**Looking for mermaid**

"The little mermaid lifted her arms up toward God's sun... she rose together with the other children of the air...'In three hundred years I shall rise like this into God's kingdom'."

Deep regret from this beautiful story ending, buried in our childhood, emerges little by little to us, when we step into the green and above us bit by bit unfolds the mirror image of the city with its Little Mermaid statue. The floating mirror image embodies an interaction between the art and the science, where the wind blows the little mermaid's mirror image mixed with occasional sky view, meanwhile transforming its force into electric current. All of a sudden, as we're still looking for the little mermaid, we understand that when the little mermaid turns to be invisible child of the air, an energy flow follows and is being transferred.

Our proposal at Refshaleøen site is

a public green land open to wide uses,

a reflection of shipyard structure in pier's industrial history,

a metal page dedicated to Andersen and his little mermaid,

a counterpart of Edvard Eriksen's statue,

an intermedium connecting artistically Copenhagen's two sides,

and an [electric](http://en.wikipedia.org/wiki/Electric_generator) generator harnessing the green energy of wind and sun...

**Artistic consideration**

Installed on a metal lattice hung by steel cable web, the floating mirror is composed of millions of polished aluminum panels. Each panel has piezoelectric transducer on one side fixed to the lattice and the other free to capture wind energy. In calm whether, their angles to the ground reflect Edvard Eriksen's statue ONLY to a position INSIDE of the site. Mathematically, they compose a parabola in the air, further cut and defined by the site's geometry projected to the sky, so that the parabolic front projects the statue's reflection to the site front and the rear to the site back edge. The parabola is easily realized due to a natural phenomenon that the web assuming originally catenary always tends to parabola when uniformly distributed load is exerted, i.e. the weight of the panels.

In this way, the mirror reproduces in the sky another Little Mermaid at Refshaleøen, and turns it into the child of the air as the image is in high sky and mixed with the sky view. As wing blows, the mirror is like a sky pond with ripples turning back from time to time to the reflection.

To convey and strengthen this concept, a number of angle-fixed binoculars are installed on the ground, one for every deck platform, to help directing the Little Mermaid's mirror image in calm weather, as well as watching wind mobile detail and understanding its energy conversion principle. Stroll or running throughout the site following the Little Mermaid is as interesting as a framed view through binocular, which introduces ground piezoelectric transducer to the site. No other complex landscape is introduced so as to leave the uses of the site open.

**Multiple interactions**

Interaction between the ecological energy and the art (/urban) makes sense only if people participate in it. To some extent, the wind mobile stages only in the presence of audience, because it doesn't change its form as other mobile does, but the visual image accepted by visitors who are exactly IN the site. In this way it invites visitors to the site, makes the visit a surprising and beautiful encounter and engages visitors in discovering process of the little mermaid.

**Changing experience**

The mirror is inclined to the site's east edge. Calculated slope ensures people from bus station see first a blade-like view. When people approach it, reflections spreads out little by little. The whole experience is ended with an urban panorama. A reverse process is for water taxi passengers.

**Dual effects**

50 meters high, the structure is visible from the Little Mermaid side, where it assumes a different appearance. During the day, it adds a green more to Copenhagen, or is artfully mixed into the sky as wind blows. At night, except aircraft warning lights, no lighting works is on the structure as to reduce unnecessary electrical consumption. The only light source, seen from the city side, is reflection of ground functional lights, which adds more starlets to Copenhagen's night sky.

