REQUEST FOR INFORMATION (RFI)
ONR RFI Announcement N00014-20-RFI-0001

Subsea and Seabed Power Sources Science & Technology Survey

I. DISCLAIMER

This announcement constitutes a Request for Information (RFI) for the purpose of obtaining information. It does not constitute a Request for Proposals (RFP), a Request for Quote (RFQ) or an indication that the Government will contract for any of the items and/or services discussed in this notice. Any formal solicitation that may subsequently be issued will be announced separately through Fedconnect. Information on the specific topics of interest is provided in the following sections of this announcement. Neither the Office of Naval Research (ONR) nor any other part of the federal government will be responsible for any cost incurred by responders in furnishing this information.

II. PURPOSE/ BACKGROUND

ONR is conducting a survey of underwater energy sources and conversion technologies and approaches and seeks to develop a Science and Technology (S&T) investment roadmap that provides a prioritized pathway to maturing promising technologies and approaches for providing underwater energy. Responses to this RFI will help ensure that promising technologies and approaches being considered or developed by industry will be included for consideration in the roadmap, and will help place promising technologies on the roadmap with respect to their technical qualities and performance, investment requirements, maturation timeline, and anticipated operational benefits/payoff.

III. INFORMATION REQUEST / APPLICATION

ONR is interested in long-lived[1] ocean energy scavenging and harvesting technologies and methodologies that provide electricity from energy that is naturally occurring in the ocean environment. Proposed solutions of interest cover the entire physical span of the oceanic water column from surface to seabed, as well as the entire spectrum of technology readiness levels (TRL).

Proposed solutions must not only identify the primary source of energy, but also practical means of conversion into electrical power (electricity). For the purpose of this RFI, ONR is not interested in purely energy storage technologies (e.g. batteries or flywheels), nor solutions that require resources not available in the local oceanic environment in order to support the energy harvesting, scavenging, or conversion process(es) (i.e. resupply and replenishment should not be required).

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[1] "Long-lived" implies that the energy source and conversion process can endure on monthly to yearly timescales with little to no human involvement to sustain power production; the proposed solution must be capable of operating nearly or fully autonomously.

In addition to providing electricity from scavengeable and harvestable energy resources, we are also interested in methodologies to obtain hydrogen and/or oxygen from undersea scavengeable and harvestable energy resources.

Please respond to all questions to the best of your ability. However, even partially completed surveys are still valuable. If the answer to a question is unknown, please leave blank or indicate "unknown" rather than provide an unsubstantiated answer. Ranges, as opposed to specific values, may be provided if more applicable.

1. <u>Energy Resource Focus</u>

1.1. What is the primary source of energy (e.g. thermal, kinetic, chemical, electromagnetic)? Describe the physical manifestation of the scavengeable or harvestable energy resource (e.g. seabed hydrothermal vent, water currents).

1.2. At what range of depths in the ocean is the scavengeable or harvestable resource primarily available (in meters)?

1.3. How does the scavengeable or harvestable resource vary geographically? (Use maps, percent of undersea prominence, qualitative description, etc.)

1.4. How does the scavengeable or harvestable resource vary temporally (i.e. what is the percent average availability or range of resource fluctuation over time? Is stability or fluctuation on the order of seconds, days, or years?

1.5. If the energy resource does vary temporally, is this variation predictable or unpredictable?

1.6. How is the energy resource located? Can location be accomplished autonomously and/or through remote sensing, or is labor-intensive surveying with human oversight or control needed?

1.7. How well is/are the location(s) of this resource documented or widely know?

2. <u>Technology Details Focus</u>

2.1. Is there a common or given name for the scavenging or harvesting technology or approach (e.g. stirling engine, fuel cell, piezoelectric converter)?

2.2. What is/are the scientific principles(s) behind the technology implementation (e.g. electromagnetic, piezoelectric, thermoelectric, electrochemical)? Describe the proposed solution’s functional components and how the technology produces electricity from the scavengeable or harvestable energy resource.

2.3. What range of power could the technology feasibly achieve (i.e. can practical devices generate power on the order of Watts, or milliwatts, or microwatts)? Some devices have practical scalability limitations; discuss if known.

2.4. What signature(s) does the proposed solution emit (e.g. acoustic, thermal, magnetic, electromagnetic, physical emissions)?

2.5. What is the anticipated operational life of the proposed solution in the targeted environment?

2.6. Is the average power or energy output of the technology (assuming constant resource availability) relatively constant over time, or is it anticipated to degrade with use? If so, by how much, or at what rate is it expected to degrade?

2.7. Are there practical means for deploying the proposed solution within the relevant environment? If so, can deployment be accomplished autonomously, or does deployment likely require human involvement and/or oversight? (Note: Deployment includes transportation and mooring / anchoring to the intended location).

2.8. If deployment methods are known or envisioned, please describe. What is the estimated weight and size of the infrastructure required? How precisely would it need to be placed?

