Department of the Navy SBIR/STTR Transition Program

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ONR Approval #43-8875-21

Topic # N191-044
Undersea Energy Harvesting from Benthic Gas Seeps and Hydrates
Advanced Cooling Technologies, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: Multiple program offices have interest in undersea energy harvesting.

Transition Target: TBD

TPOC:
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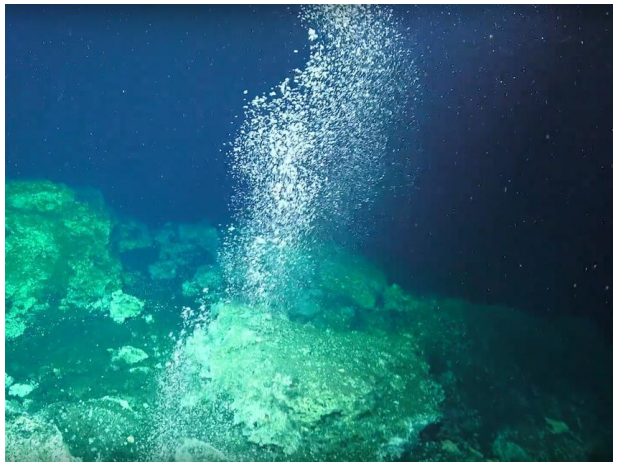
Other transition opportunities: Other transition opportunities from this project including liquid fuel reforming for portable power, deep sea methane seep collection (avoid hydrate formation), submarine life support system, heat pipe thermal management for underwater applications

Notes: 1. Demonstrated heat pipe based collection system to avoid hydrate formation
2. Developed seep collection system
3. Achieved high temperature reforming reaction via additive manufacturing of SiC Swiss-roll reformer
4. Demonstrated CO2 storage and O2 generation via KO2 reactor



https://www.usgs.gov/news/seeking-seeps

WHAT

Operational Need and Improvement: Prior research has focused on investigating benthic seep and hydrate characteristics (chemical makeup, flow, etc.), understanding associated biological lifeforms, and prediction of benthic seep and hydrate locations. Lacking is any substantive research into the potential for these energy resources to serve as sources for seabed energy conversion/storage for operational use. The Navy is currently pursuing development of technology to convert energy from seafloor hydrothermal vents and is conducting research in the area of seafloor microbial fuel cells. There are also prior and ongoing efforts to harvest energy from tidal and wave energy, as well as Ocean Thermal to Electric Conversion.

Specifications Required: Develop technologies to harvest, store, and utilize methane and other gases from benthic gas seeps and hydrates for seabed electric power production. Continuous kilowatt-scale electrical output from a single device is of interest. The design should take into consideration potential fouling of the system, a desired system lifetime of 2 years (without maintenance), the depth ranges for seeps and hydrates, and ease/practicality of system deployment. Minimizing system and deployment costs is important. It is critical to understand the biological and geological environment near benthic seeps and hydrates such that compatible technologies are pursued and ultimately developed and fielded.

Technology Developed: Novel methane harvesting system to utilize the sea floor cold seeps to extend the endurance of undersea activities. The technology aims to collect and convert abundant chemical energy in the methane seeps into electricity. The proposed technology has effective thermal and chemical integrated design to minimize the size and weight requirement. In addition, the proposed collector design is able to avoid the fouling issue during the collecting process for a wide depth range. The system proposed by ACT is self-sustained and able to provide kilowatt-scale electrical output for 2 years without any maintenance and logistic requirement.

Warfighter Value: Several underwater activities rely on battery to provide power, which has relative short endurance time. The abundant chemical energy in the seabed methane seeps could potentially be used as an energy source for battery charging enabling one to significantly extend the operational time for underwater activities.

WHEN

Contract Number: N68335-20-C-0579 **Ending on:** June 24, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Scale up KO2 reactor	Low	Scale up KO2 reactor with acceptable pressure drop	5	4th QTR FY21
Integrate KO2 reactor with fuel cell	Med	Able to capture all the CO2 from the downstream of the anode exhaust and release sufficient amount of oxygen	5	1st QTR FY22
Achieve high reforming efficiency of Swiss-roll reformer	Med	Achieve > 80% reforming efficiency with acceptable intermediate products	5	1st QTR FY22
Demonstrate integrated fuel cell and KO2 operates in underwater environment	High	Test fuel cell with KO2 reactor in underwater environment for half hour operation	6	2nd QTR FY22
Integrate Swiss-roll reformer with fuel cell	High	Demonstrate fuel cell power generation from reformate	6	3rd QTR FY22
Demonstrate methane seep collection system	Med	Able to collect methane seep at Coil Oil Pointection system	7	3rd QTR FY22

HOW

Projected Business Model: ACT plan to work with the companies who are interested in one or more of the technologies developed under this project and apply the technologies to their specific applications. Once the technologies can be successfully demonstrated, ACT will be the supplier for the technology.

Company Objectives: The technologies developed under this project can benefit several different companies. 1. Companies who are interested in methane seep collection. 2. Companies who are interested in underwater thermal management using heat pipes. 3. Companies who are interested in life support system. 4. Companies who are interested in liquid fuel reforming.

Potential Commercial Applications: The underlying technology may be utilized for liquid fuel reforming. Liquids derived from biomass resources—including ethanol and bio-oils—can be reformed to produce hydrogen in a process similar to natural gas reforming. Biomass-derived liquids can be transported more easily than their biomass feedstocks, allowing for semi-central production or possibly distributed hydrogen production at fueling stations. Biomass-derived liquid reforming is a mid-term technology pathway.

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