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Request for Proposals

Micro- and Nanosensors for Oil and Gas Exploration and Production Applications

Advanced Energy Consortium

Issued: 14 July 2008

Preproposal Abstracts due: 20 August 2008

Part
1

Advanced Energy Consortium (AEC)

2008 Request for Proposal

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OVERVIEW INFORMATION

Funding source:	Advanced Energy Consortium, Bureau of Economic Geology, The University of Texas at Austin
RFP title:	Micro- and Nanosensors for Oil and Gas Exploration and Production Applications
Announcement type:	Request for Proposals: Stage 1: Preproposals—nonenabling disclosures, not to exceed five pages in length; internal evaluations per schedule (below). Stage 2: Those selected from Stage 1 will be invited to submit full proposals not to exceed 25 pages in length; external evaluations per schedule (below).
Important dates:	**14 July 2008** Issue preproposal request **20 Aug 2008** (Midnight, Central Standard Daylight Savings Time, U.S.) First preproposals due (5+ weeks to respond) **22 Sept 2008** Announce preproposals selected on the AEC website and solicit full proposals from the finalists. **20 Oct 2008** (Central Time, U.S.) Final proposals due to AEC (4 weeks to respond) **3 Dec 2008** Selections announced on AEC website, and engagement with those selected. **31 Dec 2008** Finalize contracts **January 2009** Start projects
Description of funding opportunity:	Grants, payment against milestones and deliverables No minimum $US Expected contract level $US 50,000–$250,000/annum Larger grants possible, depending upon proposals
Contract term:	No minimum Expected .5 to 3.0 years, renewable, depending upon results
Project participants:	May include large or small companies, private, foreign and public research and technology organizations, and universities. Collaboration between groups and multi-disciplinary teams are encouraged.
Cost-share requirement:	None
Proposal delivery email address:	aec.proposals@beg.utexas.edu
For information, contact:	Natalie Silva, phone +1 (713) 466-8153
Website to view changes/updates:	http://www.beg.utexas.edu/aec/

Part 2 RFP Announcement

DESCRIPTION OF FUNDING OPPORTUNITY

The Advanced Energy Consortium (AEC) is soliciting innovative research proposals for the development of micro- and nanoscale technologies and materials to enable enhanced hydrocarbon detection in conventional reservoirs. Industry geoscientists believe that more oil and gas can be extracted by improving their understanding of the chemical and physical properties of existing oil and gas reservoirs. Even using sophisticated primary, secondary and tertiary enhanced recovery techniques, oil (and gas) is left behind. Locating the remaining petroleum and natural gas—billions of barrels of potentially available supply—is the primary research objective of the Advanced Energy Consortium (AEC)

This consortium funds pre-competitive research to identify enabling technologies through request for proposals (RFP) announcements. This RFP, including supporting information, modifications, and question/answer documents, will be available online at http://www.beg.utexas.edu/aec/. The AEC has budgeted approximately US $6-7M per annum for this program over a 3-year period. AEC expects to award between 15 and 40 individual contracts competitively in the first year in response to this RFP. Multiyear proposals will be considered; however, each contract will be subject to a go/no-go (GNG) performance review annually. AEC considers the subject area to be fundamentally multidisciplinary; teams are strongly encouraged. The number of proposals funded through this RFP will depend on the quality of the proposals received and not specifically on the availability of funds.

Advanced Energy Consortium

The Advanced Energy Consortium is a multimillion-dollar research consortium dedicated to the development of subsurface micro- and nanosensors that can help characterize the reservoir rock formation and its contents in three dimensional space. Members of the privately funded consortium include BP America Inc., Baker Hughes Incorporated, ConocoPhillips, Halliburton Energy Services Inc., Marathon Oil Corp., Occidental Oil and Gas, Schlumberger, Shell and Total. The Bureau of Economic Geology at The University of Texas at Austin is managing the Houston-based AEC on behalf of the funding members. Rice University is a collaborating technical partner.

AEC intends to act as a hub for collaborative research and technology networking with aims of bringing together the best scientists and engineers from industrial organizations and academic institutions around the world—all with the shared vision of delivering technologies that will illuminate oil and gas reservoirs in order to enable the most effective extraction and production from existing resources. In this way we can provide a secure, sustainable, and affordable energy supply for this and future generations.

Background

World energy demand is increasing monotonically, while conventional petroleum reserves are being depleted with less annual production, providing strong motivation for the AEC mission. In 2006, the U.S. Department of Energy (DOE) reported that approximately 67 percent of all U.S. oil remains in place, estimating that perhaps one-quarter of it can be recovered using conventional techniques. As of 1998, cumulative worldwide oil production spanning about 100 years stood at approximately 800 billion barrels of oil, with roughly 1,000 billion barrels remaining to be extracted by known technologies (Reis, 1998). Given the DOE figure for the amount of oil left in place after primary and secondary production, a total

resource of conventionally unrecovered petroleum of roughly 3,600 billion barrels of oil still exists—high-quality petroleum in identified deposits. This remaining oil in place (ROIP) is not easy to pinpoint or remove, however. Despite the use of 3-D and 4-D seismic surveys, advanced electromagnetic imaging methods, and sophisticated modeling and simulation technologies, fine-grained large-scale descriptions of reservoir properties and lithology are still lacking. In fact, with the exception of seismic, most sensing technologies provide information only a few inches to a couple of feet from the wellbore. Creating new technologies for precisely locating the remaining petroleum is AEC's research goal. Thus, AEC seeks to build a vital and economical hydrocarbon bridge while renewable energy resources are being developed and scaled to meaningful (terawatt) levels.

Description of Need

A primary objective of the consortium is to illuminate subsurface hydrocarbon reservoirs through the funding of research that will lead to the development of sensors that can be used to locate hydrocarbons. These sensors would migrate under their own power or with the movement of injected fluids away from the wellbores and into the interspatial areas in the reservoir, i.e., the area between wellbores. Millimeter-scale fractures and/or voids may exist in some reservoirs, but injected sensors will probably encounter a porous rock medium. Data on structure and pore fluids would be collected either directly via transmissions from the sensors or indirectly via remote interrogation of individual sensors or ensembles thereof.

A hydrocarbon reservoir is a subsurface pool including a mixture of oil, gas, water and other complex fluids, contained in a porous rock, generally of sedimentary origin. Understanding the structure and fluid content of the pore space is fundamental to effective reservoir management and production. The effective porosity (measure of the interconnected void space as a percentage of the bulk volume) of the geological medium is critical as this defines the space available for fluids (oil and gas). Determinant factors include primary grain size and degree of cementation, which can vary widely; the size of pores and (more importantly) the pore throats are generally in the low-micron range in sandstones and the mid-nanometer range in carbonates (limestone, chalk, and dolomite). A particularly challenging aspect of the application is the harsh downhole environment: conventional operating temperatures ranging from 100 to 250°C, pressures ranging from 5,000 to 20,000 PSI, and surrounded by charged rock surfaces and complex fluid mixtures variously comprising oil, hydrocarbon gas, water, acids, alkalis, tars, brines, nitrogen, carbon dioxide and hydrogen sulfide. Conventional microelectronic sensors could not even *survive* under these conditions, let alone operate and communicate.

The AEC's ultimate goals are micro- and nanoscale sensors that illuminate the hydrocarbon reservoir by describing

1. **Chemical and physical properties of reservoir fluids and rocks beyond the wellbore**
2. **Three-dimensional distribution of reservoir fluids and rocks**
3. **Dynamic paths of fluids (including all fracture-generated flow paths*)***

In addition, the following functional requirements and key questions have been articulated, and research efforts to determine solutions to these functional problems are sought:

Emplacement and Recovery
How to get sensors/materials into the reservoir? How to retrieve them?
Protection
How to protect sensors/materials from this harsh environment?
Location
How to derive 3-D location (GPS-like) information from each sensor?
Power
How to power active sensors (harvesting, generation, storage)?
Telemetry
How to retrieve data from the sensor (communication/acquisition)?

Data Processing

How to deal with data volumes (numbers of sensors, data rates)?
How to process, analyze, and use data effectively?

A detailed list of relevant properties and sensing objectives is contained in the "AEC Sensor Needs" document, which is available online. Also available are presentation videos and learning modules covering important topics in the geological and engineering aspects of hydrocarbon exploration and production. Bidders are encouraged to study these materials carefully.

Technical Areas of Interest

AEC seeks innovative proposals addressing these sensor measurement and functional problems. In addition, a number of technical areas were identified during several workshops held beginning in December 2007 and ending with a Presolicitation Workshop held on May 20 and 21, 2008, in Austin, Texas. These technical areas are defined from the perspective of the micro- and nanoresearch community and relate more to an organization of the solutions. Technical areas include "Microsensors," " Nanosensors," and "Nanotransport," as defined next.

Technical Area I: Microsensors

AEC seeks to improve formation characterization and performance by placing sensors away from the wellbore. AEC is soliciting innovative micro- and nanoresearch proposals that would enable 3-D mapping of the formation, including both natural and hydraulically induced fractures. This area of study will create and demonstrate component technologies, enabling development of microsensors to be deployed in hydraulic fractures. AEC holds that system integration of entirely existing microelectronics technologies is inappropriate at this time, and such proposals will be considered nonresponsive. Innovative components and technology demonstrations of functionality under reservoir conditions are sought, including

1. Primary sensors
2. Energy harvesting and storage
3. Communications and networking
4. Position detection
5. Hard, hermetic packaging

Technical Area II: Nanosensors

Technical Area II will address nanosensors and nanomaterials and/or image-enhancing agents used to detect discrete reservoir properties, global reservoir structure, or large-scale reservoir gradients (e.g., pressure, flow, hydrocarbon saturation). Nanosensors will be expected to traverse rock formations through native pore structures either by passive diffusion or by transport with injected fluids or eventually by active locomotion. Innovative nanostructured materials having sensing properties or functionality are sought, including

1. Synthesis and characterization of nanosensors for pressure, flow, temperature, pH, etc.
2. Detection and readout methods for discrete nanosensors
3. Remote-imaging methods for ensembles of nanosensors over large scales
4. Data analysis and inversion algorithms

Technical Area III: Nanotransport

Technical Area III addresses transport of nanomaterials in porous rock media, movement, and placement of nanosensors in hydrocarbon reservoirs. Technical demonstrations are being sought in the following areas

1. Self-propelled nanostructures and nanopropulsion methods
2. Taxis, navigation, or directional control methods for propelled nanostructures
3. Improved understanding and characterization of nanoscale fluid flow
4. Improved understanding and characterization of transport of synthetic nanostructures through nano- and microporous media

Technical Area IV: Surprises and Opportunities

The above three descriptions are intended for guidance and not constraint. The AEC Workshop may or may not have identified all reasonable approaches to illuminating hydrocarbon reservoirs and may or may not have identified all requisite enabling research needs. Proposals consistent with the AEC mission but outside of the technical areas above should be submitted under Technical Area IV.

PROPOSAL STAGES

A two-stage proposal process will be used in this RFP.

Preproposal (Stage One)

For Stage One, proposers are asked to prepare a short five page preproposal, briefly describing

1. **Project objective(s),**
2. **Benefits to the AEC mission (see problems and technical areas),**
3. **Technical approach,**
4. **Expected go/no-go (GNG) metrics,**
5. **Proposer's experience,**
6. **Team members, collaborators, industry/academic partners on project,**
7. **Estimated schedule,**
8. **Estimated budget, and**
9. **Additional information that will clarify proposal (see proposal evaluation criteria).**

Preproposals may not exceed five pages in length. Additional pages will not be reviewed. These should be nonenabling disclosures; confidential information should not be included.

Preproposals will be evaluated internally. It is the intent of AEC to significantly reduce the number of proposals that are invited for Stage Two review in order to increase the funding ratio for those writing 25 page full proposals.

Full Proposals (Stage Two)

Proposers invited to respond in Stage Two will be asked to submit a full technical and cost proposal. The total length of the full proposal may not exceed 25 pages, excluding CV's of key personnel. It is anticipated that the technical proposals will include an abstract, project objective(s), benefits to the AEC mission, technical background and approach, a work plan, GNG and secondary metrics, proposer's relevant experience, performance schedule, potential commercialization plan, available facilities and equipment, and CV's of key personnel. The format of the cost proposal should generally conform to those used for federally sponsored research (e.g., NSF, DOE, or NASA research). The specific format of full technical and cost proposals will be communicated to those selected. Stage Two full proposals may be evaluated externally.

PREPROPOSAL EVALUATION CRITERIA

Stage One (or preproposals) will be evaluated in accordance with the yes/no criteria and rated and weighted criteria listed below.

