OBJECTIVE: Develop a survivable capability to harness the Arctic Ocean/Air thermal gradient and provide low power for persistent unmanned Arctic sensors and data communications via Arctic Ocean buoys.

DESCRIPTION: The Navy runs environmental models to provide forecasts for operational use in the Arctic region. The Navy continues to invest in improved predictive capabilities for the Arctic region that will enable more skillful forecasts from weeks to months. A key challenge to modeling the Arctic is the lack of meteorological and oceanographic observational data. Improvements in environmental characterization and predictive capabilities will depend on increasing measurements of the region [Ref 1].

As the Navy continues to implement a persistent unmanned presence in the Arctic Ocean to achieve observational goals, new methods to generate power on site are required in order to sense the environment and communicate data for assimilation into operational models. Currently, unmanned Arctic buoys and platforms carry batteries that take up weight and volume. Power generation via solar and wind energy is available but compromised in the Arctic due limited sunlight hours and harsh winds that require large, expensive structures for survivability. Developing an innovative capability that uses the thermal gradient between Arctic Air and Ocean to generate in-situ power will allow the Navy to harvest an existing energy resource and improve persistence of observations in the region.

Thermal gradients between air and ocean surfaces in the Arctic, expressed as temperature differences and heat flow, can be directly converted into electrical energy [Ref 2]. While there are many factors that affect the entire Arctic Energy Budget, air temperature is a measure of the amount of energy held in the air, while ocean surface temperature is a measure of the amount of solar energy absorbed or reflected in the upper surface. Arctic air temperatures vary widely from -50 to 32°C while Arctic Ocean surface temperatures vary less with yearly averages between -1.8 to 3°C [Ref 3]. These thermal gradients are adequate to generate low power levels.

The Navy seeks an innovative prototype solution to harvest Arctic Ocean thermal energy in-situ and provide low power levels to sensors and data communications while integrated onto a free floating or ice-tethered Arctic buoy such as an Autonomous Arctic Ocean Flux Buoy (AFOB) or Ice Tethered Arctic Profiling Buoy. The planned energy persistence level is one year for low power environmental and oceanographic observational sensors as well as gateway buoy data communications. The desired performance is a 500W thermal harvesting system that can be incorporated into a standard Arctic oceanographic buoy and potentially in a configuration that is moored to the ice. The highest performance risk is the survivability of the energy generator in the harsh Arctic environment. The highest known technical risk is addressing the energy efficiency of generating power given the relatively low thermal gradient that exists on a daily average in the Arctic.

PHASE I: Define and develop a concept for a prototype that can meet the performance and technical requirements listed in the Description. Determine optimal locations and approach for integration and deployment of the prototype onto an Arctic buoy platform. Develop a Phase II plan. Note: An Oceanographic Research Institute can contribute to all phases of this research. Oceanographers familiar with the Arctic can inform the team about ocean circulation, temperature-salinity environments, currents, winds and other environmental factors that the innovative prototype will need to address. Oceanographers can provide specific power loads required from environmental and oceanographic sensors and data communications.

PHASE II: Construct a prototype using the expertise of research institute ocean engineers to inform the team of valuable lessons learned from previous Arctic platforms, which will drive down technical and performance risk.

PHASE III DUAL-USE APPLICATIONS: Integrate the Phase II prototype onto an Arctic buoy that will be deployed in September of 2022 as part of the Arctic Mobile Observing System (AMOS) Innovative Naval Prototype program. During Phase III, research institution technicians can provide invaluable insight about deploying a research prototype in the Arctic.

Dual use applications for this system would include commercial and non-DoD maritime needs such as ROV operations for the Oil and Gas Industry and non-DoD navigation and environmental monitoring in remote locations.
REFERENCES:


KEYWORDS: Thermal Energy Generation; Low Power for Sensors; Arctic Sensors; Arctic Mobile Observing System; Thermoelectric Generator; Persistent Sensing