U.S. Department of Energy
Advanced Research Projects Agency—Energy (ARPA-E)

Request for Information (RFI)
DE-FOA-0001423
on
Independent Field Testing of Methane Emissions Detection Technologies

The Advanced Research Projects Agency – Energy (ARPA-E) is considering providing financial assistance for operation of a multi-user field test site of (including some construction) for priority use by its MONITOR (Methane Observation Networks with Innovative Technology to Obtain Reductions) program awardees. ARPA-E is seeking information on associated capabilities, costs, and other considerations for operating such a field test site. The MONITOR program will support 11 project teams over three years (totaling $30M) to develop technologies focused on the detection, quantification, and localization of methane emissions. The field test site would enable MONITOR awardees to assess the technical performance of their technologies under realistic conditions on a simulated natural gas well pad.

Background:

On December 16, 2014, ARPA-E announced project selections for the MONITOR program, which seeks to develop low-cost, high sensitivity systems that detect, quantify, and locate emissions associated with the production and transportation of natural gas.

The overarching goal of the program is to enable systems which meet the following performance targets, as set forth in the MONITOR Funding Opportunity Announcement (FOA)[1].

- Detecting a leak of 6 SCFH (1 ton/year) on a 10 m x 10 m well pad, within a time period that will allow a 90% reduction of leakage, with a 90% confidence level;
- Validating the data so that the rate of “false positive” indications is no more than 1 per year; as an alternative to a binary indication of “leak” or “no leak”, the system can also choose to report the probability that a leak of a given size exists;
- Estimate mass flow rate of each leak, to within 20% error;
- Estimating the location of each leak to within 1 meter;
- Wirelessly communicate results to a remote receiver;
- Total system cost (amortized capital cost + operating cost) is less than $3,000/year for basic functionality; additional cost is allowed for enhanced functionality.

Respondents were also permitted to propose systems with enhanced capabilities, which included methane selectivity, speciation capability, thermogenic/biogenic origin differentiation, continuous measurement, and enhanced stability. For nascent technologies not yet developed to the point of incorporation in a system, respondents were permitted to propose partial solutions.

Innovative solutions across the technology spectrum were encouraged. As such, the selected MONITOR projects represent a diverse array of technical approaches to methane detection, including:

[1] FOA (DE-FOA-0001128) was issued on April 29, 2014, and can be found here.

1. Distributed arrays of low-cost chemical sensors;
2. Laser-based remote sensing, including LIDAR and backscatter TDLAS approaches ;
3. Laser-based path sensors;
4. Laser-based point sensors;
5. Fiber optic sensors;
6. Distributed collection systems;
7. Advanced dispersion modeling;
8. Tomographic reconstruction approaches;
9. Imaging spectrometers; and
10. Mass spectrometry.

Teams proposed a variety of operational concepts, including distributed arrays of low-cost sensors, single point sensors, and mobile sensors, to include UAS-mounted, truck-mounted, and person-portable solutions. Some of these technologies are capable of being deployed in multiple types of systems, while others are designed for one specific deployment method.

Contingent on the availability of funds and satisfactory performance, ARPA-E will fund MONITOR project teams from April 2015 through April 2018. During this time, ARPA-E may provide financial support for a multi-use field test facility and testing to validate technology performance under realistic conditions at a natural gas well pad. This field testing will provide a means to assess how the sensors and sensor systems perform in a realistic operating environment.

Pursuant to the program metrics established in the MONITOR Funding Opportunity Announcement (FOA), funded teams must be able to demonstrate their technologies at a test site consisting of a 10m x 10m well pad, where leakage is possible from anywhere on the site and time varying winds of up to 2.75 m/s are typical. In addition to testing MONITOR technologies within a 10m x 10m plot, ARPA-E anticipates testing in a larger, more representative plot (notionally 10m x 30m) that can accommodate additional equipment often found on natural gas well pads. Note that although the program metrics are structured around production well pads, it is expected that the sensing technologies developed through MONITOR will have applications in all segments of the industry, including midstream and local distribution; as such, the test site should be able to accommodate technologies that could deployed in various applications.

MONITOR performers are required to participate in two rounds of rigorous field testing:

- **Round 1 Field Testing** (late Fall 2016) will be the first test in an outdoor environment. This will provide the initial opportunity to evaluate all of the sensing technologies in a side-by-side comparison under favorable, but realistic testing conditions. This round of testing will also provide an opportunity for the teams to demonstrate enhanced functionality of the sensors and systems.
- **Round 2 Field Testing** (late Fall 2017) will be the final opportunity for teams to demonstrate that they have met the FOA goals and enhanced capability targets. The test conditions will be more challenging than for Round 1 Field Testing, including increased complexity on the site (e.g. more separators or other obstacles that disrupt the flow), varying environmental conditions, and varying emissions rates.

