**SEAFOREST**

***Introduction***

Although they occupy less than 2% of the surface of the ocean, corals are home to about a quarter of all marine life.[[1]](#footnote-1) In Port Phillip Bay, scientists recently discovered an astonishing diversity of corals previously unknown--reefs rivalling the size and composition of the Great Barrier Reef.[[2]](#footnote-2) Invisible to the thousands of vacationers who flock to St. Kilda to swim in the bay, these corals comprise the backbone of a vibrant marine ecology while protecting the coast from storm surges. Yet climate change is exacerbating an unprecedented loss of these corals. Scientists estimate that 50% of corals the world over have disappeared, and predict that 90% of corals will vanish in the coming decades without a dramatic intervention.[[3]](#footnote-3)

***Design Concept***

Sea pens are among the most charismatic yet obscure of the corals of Port Phillip Bay--graceful, otherworldly invertebrates that resemble antique writing quills. These feather-like corals comprise colonies that spread across the sand, forming surreal marine forests that create habitat for crabs, small fish, and algae. Sea pens are an important food source for sea stars and nudibranchs, characteristic invertebrate species of Port Phillip Bay.

Like many other corals, sea pens are threatened by climate change. As sea pens disappear, their absence can indicate the collapse of an entire marine ecosystem.

SEAFORESTrefuses to allow these incredible creatures to vanish, bringing them directly to the shore of St. Kilda, where their graceful forms become the basis for a new energy aesthetic. This vibrant new installation is capable of harvesting breezes from Port Phillip Bay, collectively producing enough energy to power over 700 homes for a year. SEAFOREST *is an artful reminder that society’s transition to a clean energy economy is intimately linked to the conservation of the world’s coral reefs*.

***A Biomimetic Solution***

Sea pens are comprised of a central, vertically oriented polyp along which smaller polyps are arranged on outstretched, fleshy “arms.” Each of these smaller polyps contain flexible tentacles that capture plankton as it floats nearby. Sea pen bodies are pliant, giving them the ability to respond to hydraulic flows--they bend and give way as they are caressed by the ocean’s currents. A large fleshy mass called a peduncle at the base of each sea pen allows these corals to stay rooted in the sandy substrate of the sea floor.[[4]](#footnote-4)

Inspired by the form of sea pens, SEAFOREST installations consist of a central steel support with jointed steel arms arranged symmetrically. These components contain hinging elements that allow for flexibility during strong wind and storm events, similar to how sea pen bodies respond to waves. The length of each arm provides a base for thousands of pliable carbon fiber tubes--inspired by sea pens’ tiny tentacles. Each tube contains twelve piezoelectric discs capable of responding to wind movement from every direction. As the tubes are disturbed by the ocean breeze, they generate electricity--similar to the way sea pens harvest energy from the movement of plankton along oceanic currents.

Each sculpture is supported by a concrete footing, which also houses a piezoelectric generator to convert mechanical energy into electrical energy. Energy storage could be accommodated in the underground parking garage facility, separated from public interaction with the site. Within the primary site boundary, installations can be located to align with the support structures of the underground parking garage, ensuring the structural capacity of the facility.

***SEAFOREST can produce a total annual output of 10,764,400 kWh.***

***Energy Production Summary***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Size** | **# Piezo-filled tubes** | **Output (kWh)** | **# Installed** | **Energy production (kWh)** |
| **Seapen 1** | 6.2m max ht x 2.4m max width | 1,064 | 44,700 | 142 | **6,347,400** |
| **Seapen 2** | 8 m max ht x 3.5m max width | 1,176 | 49,400 | 35 | **1,729,000** |
| **Seapen 3** | 9.6m max ht x  4.03 max width | 1,702 | 71,400 | 20 | **1,428,000** |
| **Seapen 4** | 9.8m max ht x 6.2 m max width | 2,144 | 90,000 | 14 | **1,260,000** |
| **ANNUAL TOTAL** |  |  |  |  | **10,764,400 kWh** |

