Office of Science
Notice 00-09

Carbon Sequestration Research Program

Department of Energy
Office of Science

Office of Science Financial Assistance Program Notice 00-09: Carbon Sequestration Research Program

AGENCY: U.S. Department of Energy (DOE)

ACTION: Notice inviting grant applications.

SUMMARY: The Office of Biological and Environmental Research (OBER) of the Office of Science (SC), U.S. Department of Energy (DOE), hereby announces its interest in receiving applications for research on Carbon Sequestration in the Terrestrial Biosphere and the Oceans.

DATES: Applicants are encouraged (but not required) to submit a brief preapplication for programmatic review. Early submission of preapplications is encouraged to allow time for meaningful dialog.

The deadline for receipt of formal applications is 4:30 p.m., E.S.T., March 2, 2000, to be accepted for merit review and to permit timely consideration for award in Fiscal Year 2000 and early Fiscal Year 2001.

ADDRESSES: Preapplications, referencing Program Notice 00-09, for Section A on Terrestrial Biosphere should be sent E-mail to roger.dahlman@science.doe.gov and for Section B on the Oceans to anna.palmisano@science.doe.gov.

Formal applications, referencing Program Notice 00-09, should be sent to: U.S. Department of Energy, Office of Science, