Assessing the Feasibility of Deploying Solar-powered Underwater Devices in Waters Surrounding NYC

Solar energy collection in aquatic environments is promising for the deployment of solar-powered underwater sensors and communication devices, which could revolutionize environmental and oceanographic monitoring. However, identifying optimal solar technologies for these applications is challenging because of the time and material costs of field deployments. This research aims to estimate the feasibility of underwater solar-powered devices using computational models based on waters' absorbance data. Water samples were firstly collected from various locations around New York City, including the East River, Bowery Bay, Flushing Bay, Little Neck Bay, Harlem River, Long Island Sound, Hudson River, and Jamaica Bay. These water samples were analyzed using a Cary 60 UV-Vis spectrophotometer to measure absorbance from wavelength of 300 nm to 800 nm. The absorbance data was processed using Python-based code to calculate absorption coefficients, which were then plotted to visualize the characteristics of each water source. By comparing the absorption coefficient of different water sources, whether the sunlight would be sufficient to power basic electronics were examined. The data were inserted into computational solar cell models. The result was that the maximum coefficient at 0.4m under water is 46%, and the maximum bandgap is 1.65eV. It is feasible to utilize underwater devices to generate power around NYC.

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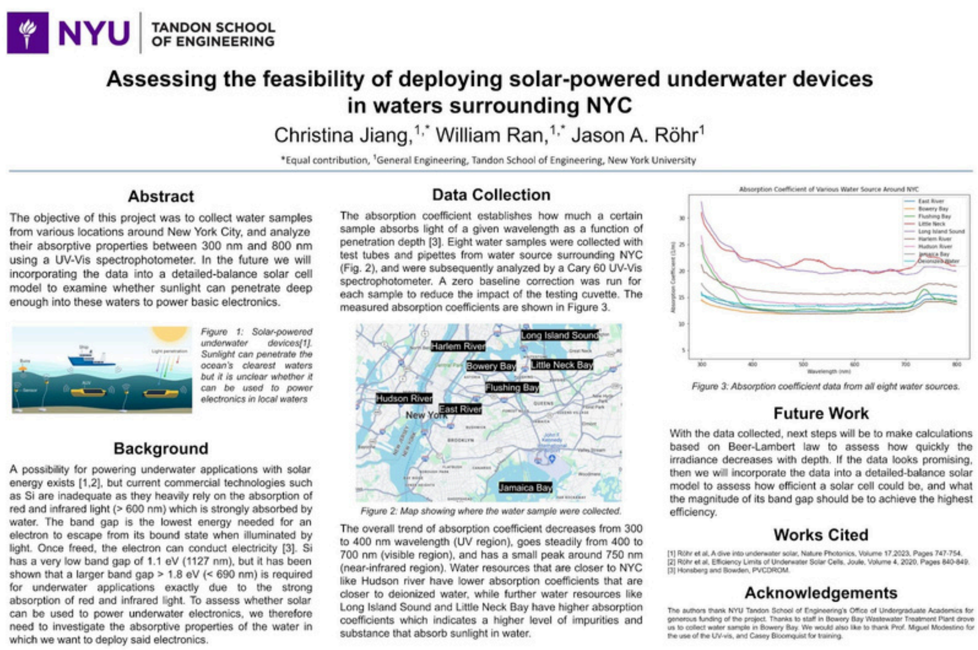

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Assessing the feasibility of deploying solar-powered underwater devices in waters surrounding NYC

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Abstract

The objective of this project was to collect water samples from various locations around New York City, and analyze their absorptive properties between 300 nm and 800 nm using a UV-Vis spectrophotometer. In the future we will incorporating the data into a detailed-balance solar cell model to examine whether sunlight can penetrate deep enough into these waters to power basic electronics.

Figure 1: Solar-powered underwater devices[1]. Sunlight can penetrate the ocean's clearest waters but it is unclear whether it can be used to power electronics in local waters

Background

A possibility for powering underwater applications with solar energy exists [1,2], but current commercial technologies such as Si are inadequate as they heavily rely on the absorption of red and infrared light (> 600 nm) which is strongly absorbed by water. The band gap is the lowest energy needed for an electron to escape from its bound state when illuminated by light. Once freed, the electron can conduct electricity [3]. Si has a very low band gap of 1.1 eV (1127 nm), but it has been shown that a larger band gap > 1.8 eV (< 690 nm) is required for underwater applications exactly due to the strong absorption of red and infrared light. To assess whether solar can be used to power underwater electronics, we therefore need to investigate the absorptive properties of the water in which we want to deploy said electronics.

Data Collection

The absorption coefficient establishes how much a certain sample absorbs light of a given wavelength as a function of penetration depth [3]. Eight water samples were collected with test tubes and pipettes from water source surrounding NYC (Fig. 2), and were subsequently analyzed by a Cary 60 UV-Vis spectrophotometer. A zero baseline correction was run for each sample to reduce the impact of the testing cuvette. The measured absorption coefficients are shown in Figure 3.

Harlem River
Long Island Sound
Bowery Bay
Little Neck Bay
Flushing Bay
Hudson River
East River
New York
Jamaica Bay

Figure 2: Map showing where the water sample were collected.

The overall trend of absorption coefficient decreases from 300 to 400 nm wavelength (UV region), goes steadily from 400 to 700 nm (visible region), and has a small peak around 750 nm (near-infrared region). Water resources that are closer to NYC like Hudson river have lower absorption coefficients that are closer to deionized water, while further water resources like Long Island Sound and Little Neck Bay have higher absorption coefficients which indicates a higher level of impurities and substance that absorb sunlight in water.

Absorption Coefficient of Various Water Source Around NYC

Figure 3: Absorption coefficient data from all eight water sources.

Future Work

With the data collected, next steps will be to make calculations based on Beer-Lambert law to assess how quickly the irradiance decreases with depth. If the data looks promising, then we will incorporate the data into a detailed-balance solar model to assess how efficient a solar cell could be, and what the magnitude of its band gap should be to achieve the highest efficiency.

Works Cited

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