***Energy Calculations***

**SEAPEN MODULE 1**

72 W (6W x 12 discs in filaments) / 1,000 W → kW =

x 0.0666 capacity factor

x 365 days/year  
x 24 hours per day = 0.042  
x 1,064 tubes

= 44,700 kWh per year

**SEAPEN MODULE 2**

72 W (6W x 12 discs in filaments) / 1,000 W → kW

x 0.0666 capacity factor

x 365 days/year  
x 24 hours per day =0.042  
x 1,176 tubes

= 49,400 kWh per year

**SEAPEN MODULE 3**

72 W (6W x 12 discs in filaments) / 1,000 W → kW

x 0.0666 capacity factor

x 365 days/year  
x 24 hours per day = .042  
x 1,702 tubes  
= 71,400 kWh per year

**SEAPEN MODULE 4**

72 W (6W x 12 discs in filaments) / 1,000 W → kW

x 0.0666 capacity factor

x 365 days/year  
x 24 hours per day   
x 2,144 tubes  
= 90,000 kWh per year

***Environmental Impact Statement***

Each sea pen module is constructed of recycled stainless steel sourced locally from Melbourne. Recycled stainless steel has an embodied energy of 51,500 MJ, which is much more sustainable than comparable metals such as copper, titanium or aluminum.[[5]](#footnote-5) Stainless steel is both corrosion resistant and durable, demonstrating the ability to last even in harsh outdoor conditions for many years--reducing the need to repair or replace the sea pen modules over time. Although the initial embodied energy of steel is high, its ability to last in the coastal environment makes it an appropriate materials for use in this application.

Assuming the average weight in steel of each sea pen is 40kg, the total weight of the installation is 8,440 kg, or 8.44 metric tons. The embodied carbon of one metric ton of stainless steel is 6,150 kg CO2[[6]](#footnote-6); thus, the embodied carbon of the entire installation is 51,906 kg CO2. Based on the SEAFOREST installation’s generative capacity of approximately 29,490 kWh per day, SEAFOREST would offset its embodied CO2 emissions in less than two days.[[7]](#footnote-7)

***Conclusion***

The challenges of achieving a carbon neutral future are daunting, but the rewards of safeguarding our precious natural resources are priceless. SEAFOREST is a hopeful exploration of emerging renewable energy technology, a celebration of nature’s forms, and a call to arms to defend the unique living creatures that make our world a home.

1. Knowlton, Nancy, The Smithsonian Museum of Natural History. 2017. “Corals and Coral Reefs.” <http://ocean.si.edu/corals-and-coral-reefs>. [↑](#footnote-ref-1)
2. Lambert, Catherine. “Port Phillip Bay Divers Discover Coral Reefs Full of Sea Life.” *Herald Sun*, 13 May 2017. [↑](#footnote-ref-2)
3. Becatoros, Elena. “More than 90 Percent of World’s Coral Reefs Will Die by 2050.” *The Independent*, 13 Mar. 2017. [↑](#footnote-ref-3)
4. Monterey Bay Aquarium Foundation. *Sea Pen*.<https://www.montereybayaquarium.org/animal-guide/invertebrates/sea-pen>. [↑](#footnote-ref-4)
5. Calkins, Meg LEED AP. *Materials for Sustainable Sites: A Complete Guide to the Evaluation, Selection, and Use of Sustainable Construction Materials.* John Wiley & Sons, 2009. [↑](#footnote-ref-5)
6. Ibid. [↑](#footnote-ref-6)
7. Offset value determined with assumption that 1 kWh of electricity, when produced from a coal burning power plant, will generate 0.94 kg (or 2.07 lbs) of CO2 emissions to the atmosphere [according to CNCF](https://cncf.com.au/carbon-calculator/) (https://cncf.com.au/carbon-calculator/) [↑](#footnote-ref-7)