In addition, MONITOR performers may schedule ad hoc, voluntary tests beginning in the second year of the program (April 2016). These optional tests, scheduled individually with the test site operator, will allow project teams to validate their technologies' performance outside of both the laboratory and program-mandated field tests. The general timeline below provides an anticipated schedule for field testing:

	2016			**2017**				**2018**
Test	Apr-Jun	Jul-Sept	Oct - Dec	Jan - Mar	Apr-Jun	Jul-Sept	Oct - Dec	Jan - Mar
Ad hoc								
Round 1 Field								
Round 2 Field								

Site Requirements:
Any site (or multiple sites) must provide for field testing where realistic methane emission scenarios can be simulated and accommodate a range of leak detection technologies irrespective of their mode of use (in other words, the site must be able to test handheld devices, fixed devices, and devices mounted to unmanned aircraft systems (UAS)).

The test site operator must be able to establish detailed test procedures and criteria based on the goals of the MONITOR program; design and construct a site with the necessary equipment to initiate controlled emissions releases; operate the test site safely and securely; and ensure the accuracy of test measurements and findings.

Access to and testing at the site will be for priority use of MONITOR program performers.

Information Being Sought:

Interested parties are free to provide any information that they believe may assist ARPA-E; however the Agency will not pay for any information submitted. Comments in response to this RFI should be submitted in PDF format to the email address **ARPA-E-RFI@hq.doe.gov** with the subject line **"Responses for RFI for DE-FOA-0001423"**. Information should be submitted not later than 11/13/15. Respondents are requested to include the following information as part of the submission:

- Company/institution name;
- Individual contact name and title;
- Mailing address;
- Phone number;
- Email address; and
- Type of company/institution (i.e., university, non-governmental organization, small business, large business, federally funded research and development center (FFRDC), government-owned/government-operated (GOGO)).

In your response, please address the following prompts and **limit your response to no more than eight pages**:

- Describe your team's capabilities, experience, and assets (i.e., equipment and property) relevant to this RFI. (~2 page)
- Describe your overarching technical approach to the design, construction, and operation of a field test site that can test MONITOR-funded technologies under real-world conditions. This should include the ability to test against the program goals. We are also interested in evaluating performance under an expanded set of conditions, which may include changing weather conditions or emissions due to human error. (~3 pages)
- Propose a geographic location for field testing and include a discussion of constraints related to resources or site access. Please specify the proximity to major nearby airports, and include a map. (~0.5 page)
- Provide a diagram of a notional test site. (~1 page)
- Provide a budget estimate, including capital and operating expenditures. (~1 page)

DO NOT SUBMIT CONFIDENTIAL OR PROPRIETY INFORMATION

Additional Information:

The purpose of this RFI is to solicit information and gain knowledge of interest, capabilities, and qualifications related to field testing of methane emission detection technologies and systems. Respondents are free to provide any information that they believe will assist ARPA-E. However, ARPA-E will not pay for information submitted. Information or data that is restricted in any way or limited for use by the government is not solicited and will not be considered.

This RFI is for planning purposes only and does not constitute an FOA. ARPA-E is not presently accepting applications for financial assistance and there is no guarantee that a FOA will be published following ARPA-E's evaluation of information submitted. ARPA-E may decide at a later date to issue a FOA based, in part, on consideration of the input received.

Material submitted for review will not be returned and there will be no formal or informal debriefing concerning the review of any submitted material. ARPA-E may contact respondents to request clarification or other information relevant to this request. ARPA-E will not respond to individual submissions or publish publicly a compendium of responses. Although ARPA-E does not plan to release responses publicly, please be aware that your entire comment may be made publicly available at any time.

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APPENDIX: MONITOR Project Selections[2]

Bridger Photonics, Inc. – Bozeman, MT
Mobile LiDAR Sensors for Methane Leak Detection
Bridger Photonics will develop a light-detection and ranging (LiDAR) system capable of rapid and precise methane measurements resulting in 3D topographic information about potential leak locations. A novel near-infrared fiber laser will enable long range detection with high sensitivity and can be deployed on a range of mobile platforms to survey multiple sites per day. This mobile LiDAR system will dramatically reduce the cost to identify, quantify, and locate methane leaks compared to currently available technologies.

IBM – Yorktown Heights, NY
On-Chip Optical Sensors and Network for Methane Leak Detection
IBM will develop new low-cost optical sensors and integrate them in a distributed sensor network to enable enhanced methane leak detection from natural gas systems. The optical sensors will use on-chip tunable diode laser absorption spectroscopy (TDLAS) enabled by shortwave infrared silicon photonics technology. The team will leverage IBM's capabilities in advanced communication, networking, and analytics to create an ultra-low-power sensor network with custom models for source localization; the network approach can also incorporate diverse sensor technologies such as catalytic chemical sensors and long path optical sensors. This proposed self-organized network will enable a significant cost reduction to identify, quantify, and locate methane leaks compared to currently available technologies.

