**Battery H2O - Batteriet H2O**

***A Post-Carbon Age Ecosystem***

***Carbon-Eftertiden Økosystem***

The Carbon Age is coming to an end. With mankind facing the dire consequences of our carbon based energy system, we are forced to transition to a new human epoch powered by the natural elements of wind, sun and water.

Battery H2O is an innovative approach for new green infrastructure projects on industrial waterfront sites. On a technical level it is a water battery storage device for renewable energy resources. A regenerative site plan re-introduces a Baltic Sea coastal ecosystem and acts as a filter to cleanse the water of Copenhagen Harbor. It is also a public park to anchor the redevelopment of Refshaleøen. In this park, people will come to gather, recreate and wander amongst a series of monoliths made from oil tanker hulls, a most recognizable symbol of the Carbon age.

**Renewable Energy and Water Battery Storage System**

Battery H2O incorporates a pumped storage hydro-electricity system made from the hulls of re-purposed oil tankers. Water from Copenhagen Harbor is pumped to high elevation storage reservoirs in the tanker hulls with three vertical axis windmill pumps. Power from the proposed PV array in Refshaleøen will provide supplemental pumping power allowing both wind and solar power to be stored in the water battery system. The elevated water storage creates pressure heads to power three hydro-electric turbines which in turn provide power to a micro-grid that will be established in Refshaleøen. The micro-grid control center and equipment is located within the Ship Breaker Battery. This system will monitor and control energy flows in the development and ensures that Refshaleøen will be powered with 100% renewable energy resources and will meet its goal of being carbon neutral by 2020.

A Master plan for the re-development of Refshaleøen has been included in this submission and allows the Battery H2O to be sized to meet the power needs of the overall development. The following power statistics assume that all new and renovated buildings will be built to high level energy efficiency standards. It also assumes that the buildings of Refshaleøen will be connected to a district heating & cooling loop supplied by the Lynetten waste water treatment CHP plant.

Power Statistics

Renovated building area: 140,565 Sq. M

New building area: 37,500 Sq. M

Total Building Area: 178,065 Sq. M

Estimated Annual Power Consumption: 6,621,863 KWH

*(assumed annual power consumption range: 15-55 KWH per Sq. M, depending on building type)*

Renewable Energy systems: (3) 1.5 MW equivalent Vertical Axis windmill pumps and 2 MW PV Array (located off site in the Refshaleøen development) supply pumping power for water storage.

(3) 1.5 MW hydroelectric Francis turbines provide power to the Refshaleøen micro-gird.

Total Annual Production: 8,379,957 KWH

Annual CO2 Equivalent: 4006 MT

Water Battery Storage Capacity: 80,000 Cu. M of water storage with variable pressure heads of 120 M, 95 M and 85 M.

Total energy storage capacity: 25,929 KWH

The battery storage contains enough energy to power the Refshaleøen micro-grid for up to 2.5 days of minimal solar and wind power input (assuming some demand side management through the micro-grid). The combined renewable energy system produces an annual surplus of 1,758,094 KWH that can be sold back to the gird while the water battery storage capacity of the system allows that surplus energy to be sold to the grid when it is actually needed. This system provides abundant storage for renewable energy in the form on an inert material in water rather than the toxic materials typically found chemical batteries.

**Park in the Heart of Refshaleøen**

Battery H2O is more than just a renewable energy production & storage system. It will be a park to anchor the redevelopment of Refshaleøen by providing residents with passive and active recreation offerings. It will also be a unique destination to attract visitors and will be the gateway to Refshaleøen via the site’s water taxi. The proposed redevelopment master plan has been adapted from the Refshaleøen local plan with some significant changes. Foremost is the re-location of park land from other waterfront parcels to the competition site. This allows Battery H2O to become the primary park for Refshaleøen, as well as open up prime real estate fo­r future development opportunities. The master plan proposes that most of the existing buildings on the site be re-developed as flexible mixed use – loft spaces. Refshalevej will be converted into a major commercial thoroughfare anchored by a public square adjacent to the competition site. The metal building currently separating the site from the public square will be demolished and in its place, 2 new buildings with a total area of approximately 10,500 Sq. M will be constructed. These buildings will flank a connection between the public square and the Battery H2O park.