Yes/No and Category Questions:

1. Is this proposal applicable to the oil and gas industry? YES ☐ NO ☐
2. Does the proposal address an objective/problem defined by AEC? YES ☐ NO ☐
   If YES, which one?
   a. Chemical and physical properties of the reservoir? ☐
   b. Static 3-D description of the reservoir and/or rocks? ☐
   c. Dynamic paths of reservoir fluids (4-D)? ☐
   d. Sensor capabilities:
      i. Emplacement and recovery ☐
      ii. Protection ☐
      iii. Location ☐
      iv. Power ☐
      v. Telemetry ☐
      vi. Data processing ☐
3. Is there technical viability (is it plausible for oil & gas E&P)? YES ☐ NO ☐
4. Is this proposal for a Microsensor (Technical Area I)? ☐
   or Nanosensor (TA II)? ☐
   or Nanotransport (TA III)? ☐
   or Surprise and opportunity (TA IV)? ☐
5. Is it new or novel technology? ☐
   or incremental (building on existing project or technology)? ☐
6. Have health, safety, and environment (HSE) been considered? YES ☐ NO ☐

Rated and Weighted Questions:

1. What is the impact of the proposal on AEC's mission?

2. What is the technical risk of the project? (probability of success)

3. How well have the proposers articulated a reasonable and realistic execution plan?

4. What is the technical credibility and/or experience level of the team who will contribute to this project? Have the proposers put together a qualified and multi-disciplinary team, suitable for the technology?

5. How well does the project proposal fit into the AEC research portfolio and technology roadmap?

PROGRAM ORGANIZATION AND METRICS

The selected projects may be conducted in two phases, both of which will have well-defined metrics, the most critical of which are designated as go/no-go (GNG) metrics. For example, Phase I could be a demonstration of proof of principal of the proposed innovation and would span no more than 1 year. Phase II could build on the results of Phase I and culminate in a laboratory demonstration of the proposed innovation, as appropriate. Total duration of Phases I and II will not exceed 3 years.

Each phase will culminate in specified demonstration(s), which will serve to ensure that the goals of that phase have been achieved and that the performer has met the GNG metrics. Proposers should describe, in detail within their proposal, how they plan to evaluate the demonstration GNG requirements. In addition to GNG

metrics, bidders are requested to propose additional metrics (proposer-defined metrics). Such metrics may be specific to the particular approach and should provide insight into some secondary performance goals expected to be met by the end of each phase and consistent with achieving the program's GNG metrics.

Proposers must define a realistic schedule and budget that meet metric and deliverable requirements. The proposed period of performance for each of these phases and metric schedule will be included by proposers within their technical proposals and will be factors considered as part of the selection process (see above). In general, shorter phases are preferable, but each phase should be adequate in duration to meet its objectives, assuming reasonable risks and costs. Proposals should discuss plans for managing these factors. Program plans should include proposer-defined metrics every 6 months.

DELIVERABLES

Primary deliverables for each phase of the program should be substantive and detailed results for the AEC and its members develop, for example, experimental demonstrations against GNG metrics. AEC recognizes that each project will have its own unique character, pace and deliverables, but to be successful with industry partners there must be some level of engagement. Each funded project will be partnered with an industry mentor who will actively dialog and engage with the proposal team. Confidential web space (bulletin-board style) will be devoted to each project, where researchers can post informal updates, progress, and questions. It is anticipated that funded projects should expect (1) status or progress reports, (2) quarterly technical reports, (3) semiannual regular face-to-face visits from industry mentors, (4) one official site visit and review per year, and (4) one formal annual project review (in Houston or Austin).

AWARD INFORMATION

Multiple awards are anticipated. The number of awards funded will depend on the quality of the proposals received and not specifically on the availability of funds.

Foreign participants and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the contract.

AEC reserves the right to select for negotiation all, some, one, or none of the proposals received in response to this solicitation and to make awards without discussions with proposers. AEC reserves the right to accept proposals in their entirety or to select only parts of proposals for award. In the event that AEC desires to award only parts of a proposal, negotiations may be opened with that proposer. If the proposed research is inherently divisible and nothing is gained from aggregation, proposers should consider submitting it as multiple independent efforts. AEC reserves the right to fund proposals in phases, with options for continued work at the end of one or more of the phases.

CONTRACTS

A standard AEC contract has been developed on the basis of discussions at the 2008 workshops and feedback from contract personnel at a number of research groups. Every effort was made to establish reasonable and supportive terms that will be appropriate for a wide set of subawardee's.