**Dimensions and primary materials list**

Height: 50M (same to nearby Lynetten wind farm)

Length (projected): 112/ 107/ 96/ 127M (N/ E/ S/ W)

Primary materials list \*

|  |  |  |  |
| --- | --- | --- | --- |
| Material | Quantity | Size | Remarks |
| Al. panel | 69000 (approx.) | 0.4MX0.4M | Flexible |
| Steel cable (of the web) | 22 | 2500M (L/approx.) | Wire-cable |
| Hangers | 99 |  |  |
| CIGS cell |  | 1414M2 | Flexible. Outermost cables are exposed  |
| Deck |  | 809M2 |  |

\* Electrical substation excluded

**Technology used**

In a country of plentiful wind energy, increase of the share of electricity production from wind is always significant. The electricity generation of our proposal is first based on piezoelectric wind harvesting method that special sheets such as PZT are bonded on fixed side of aluminum panels' top surface, connected in parallel and make conversion of wind energy to electricity. Energy source are both westerly wind (prevailing and dominant wind) and the convection induced by focused heat above the panels' parabolic surface. In addition, tiny parabola of each panel bent by the wind also boosts on a large scale the accumulation of the heat. For the latter operating mechanism, the wind's blowing and the panels' bending create a positive chain reaction to reach a higher energy state. In an ideal state of calm whether, a temperature difference of 33°C, possibly to reach, between water surface and the space above panels, produces a constant wind more than 4 s/m in the middle of the mirror. This velocity rises more and more slowly with linear growth of temperature difference, ex. 4-5 s/m for 50°C. But it is possibly added to that of existing wind to produce higher strength, and the heat draws also strong wind through the mirror. Tiny deflection of piezoelectric material can produce a certain charges. A tip deflection of ± 28µm can output a power of 810mW under certain conditions, as is noted in the guideline of Piezo Systems. With the same standard which could be ideal and the duration of 8322 hours for wind blowing per year, system has an annual output of 5852 MWh. Even with a reasonable discount, it's still a utility-scale project.

As a by-product, parabola-focused sunlight environment is a rare chance in North Europe for solar cell. Flexible CIGS cells are thus wrapped around the structural web's tubes. Their cylindrical form helps absorbing sunlight from all directions. For this reason, a projected area of 450 M2 is valid for any angle of incidence of sunlight. Estimation is then established on the conditions of 1kW/M2 for solar radiation, 10.7% for CIGS module efficiency and 1539 H/y for sunshine duration in Copenhagen, and an output of 74 MWh is get.

Furthermore, some other piezoelectric transducers are installed on the viewing platforms as well as most used pathways among them to simultaneously sense and harvest the energy of passersby's kinetic energy.

The total energy (5,926,000 kWh/y) is stored, transformed and transmitted to a grid connection point via electrical substation. It's built under a slanted green roof connecting to the land in the north-east corner of the site.

**Environmental impact**

**Basic considerations**

Except substation and observation decks, brief interventions are four columns (maintenance ladder inside) and the shadow cast on the green. Light weight of aluminum panels minimizes the columns' footprint. The peripheral positions of foundations allow for future probable planning project including independent soil treatment inside. The shadow might cover a big area at a certain time of day. However, the real area is reduced due to the porosity and the height of the mirror. It is also applicable to rainwater, snow, etc.. Little impact is on the ground environment, including native wild grass or any future possible landscape project.

Other risks are relatively minor. No light pollution occurs, as the convex of the mirror ceiling diffuses lights. The layout of pathways is projected to follow people's habitual traces, then be covered with gravels; along with decking of observation platforms, the impact on the site’s hydrology is negligible.

There are no emissions directly related to electricity production. Most of the CO2 emission might come from the construction.

[**Impacts on people**](http://en.wikipedia.org/wiki/Environmental_impact_of_wind_power#Impacts_on_people)

CIGS cells has potential toxicity because of its CdS buffer layer. However, recent Cd-free cells eliminate the worries related to the toxicity and environmental impact (wikipedia: Copper indium gallium selenide solar cells).

[**Impact on wildlife**](http://en.wikipedia.org/wiki/Environmental_impact_of_wind_power#Impact_on_wildlife)

High Structure may [influence wildlife](http://en.wikipedia.org/wiki/Environmental_impact_of_wind_power#Impact_on_wildlife) such as bird and bat. The proposed surface composed of flexible panels is not hard. Unavoidable knock doesn't hurt birds. Height of 50M is also under the average bird migration altitude in Denmark (300-1500M).