Since the tanker water containers are tower elements, the opportunity exists to interject programmatic elements into their construction as well as the rest of the site. These programmatic elements provide attractions to lure visitors to this location as well as potential revenue streams for the development:

1. Observation deck with views of the harbor and central Copenhagen
2. Harbor Bath is relocated from the designated area on the local plan to a tanker container at an elevation of 100 M.
3. Event Space suitable as a rental hall for special events.
4. Central Open space suitable for public functions and events such as music festivals.
5. Walking paths and boardwalks to enable visitors to traverse the entire site, witness the hydro-electric power generation up close and learn about costal ecology.

**Construction** **Sequence**

The former Burmeister & Wain shipyard has been a landmark in Copenhagen since 1872. The design and construction of Battery H2O is tied directly to the history of the site. The vertical axis windmill pumps are constructed of masts and sails while the water storage tanks are constructed from re-purposed oil tanker hulls; creating a direct lineage from Copenhagen’s early nautical history through the present day and into our post-Carbon Age future. The shipyard facilities at Refshaleøen will be temporarily recommissioned and become a “ship breaking” facility to construct the Battery H2O in the following construction sequence:

1. The berth adjacent to the site will converted into a temporary drydock. Two oil tankers that have reached their useful lifespan, and are scheduled for decommissioning, will be diverted for use in the project. Unnecessary equipment and features will be stripped and recycled.
2. The oil tankers hulls will be cut into their principle sections. These “double hull” sections contain an interstitial space which will be reinforced with additional steel in order to accommodate the new stresses placed upon them. The sections will be cleaned, treated to accommodate saltwater and have necessary plumbing installed. The sections will be assembled into the storage containers with maritime cranes.
3. Organically inspired corten steel armatures will be added to accommodate the park’s programmatic functions and provide vertical circulation. Underground utilities, plumbing and hydro-electric turbines will be installed.
4. The contours of the site will be sculpted to create a Baltic Sea costal ecosystem. Pathways, boardwalks, windmills and final landscaping will be completed.

**A Restorative Waterfront**

Unlike most waterfront development, the Battery H2O will have a beneficial environmental impact on its surroundings. In the past, Copenhagen Harbor was dredged to create new land for development. This project reverses that approach by giving some of the land back to the harbor in order restore a coastal ecology, mitigate and adapt to the effects of climate change. In the place of a hard waterfront edge; a permeable shoreline will be created. Modeled on a typical Baltic seashore it contains the following ecological zones:

Open Water – A part of the harbor with underwater sea grasses and oyster beds

Sand Bar – Controls coastal erosion with stabilization provided by dune grasses.

Lagoon – Saltwater marsh situated behind sandbars with wetland plants to provide habitat and nesting grounds for aquatic life and to cleanse stormwater run-off as it enters Copenhagen Harbor.

Beach – Sand dunes sloping down to the water’s edge stabilized with dune grasses.

Woodland - The land slopes up to provide an elevated building platform for Oak, Beech and Pine trees typical of Danish woodlands provide a transition zone to the rest of Refshaleøen.

**A Post – Carbon Age Ecosystem**

The Battery H2O park will be a place where nature, mankind and energy will connect in a mutually beneficial symbiotic relationship. Whereas energy production in the past has depended on the flow of carbon form the ground into the atmosphere, the energy production and storage in Battery H2O involves the flow of water to and from Copenhagen Harbor. Water is pumped and stored in the recycled tanker hulls for output through hydro-electric turbines. These turbines provide water features for the residents of Copenhagen to both enjoy and to visualize their energy use through the tangible flow of water. Additionally, the system acts as a natural cleansing filter for harbor water. Water is drawn though an intake located in an oyster bed. These mollusks filter pollutants out of the water as it enters the system. As the water exists the system it flows through salt water marshes which further filter pollutants from the water. By developing this energy infrastructure as an attraction and park, it gives urban residents a chance to connect with nature and consider mankind’s place on the earth. They will be able to stroll through the dunes, boardwalks and tanker hulls while contemplating the flows of energy and water and the end of the Carbon Age.