Site + Location + Façade

The project is situated on the northern coast of Vieques, a small island east of mainland Puerto Rico. Located a half mile west of Isabel II Barrio, the site overlooks Puerto de Vieques. A short distance from Route 200, the site has direct access to critical points of local infrastructure, other medical facilities, the Vieques Ferry Terminal, and Antonio Rivera Rodríguez Airport (the island's sole point of entry by air). The building is positioned towards the apex of the local topography, set into the landscape to conceal its scale from the nearby neighborhood. The building features two residential wings that extend north towards the coast.

The primary façade is an array of structural wood frames, that act as a shading mechanism for the inner glass-and-block wall structure, and a support for roof PV arrays. The open facade enables cross breezes, both for the comfort and storm resilience.

Community Engagement

The site was chosen to serve vulnerable and under-resourced locations to strengthen the local disaster-relief infrastructure. In a hurricane, Vieques is affected adversely due to its location, remoteness from the mainland, and limited points of access. The proposed building is designed to function as a shelter, acting as an additional hub of resources and transportation with the mainland, by water and air. The site's distinctive piers that extend into the ocean, provide an additional point of departure for refugees or entry for emergency supplies and relief efforts.

Although close to the ocean, the site is inclined away from the water, mitigating the potential for flooding. The north side of the island is sheltered from heavy winds and tides that result from tropical storms sweeping northwest across the island. To further improve the site's resiliency, wetlands have been introduced around the building to act as a buffer against high tides and erosion.

In response to extreme weather, all mechanical rooms and equipment have been located above the 500-yr floor plain. Emergency power storage is sized for 3 months of islanded operation without wind or tidal generation, while still exporting surplus to the community. Two large volume storage tanks have been buried beneath the building. The first is filled with potable water for emergency use, and the seconds serves as waste storage. Seven times the annual domestic hot water consumption will be collected, allowing surplus to be exported to neighboring communities

Power Production

This building is to be powered solely by renewable energy: (1) solar PV, (2) off-shore wind, (3) tidal energy. Renewable energy generation systems were designed with enough capacity to power the building in an isolated manner during emergencies, while still exporting surplus renewable energy to the local community! The 2-axis PV Solar array will be located on the roof. The off-shore wind turbine was optimized by rotor height and diameter for performance. The tidal turbines will be installed in the current beneath the wind turbine footprint. Key parameters and performance of the renewable sources are in the table below.

Source	Dimensions	Assumptions	Annual Energy (kWh/yr)	SPB (yr)
Solar	90% of Roof	AC energy density: 334 kWh/m^2	1,250,000	<1
Off-Shore Wind	Rotor Height: 94m; Rotor Diam: 95m	Mean wind-speed:7.8 m/s @ 90 m Betz Limit: 59.3% Weibull Curve: K=2	~10,000,000	1.05
Tidal	10 x 10m diam	Mean tidal-speed: 70cm/s Weibull Curve: K=2	3,000,000	2.1

The building is designed to use 2,342,000 kBtu/year of electricity while producing 4,298,000 kBtu/yr of electricity, making it net energy positive by a factor of 2! This surplus power is to be designed to be used 3 ways: (1) exported to the local community, particularly in times of distress, (2) stored on site by utilizing H_2O electrolyzers; (3) surplus hydrogen can hydrogenate sequestered CO_2, creating fossil-fuel free methanol for combustion in vehicles or materials processing.

Air Handling Unit (AHU) with Energy Recovery

All AHUs are DOAS that provide ventilation air to the zones. Dual regenerative core energy recovery allows for latent and sensible heat recovery of up to 95% in the winter. A second desiccant wheel has been added for reheat or added dehumidification.

Active chilled beams (ACB) served by fan-powered boxes provide heating and cooling by decoupling ventilation air and sensible loads. During minimum energy operation, return air is not ventilated, but brought back to the AHU where high-grade waste heat powers a CO_2 absorber when passed through a NaOH-$CaCO_3$ direct air capture to store CO_2 typically rejected to the atmosphere, making this building carbon negative! Surplus oxygen from the electrolyzers is added to the supply airstream, which combined with UV lights and MERV 15 filters, serves as ventilation air, eliminating the need for outdoor air precool/preheat loads.

All supplemental heating and cooling shall come from the same heat pumps, which reject or reclaim heat from heat exchangers connected to the local water. Due to the temperatures, volume, and flow rate of the coastal waterways, heat can be rejected or reclaimed at more efficient operating points than even ground-source heat pumps, without disturbing wildlife.