The AEC does not wish to distribute its contract broadly and thinks it unnecessary for Stage One. However, some key provisions of the contract can be summarized as follows:

1. The funding will be in the form of subawards between the University of Texas at Austin and the proposer (subawardee).

2. Intellectual property and inventions made or developed solely by subawardees will remain the property of the subawardee.
3. Intellectual property and inventions made or developed jointly by subawardee and the AEC will be jointly owned.
4. Subawardee will have the right to publish findings.
5. IP and inventions resulting from AEC funded research will be available to AEC members through an irrevocable, worldwide, royalty-free, perpetual, paid-up, non-exclusive license. IP and inventions resulting from AEC funded projects will benefit members exclusively (within the oil and gas industry) for a reasonable period of time.
6. Provisions will exist so that AEC members can negotiate to extend this exclusivity beyond the initial period.

The standard contract will be included in each invitation to submit proposals for Stage Two review (full technical and cost proposals).

Proposers should note that the ability of the proposer/team to sign the existing standard contract with no modifications is one of the selection criteria that will be used to evaluate final proposal submissions (AEC and its members do not want to expend resources on individual and prolonged contract negotiations).

SCHEDULE

14 July 2008	Issue preproposal request
20 August 2008 (Central Time, U.S.)	Preproposals due (5+ weeks to respond)
22 September 2008	Announce preproposals selected on the AEC website and solicit full proposals from the finalists.
20 October 2008 (Central Time, U.S.)	Final proposals due to AEC (4 weeks to respond)
3 December 2008	Selections announced on AEC website, and engagement with those selected.
31 December 2008	Finalize contracts
January 2009	Start project

PREPROPOSAL SUBMISSION INSTRUCTIONS

Format—All information shall be submitted electronically using Adobe PDF format. Proposals shall be written in English, using margins not less than one inch and typeface not smaller than 10 points.

Submission Address—All submissions shall be sent electronically to aec.proposals@beg.utexas.edu. Subject line of email should include AECRFP2008—Company, university, or research group name

Preproposal Due Date—All proposal submissions are due to the AEC by Midnight, Central Standard Daylight Savings Time, Wednesday, 20 August 2008. Proposers are responsible for confirming receipt of their proposals. Proposers will receive an automated-reply email indicating that the proposal was received. Proposers are encouraged to submit proposals at least 24 hours prior to the due date and time to allow for electronic receipt processing. The email address for submissions will be unavailable for accepting proposals after the due date and time. Proposers will receive an automated-reply email indicating "delivery refused," if they attempt to transmit a proposal after the due date and time. If transmission issues occur when proposals are emailed, issues can be resolved by calling (713) 466-8153.

Late/Nonresponsive Offers—Unless the RFP due date is extended, proposals will not be accepted by the electronic system after the due date and time. In the event that a proposal is transmitted after the due date and time, it will be rejected immediately and not considered in the evaluation process. All information required by the RFP must be received in order to constitute a responsive offer. Nonresponsive offers will not be considered for Stage Two.

Validity Period—The offeror's preproposal shall remain valid for a period of 120 calendar days from AEC's due date.

Taxes—Contract request must be inclusive of all applicable Federal or Foreign, State, and local taxes. **Indirect Costs** – Proposal budgets may include indirect costs at the submitting organizations' rates approved for Federally sponsored research.

Cost-Sharing – Cost sharing is allowed, but is not required.

Proprietary Data—AEC encourages proposers not to include proprietary data in these preproposals. Initial proposals should be nonenabling disclosures. If a proposer believes that proprietary information must be included, please contact AEC directly to seek approval.

Liability—The offeror shall hold AEC, the Bureau of Economic Geology, The University of Texas at Austin, its member companies, its officers, agents, servants, and employees harmless from liability of any kind because of use of any copyrighted, or uncopyrighted, compositions; secret process, patented or unpatented invention; articles or appliances furnished or used under this offer.

Gratuities—By acknowledgment of response to this RFP, the offeror hereby certifies that no gratuities were offered by the offeror or solicited by any AEC employee either directly or indirectly. Any situation where a gratuity is solicited should be reported immediately to the AEC Contracts/Procurement Manager, Julie Duiker, at (512) 471-0116.

Hyperlinks—This RFP contains hyperlinks to other documents within AEC's website and to the World Wide Web. If difficulty is encountered in clicking and getting to the hyperlink, the website at http://www.beg.utexas.edu/aec/ has additional information.

Cited Literature: Reis, R. *Scientific American* July, **1998**, p. *279*.