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OPERATIONAL RESULTS OF RUSSIAN-BUILT PHOTOVOLTAIC ALTERNATIVE ENERGY POWERED LIGHTHOUSES IN EXTREME CLIMATES

ABSTRACT

Under the United States Department of Energy (DOE) International Radiological Threat Reduction Program (IRTR), a cooperative effort between DOE and the Russian Federation Navy was implemented to replace the radiological thermoelectric generators (RTGs) used to power approximately 400 lighthouses with alternative energy systems. This unusual application of renewable energy (PV and wind) allowed the disposal of highly radioactive sources from remote locations where RTGs were in use.

Initially, two Russian-built photovoltaic systems (Saturn Company of Krasnodar, Russia) were installed in Honningsvag, Norway and at Cape Shavor in the Murmansk region of Russia. Figure 1 shows the PV, controller, batteries, and lighthouse unit installed in Honningsvag, Norway. Sandia National Laboratories and the Southwest Technology Development Institute developed a data acquisition system (DAS) for recording operational data of the Honningsvag installation. The Norwegian Kystverket Lighthouse Commission implemented the DAS and collected the data. Kurchatov Institute in Moscow was contracted to develop and implement a similar system for the Cape Shavor lighthouse in the Murmansk installation and for other pilot installations that followed.

This paper summarizes operational histories of three of the initial Russian-designed PV lighthouses: the first in Norway and two in Russia. All lighthouses were monitored to evaluate system performance with particular attention on the Nickel Cadmium (NiCad) batteries to determine battery capacity, charging trends, temperature, and reliability. This paper presents operational data obtained from January 2004 through August 2007.

Initial evaluations showed mechanical deficiencies in the design of some components, but it was found that the Nickel Cadmium batteries will operate reliably under operational conditions of the extreme North. All three lighthouses performed well during the sunny months (March to November) sufficiently charging and maintaining battery voltage in excess of 12.2 V (average). During the winter periods of darkness (November through early February), NiCad batteries experienced voltage drop to as low as 8.8V. Despite the low voltage, the batteries maintained sufficient capacity to keep the load powered throughout the winter months until PV current charging increased in early March.

Comparison of the histories of the three systems reveals valuable performance characteristics of both PV and NiCad batteries in Arctic conditions. The durability of NiCad batteries is demonstrated by their continuous operation in discharge mode during months of darkness and sub-freezing temperatures. The practical use of PV in this unusual mode, months of battery charging followed by months of battery discharging, is documented and assessed.

This project demonstrates that alternative energy systems can be used effectively to power remote lighthouses and beacons even in extreme Arctic conditions. The unique and robust characteristics of these renewable energy systems enable the removal of highly radioactive materials from the environment.

Figure 1 - Saturn Photovoltaic System in Honningsvag, Norway.

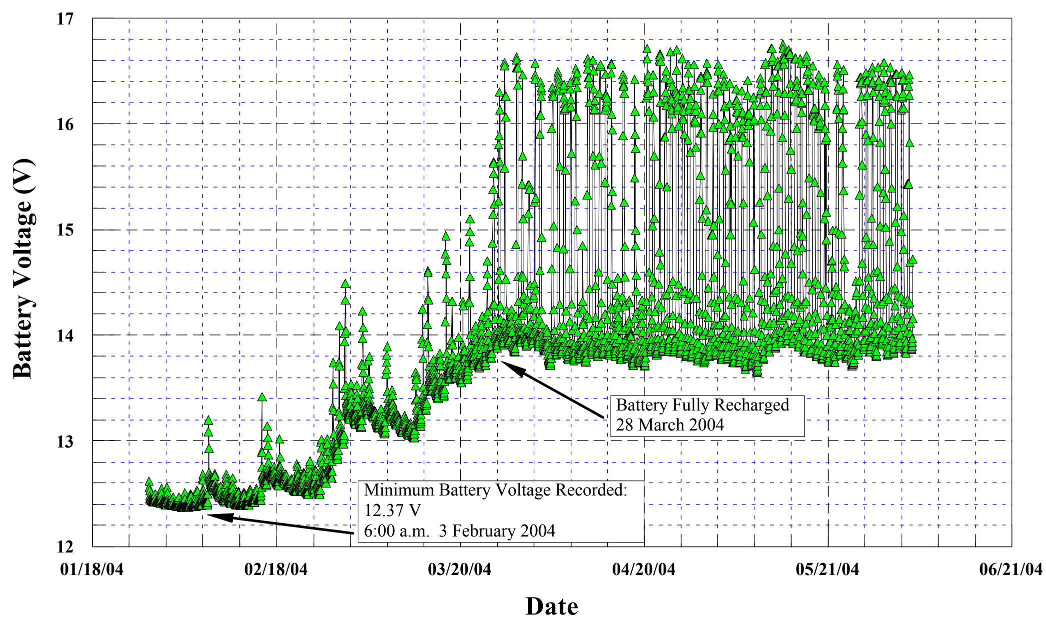

Figure 2 - Honningsvag Nickel Cadmium Battery Voltage, 2004.