***Refkløver//RK002014***

Refshaleøen, Copenhagen

*Dancing, breathing, growing, pausing,*

*Energy given and created-*

*The sound of petals whisper to the lapping tides.*

**Concept**

The design for *Refkløver* is a dynamic combination of biomimicry of the region’s botanical species with Norse mythology. Taken from microscopic studies of the Danish national flower, the rødkløver (red clover, *Trifolium pratense*), the form of the energy-generating structures mimics the veins found on the leaves and bracts of the plant. These veins act as highways for photosynethetic processes, transporting energy and sugars to the rest of the plant. The design of *Refkløver* acts in a similar way. Using piezoelectric wires to represent the veins of the plant, wind movement will generate energy through these delicate fibers, and will be transported to the city grid.

Further merging traditions of Norse mythology, the experience of the meandering and interconnecting pathways is derived from the idea of a labyrinth. With no dead ends, the fluidity of the pathways incites a meditation through travel by foot, allowing the mind to wander and be found again at critical viewpoints.

The design emerges as a participatory event, as further energy will be produced by foot traffic via the use of kinetic flooring tiles. Drawing from the urban design characteristics of Copenhagen’s public spaces, *Refkløver* is a space of symbiosis between people and the landscape. A system of active walkways will connect passive nodes, which are guarded by the sculptural forms, making visitors feel like a very small organism within the epicenter of the red clover. *Refkløver* will contribute to the idea of free and open public spaces for everyone that enhances the developing community of Refshaleøen. The space provides a harbor-front park for the people of Copenhagen, and the people of Copenhagen help generate energy for the city’s grid by occupying and moving through the site.

Plants were selected based on their flowering season, relevance to local ecosystems, and references in Norse mythology. Freya, the Norse goddess of love, beauty and war, is said to have flowers falling from her hair. Species mentioned in the mythology that are used for *Refkløver* include milkwort (*Polygala vulgaris)*, cowslip (*Primula veris)* and sea aster (*Aster tripolium).* The key plant species in the planting scheme is the red clover (*Trifolium pratense)*, Denmark’s national flower. The red clover is known to have healing properties for soil, agricultural utility, and humans. The importance of the planting design is integral to the concept of the site design, as the form of the energy-generating structures is botanic in nature, and the entire site mimics the natural processes found in the plant kingdom. The variety of species ensures seasonal change and cover throughout the year, providing an aesthetic environment and healthy ecology in all twelve months.

*Refkløver* brings foot traffic to this developing area, but can also be used as a serene escape onto the waterfront. The design for the site acts as a gateway to Refshaleøen, as visitors disembarking from the water taxi will interact with the site design upon leaving the terminal. The vertical energy-generating structures are a subtle silhouette along the panorama of the harbor, drawing intrigue and curiosity to the developing area of Refshaleøen without being a clichéd symbol of Danish culture.

**Technology and Materials**

Each energy-producing node consists of a cluster of four recycled stainless steel structures of various heights, with piezoelectric wires spanning across each surface; these wires transform their own movement, caused by wind currents, into electrical energy. The specific piezoelectric technology used is nanoparticle-coated yarns patented by Perera & Mauretti, 2009. These fibers are embedded within 1mm braided stainless steel threads. The localized patterns of wind motion will cause variance in the amount of energy produced. However, the various orientation of the triangular planes to each angle on a 360° circumference ensures that seasonal changes in wind direction will be captured.

There are 300 small clusters, 168 medium clusters, and 260 large clusters of triangles found on the site. Each small cluster covers 16 square meters, each medium cluster covers 44 square meters, and each large cluster covers 72 square meters. Structures in the small clusters range in height from four to six meters. Structures in the medium clusters range in height from eight to ten meters. Structures in large clusters range in height from fourteen to sixteen meters. With an average windspeed of 10 meters per second, at an assumed 50% efficiency, the piezoelectric wires will produce 44,895 MWh per year. The sculptures are constructed of 1mm braided stainless steel threads and recycled stainless steel tube framing.

1,557 Pavegen kinetic flooring tiles are interspersed throughout the paved path. The Pavegen floor tiles, a technology developed by Pavegen Systems, converts kinetic energy into electricity. Every time someone walks on a Pavegen tile, renewable energy is harvested from the footstep. Thus, the design of the site is symbiotic in the sense that a public space is created for the people, and in turn, visitors to the site help to generate electricity.

It is assumed that each tile will receive 120 steps per hour, during active times. Thus, at 25% efficiency, 858.5 MWh per year are captured through the Pavegen tiles. Each tile measures 600mmx450mm with a depth of 56mm. The tile is constructed of recycled rubber surfacing and stainless steel.

The design in total will harvest 45,753 MWh per year, which is enough to power 11,400 homes in Denmark annually.

Wind and kinetic energy is stored in each plaza in a cluster storage unit, and then transferred to the main energy storage unit. The energy is then transferred to the city grid.

**Environmental Impact**

To increase plant biodiversity on site, a botanical theme was chosen and implemented via the form of the energy-generating structures, as well as a detailed planting palette with plants significant to Danish ecology and culture. The semi-transparency of the structures allows sunlight to reach the surrounding planting areas. The plantings absorb CO2, enhancing Denmark’s efforts to achieve a carbon neutral status by 2025.

Planting areas offer habitat areas, increasing biodiversity in the area. Plants are attractors for pollinators, such as butterflies and bees. Key bird species that will benefit are the smew (*Mergellus albellus*), white-tailed Eagle (*Haliaeetus albicilla*), crane (*Grus grus*), broad-billed Sandpiper (*Limicola falcinellus*), Caspian Tern (*Sterna caspia*), and waxwing (*Bombycilla garrulus*).

The use of recycled materials ensures an environmentally ethical sourcing of design components. Recycled stainless steel will be used for construction of the energy-generating structures. Pavegen tiles are constructed of recycled rubber surfacing.

The viewpoints and vertical elements of the design frame key points along the harbor. The semi-transparent nature of the sculptures ensures that there is no fragmentation of the viewshed. The design offers minimal disturbance to the surrounding waterways.

**Conclusion**

*Refkløver* is a contemporary urban adaptation of picturesque meadow drifts, allowing contemplation and the regeneration of energy, literally and metaphorically, for the city of Copenhagen. Geometric forms subtly merge with the organic; visitors will hear the sound of the wind in the grasses and perennials, sensing the energy created by the elements affecting the site. Kinetic energy generation allows for the contribution of visitors to the design, and the city at large. *Refkløver* is for the people of Copenhagen-in the past, present, and future.