2.9. If concepts to retrieve, relocate, and/or redeploy the proposed solution are known or envisioned, please describe.

2.10. Using realistic assumptions for the energy resource, what is the average continuous power density in terms of microwatts per cubic centimeter (uW/cm^3), or (alternatively) the per-cycle or per-day energy density ($uWh/cycle*cm^3$ or $uWh/day*cm^3$) of the technology? Calculations and approximations should include the full balance-of-plant (e.g. packaging, power electronics) for a fully-realized, long-lived energy generation system. If balance of plant predictions have not been made or cannot yet be made, estimates may be provided for the conversion technology alone (please indicate this caveat).

2.11. Using realistic assumptions for the energy resource, what is the estimated cost of the technology in terms of $/uW (average continuous power output basis) or $/uWh (average daily energy production basis)?

2.12. Some proposed solutions may have additional or alternative figures of merit that are more specific or relevant than requested above; if so, please provide them here.

2.13. Does the proposed solution currently require any environmentally hazardous materials? If so, is it envisioned that less hazardous materials may be utilized?

2.14. Does the proposed solution present hazards to humans during transportation or deployment? If so, can these hazards be mitigated? How?

2.15. Does the proposed solution incorporate any means of self-diagnostics, single- or multiple-fault tolerance or redundancy, or self-repair / "self-healing"? If so, please describe. (Note: This consideration is important because it helps provide resiliency in long-lived applications where human interaction is not desirable).

Technology Maturation and Development Focus

2.16. Table 1) achieved for the technology? If not necessarily within the ocean environment, please specify the environment.

2.17. Has a device that is capable of scaling to relevant production quantities been built and proven to function in a relevant environment?

2.18. Who is the primary driver behind the development of the technology or proposed solution (e.g. academia, private industry, and/or government)?

2.19. Given sufficient investment, what is the earliest timeframe this proposed solution is foreseen to reach TRL-7?

- Immediate Term, 0-2 Years
- Near-Term, 3-5 Years
- Mid-Term, 6-15 Years
- Far-Term, 15+ Years
- Unknown

2.20. What is the estimated investment cost required to reach TRL-7?

- $1-5M
- $5-15M
- $15-50M
- Other
- Unknown

2.21. How much investment (in dollars) has this technology or proposed solution already received (a) in general, and (b) with your team/company?

IV. SUBMISSION INSTRUCTIONS and FORMATTING REQUIREMENTS

Please include: 'ONR Subsea and Seabed Power Sources' in the subject line of all electronic communications and submissions.

Submit responses to ONR on or before **07 August 2020** for consideration for inclusion in the ONR Subsea and Seabed power roadmap, although responses submitted after this date may still be considered. All responses shall be submitted in PDF format and e-mailed to the addressees listed below. Responses should not exceed ten (10) pages and should to be typed in 12-point, Times New Roman font, with 1-inch margins. Responses shall follow the numbering format of the questions provided in the RFI. If technical or academic literature is available on the proposed approach or solution, please submit them with this RFI. As part of your submission, please also include your organization's name and point of contact information (name, phone, and email) in the event the Government or the ONR Experimentation & Analysis (E&A) study members wish to contact you.

All responses should be unclassified. If desired, a classified supplement may be submitted separately. Please contact the Technical Point of Contact for directions on submission of any sensitive or classified information. All information received in response to this RFI that is marked proprietary will be handled accordingly. Responses to this notice will not be returned.

V. POINTS OF CONTACT

Technical questions regarding this RFI must be sent to the following Technical Point of Contact:

Name: Mr. Matt Huffman

Title: ONR E&A Project Support Staff
Division Title: Expeditionary and Developmental Power and Energy Branch (EDPEB)
Division Code: 635
Address: 9500 MacArthur Blvd, Bethesda, MD 20817
Email Address: matthew.huffman1@navy.mil

Abstract submissions or other administrative questions regarding this RFI must be sent to the following Point of Contact:

Name: Dr. H. Scott Coombe
Title: Program Officer
Division Title: Mission Capable Persistent and Survivable Naval Platforms
Department Code: 33
Address: 875 N Randolph St., Arlington, VA 22203
Email Address: Harold.coombe@navy.mil

Table 1. Technology Readiness Level (TRL) Definitions

Technology readiness level	Description	Supporting information
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology. References to who, where, when.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.	Publications or other references that outline the application being considered and that provide analysis to support the concept.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active R&D is initiated. This includes analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. References to who, where, and when these tests and comparisons were performed.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.	System concepts that have been considered and results from testing laboratory-scale breadboard(s). References to who did this work and when. Provide an estimate of how breadboard hardware and test results differ from the expected system goals.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.	Results from testing laboratory breadboard system are integrated with other supporting elements in a simulated operational environment. How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match the expected system goals?
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space).	Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
8. Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation (DT&E) of the system in its intended weapon system to determine if it meets design specifications.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before finalizing the design?
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational mission conditions.	OT&E (operational test and evaluation) reports.