Rebellion Photonics – Houston, TX
Portable Imaging Spectrometer for Methane Leak Detection
Rebellion Photonics will miniaturize a long wavelength infrared imaging spectrometer that is lightweight and highly portable. The image will contain multiple bands of spectral data for detection and characterization of methane leaks. The data will be processed using a cloud-based computing architecture that will stream results to mobile devices. The imager's low cost and high portability will allow for widespread deployment while mobile integration will provide increased awareness of leaks for faster leak repair.

Physical Sciences, Inc. – Andover, MA
UAV-based Laser Spectroscopy for Methane Leak Detection
Physical Sciences will develop a complete system for methane detection based on a novel infrared backscatter technique. The system will exploit lightweight mid-infrared lasers, operate in multiple modes, and be mounted on a small unmanned aerial vehicle (UAV) to provide continuous perimeter monitoring and aerial surveillance for precise leak localization. This system will dramatically reduce the cost to identify, quantify, and locate methane leaks compared to currently available technologies.

Palo Alto Research Center – Palo Alto, CA
Printed Carbon Nanotube Sensors for Methane Leak Detection
Palo Alto Research Center (PARC) will create novel printed sensor arrays and integrate them into a system that can quantify and locate methane leaks. The team will use a variety of modified carbon nanotube (CNT) sensors to build a sensor array that provides a unique methane "fingerprint" resulting from the responses of each sensor in the array. The novel CNT sensor arrays offer a low-cost solution to identify, quantify, and locate methane leaks compared to currently available technologies.

Aeris Technologies – Redwood City, CA
Miniaturized Tunable Laser Spectrometer for Methane Leak Detection
Aeris Technologies will build a miniaturized spectrometer with low power requirements to provide a robust solution for continuous leak monitoring for methane at natural gas production sites. The team will combine their mid-infrared sensor with a leak quantification algorithm based on advanced dispersion modeling and artificial neural networks. This system will be able to identify, quantify and locate methane leaks at a much lower cost compared to currently available technologies.

LI-COR – Lincoln, NE
Laser Spectroscopic Point Sensor for Methane Leak Detection
LI-COR will develop a low-cost optical sensor for methane based on a unique cavity mode spectrometer. The sensor will have minimal calibration requirements enabled by advanced software controls and a simplified hardware design. In addition, cost will be dramatically reduced by eliminating the need for expensive optical components. This project will produce a robust, highly sensitive, low-cost sensor to identify, quantify, and locate methane leaks from natural gas systems.

[2] These projects have been selected for negotiation of awards; final award amounts may vary.

Maxion Technologies, Inc. – Jessup, MD
Tunable Mid-infrared Laser for Methane Sensing
Maxion Technologies will develop a low cost, widely tunable, mid-infrared laser source to be used in systems to detect and quantify methane emissions. The design targets a strong methane absorption region currently accessible only by expensive lasers, and will improve the sensitivity and selectivity of optical methane sensors. The design allows for a 40x reduction in laser source cost, and the wide tunability will allow the same laser design to be shared across many applications, further increasing economies of scale and reducing costs. When incorporated into a methane detection system, this technology will enable significant reductions in the cost associated with identifying, quantifying, and locating methane leaks compared to currently available technologies.

General Electric Company – Niskayuna, NY
Microstructured Optical Fiber for Methane Sensing
GE Global Research will use a novel microstructured optical fiber as part of an infrared spectroscopic system to detect and quantify methane emissions. The hollow optical fiber will utilize a microstructured design that allows permeability to methane but maintains low-loss propagation of light over long distances. The design allows identification of the location of methane leaks along the length of the fiber, which provides significant flexibility in deployment. When fielded as a full methane detection system, this technology will enable significant reductions in the cost associated with identifying, quantifying, and locating methane leaks compared to currently available technologies.

The University of Colorado – Boulder, CO
Frequency Comb-based Methane Sensing
The University of Colorado at Boulder will develop a reduced-cost frequency comb system for detection of methane over kilometer distances. Frequency combs are extremely sensitive, precise, and stable tools for spectroscopic identification of natural gas constituents. The planned dual frequency comb spectrometer will be able to distinguish methane, ethane, and propane, as well as methane with different carbon isotopes for differentiating biogenic and geologic methane sources. When employed as a full methane detection system, this technology will enable significant reductions in the cost associated with identifying, quantifying, and locating methane leaks compared to currently available technologies.

Duke University – Durham, NC
Miniaturized Coded Aperture Mass Spectrometer for Methane Sensing
Duke University will build a miniaturized, coded aperture mass spectrometer for methane sensing. The coded aperture enables high resolution and high throughput in a compact device. The mass spectrometer design will be optimized for methane, and will provide the ability to distinguish between methane with different isotopic signatures for differentiating biogenic and geologic methane sources. Additionally, the sensor will identify other molecules that are common constituents of natural gas, as well as hazardous aromatic compounds such as benzene. The miniature mass spectrometer can be readily deployed and will dramatically reduce the cost to identify, quantify, and locate methane leaks compared to currently available technologies.