PHOTOVOLTAIC POWER WITHOUT BATTERIES FOR CONTINUOUS CATHODIC PROTECTION

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ABSTRACT

The objective of this project was to successfully demonstrate that renewable energy can efficiently and economically replace dedicated non-renewable power sources.

The COASTSYSTA designed, installed, and started up on 20 January 1990, a state-of-the-art photovoltaic powered impressed current cathodic protection system (PVCPSYS) not requiring any auxiliary/battery backup power for steel and iron submerged structures. The PVCPSYS installed on 775' of steel sheet piling of a Navy bulkhead is continuing to provide complete, continuous corrosion protection well documented by COASTSYSTA and verified on-site by the U.S. Army Corps of Engineers.

The PVCPSYS uses only renewable energy and is environmentally clean. A patent is pending on the new technology. Other possible PVCPSYS applications are mothballed ships, docks, dams, locks, bridges, marinas, and pipelines.

The Department of Defense Photovoltaic Review Committee and Sandia National Laboratories consider this successful and cost effective system a major advance in the application of photovoltaics.

The objective of this project was to successfully demonstrate that renewable energy can efficiently and economically replace or be used instead of continuous non-renewable power sources. An opportunity to clearly show that photovoltaic power is practical was the result of a recommendation to provide cathodic protection to the Naval Diving and Salvage Training Center bulkhead.

The COASTSYSTA in Panama City, Florida, has broken new ground in the application of solar energy for cathodic protection. Photovoltaic arrays without battery backup have been connected to the 775 foot-long steel sheet piling of a dock bulkhead via a cathodic protection system, to prevent corrosion on that steel structure in a salt water environment.

Cathodic protection, as the name signifies, is the process by which, in the COASTSYSTA impressed current type application, the entire steel sheet piling is transformed into a cathode via a series of anodes mounted in PVC standoff racks, in the water, next to the piling. When direct current (DC) energy is applied to the anodes and sufficient electrical potential is attained by current flow from the anodes via an electrolyte (seawater) to the piling, the corrosion is transferred to the anodes, preventing piling corrosion.

Mr. Wally Muehl, Publics Works Engineer at the Coastal Systems Station, was evaluating power sources to protect the Naval Diving and Salvage Training Center bulkhead when he focused on photovoltaics. Although there are 10 other impressed current cathodic protection systems installed on the docks, all are powered by a continuous power source with the current rectified to DC.

The Naval Diving and Salvage Training Center is in a separate location from these docks, and it was determined that power was not readily available and would be expensive to provide rectifiers on the dock due to the dock configuration. Rectifiers would also pose a safety hazard on the dock that is regularly used for diver and salvage training. This bulkhead was 12-years old and other than the initial coating, received no corrosion protection.

Mr. Muehl developed a state-of-the-art solar powered system for impressed current cathodic protection of submerged steel and iron type structures without requiring any battery backup power. Battery backup power is considered costly and an environmental problem. To date, all impressed current systems require a continuous DC power supply in order to provide cathodic protection.

The COASTSYSTA photovoltaic power system is a fixed-axis system which is suitable for the Panama City latitude of 30°10'N, 85°22'W. The tilt of the arrays were set at latitude instead of +15 degrees in January 1990, and have not been changed. This is a good indication that other areas with good distribution, but lower insolation levels, would be excellent prospects for a similar type of photovoltaic powered system. For higher latitudes, there are several other options to improve system performance without battery backup. These include one-axis East-West tracking, two-axis North-South, East-West tracking, or simply adding a module or two to meet the additional current requirements.

As engineer in charge, Mr. Muehl, who designed, prepared the specifications, and monitored the installation, also had two other problems that had to be considered and resolved in order to install a impressed current cathodic protection system. The first problem was ensuring that the steel piling had electrical continuity. Another problem was providing sufficient impression of current "carry over" to overcome a 155-foot section of piling that had to be bypassed, and provide cathodic protection, without anode placement in the area having a water depth of 27 feet, where diving takes place. Both problems were overcome in the design.

To facilitate the use of a photovoltaic powered cathodic protection systems without battery backup, the steel sheet pilings were provided an initial one-time only preconditioning polarization for a predetermined continuous time period to the extent that these pilings were initially polarized to a high negative potential by a temporary DC power source. It is to be noted that the evolution of a protective hydrogen film is merely a beneficial by-product of the preconditioning polarization at the higher negative potentials. The initial DC power for polarization can be provided by a DC power source such as a portable motor driven DC generator or a portable motor driven DC welder.

The COASTSYSTA photovoltaic powered cathodic protection system tests performed and other data obtained, provide a further explanation that the anode-seawater-cathode piling structure acts like a battery and when allowed to rest, the polarity level recovers and is electrochemical in nature. An electrochemical lead-acid battery, for example, can recover charge if allowed to rest after serving a load. The electrochemical reaction reverses slightly when the load is disconnected, however, a capacitor without an external current source cannot recover by simply removing the load. It is believed that the one-time only initial preconditioning polarization of the structure embeds atomic hydrogen which can also migrate and diffuse in the structure. This system delays the decay of the negative potential and permits the photovoltaic

arrays to provide a "trickle" charge, allowing the system to easily provide complete continuous cathodic corrosion protection including cloudy, overcast, rainy and nighttime conditions without the necessity for DC power backup such as batteries.

In summary, the foregoing novel method and system of a one-time-only preconditioning or prepolarizing the structure prior to energizing the PV solar array on-line with the system, provides a relatively higher negative potential that has a slow rate of decay. This permits the use of regulated PV solar energy with excess available power, and without any backup power, to easily provide complete continuous corrosion protection, including cloudy, overcast, rainy and nighttime conditions, with excellent polarization levels and improving with time. An analogy may be that the steel structure becomes very effectively polarized, and will remain so by the variable DC charge effect provided by the simple solar array system, much like a piece of steel or iron can become magnetized by the application of a DC electrical current.

The installation, start up, and continuing operation, including underwater inspections, are well documented to date by the Coastal Systems Station and verified on site, during the day and at nighttime by the U. S. Army Corps of Engineers, Construction Engineering Research Laboratory, Naval Energy Program Office and members of the Department of Defense (DoD) Photovoltaic Review Committee. The average amount of available sunshine for the three weeks prior to these organizations visit, per data provided by the National Weather Service, averaged 24%.

This system has been in operation almost 2 1/2 years without requiring any maintenance or adjustment. A patent is pending on the new technology. Other possible applications are mothballed ships, docks, dams, locks, bridges, marinas, and pipelines.

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