the oldest and most common forms of public art are monuments, memorials and statues, contemporary public art comprises a wide range of methodologies, forms and content. Public art ranges in scope from large-scale, commissioned works, which require significant collaboration amongst artists, funders and governmental agencies to implement, to independently executed small-scale works that require little to no funding. Public artworks may be site-specific, exhibited in non-conventional spaces or may alter the common function of a space. Approaches to contemporary public art include interactive art, guerilla art, sound art, community-based projects, and performance.

SEMITRANSPARENT PHOTOVOLTAICS
Solar cells that are encased in a transparent material in such a way that allows light to pass through partially. The pattern of the photovoltaic material placement can be small or large, patterned or irregular.

SOCIAL PRACTICE ART
Social practice art includes a wide variety of methodologies, strategies and techniques in which social interaction and exchange are the means for the artwork. Social practice art may involve community-based practice, performative aspects, guerilla art, interactive media and social activism. Media such as video, sound, sculpture, performance, and text are often incorporated. Collaboration between artists and individuals from non-art backgrounds, especially those who are part of the intended audience, is an integral aspect of social practice art.

SOLAR FABRIC
Flexible photovoltaic material integrated into canvas.

SOLAR THERMAL
Solar radiation used to heat a medium such as water or air.

SOLAR UPDRAFT (SOLAR CHIMNEY)

Combines the chimney/stack effect and greenhouse effect with wind turbines located at the base of a very tall tower. The tower is surrounded by a large greenhouse which serves to create superheated air at the ground level. With a sufficiently tall chimney structure, the air temperature at the top of the tower will be cool enough to provide a strong convection movement of air from the greenhouse area, into the bottom of the chimney and out of the top of the chimney (warmer air is higher pressure and moves to the lower pressure system at the top of the tower). At the outside perimeter of the greenhouse, new surface air is constantly taken into the system to be heated. As air passes from the greenhouse area into the base of the tower, it powers wind turbines located there.

STIRLING HEAT ENGINE

Device that converts heat into mechanical energy with high efficiency. This mechanical energy can then be used to power an electrical generator.

TENSEGRITY

Individual structural members (usually metal bars) working in compression are suspended away from each other by means of a continuous tension net (usually comprised of metal cables). The term was coined by Buckminster Fuller as a portmanteau of “tensional” and “integrity.” The structural system has been used in many works of public art, including those by Kenneth Snelson.

THIN FILM

As applied to photovoltaics, any of a variety of non-crystalline solar cell technologies that can be applied in very thin layers thus reducing material costs.

THIRD-GENERATION PHOTOVOLTAIC

Term applied to technological innovations that have allowed conversion efficiencies of solar cells to increase greatly via tandem or multi-junction structures that have varying bandgaps (physical property of the material that pertains to the flow of electrons through it or from it under conditions of excitation such as that provided by solar radiation). In single junction solar cells, there is energy lost when photoexcitation exceeds the limits of the particular semiconductor’s bandgap.

TURBINE ROTOR

The moving part of a turbine engine which consists of a drum or a shaft with blades attached to it.

UTILITY-SCALE

Significant enough power generation so as to warrant the distribution of the energy to the utility grid (as opposed to “on-site” power generation for local use).

VENTURI EFFECT

When a fluid body, such as air, is in motion and is constricted in its path, such as by a funnel, the velocity of the fluid will increase and its static pressure will be reduced. The effect can be felt in urban areas when standing between two tall buildings, which together act as a funnel. This principle is incorporated into the design of compact wind acceleration turbines (CWAT).

VERTICAL-AXIS WIND TURBINE

Any wind turbine in which the rotational axis is vertical in orientation (perpendicular to the ground plane). Types of vertical-axis wind turbines include Savonius, Darrieus (eggbeater), and Giromills.

WASTE TO ENERGY (WtE)

The use of non-recyclable waste for combustion (incineration) to generate electricity, or in a small number of cases for processing into methane or similar fuel.
There are some emerging WtE technologies that do not require incineration:

- Gasification (produces hydrogen, synthetic fuels)
- Thermal depolymerisation (produces synthetic crude oil)
- Pyrolysis (produces combustible tar, bio-oil, and biochars)
- Plasma arc gasification, PGP (produces syngas)

Non-thermal technologies:

- Anaerobic digestion (biogas rich in methane)
- Fermentation production (ethanol, lactic acid, hydrogen)
- Mechanical biological treatment (MBT)

Limestone scrubbers can greatly reduce the emission of harmful chemicals from WtE incineration, and while there is CO_2 released, the effect of this is less than the more toxic greenhouse gases that are produced by landfill off-gassing of methane, even if much of that methane is captured.

WATER-SOURCE HEAT SINK LOOP

A geothermal or ground-source heat pump operating in a cooling capacity. Water is passed via coiled tubing through the earth (which maintains a constant temperature between 10° Celsius and 16° Celsius depending on latitude) and then used for cooling interior space via a heat exchanger.

WATT (W)

Unit of measure of electrical power equivalent to 1/746 horsepower.
W = Volts x Amperes

WATT-HOUR

A measure of electrical energy equivalent to one watt of power used or produced for a one-hour duration.

WELLS TURBINE

Usually a small turbine that maintains its rotation with fluid movement coming from either direction. Wells Turbines are often used inside wave energy devices.

WIND MICROTURBINE

A small wind turbine with less than 3,000 watt peak capacity.

WINDROSE

A graphic representation of the wind at any one location as measured over a long period of time. The windrose diagram shows the frequency of wind speed and cardinal direction.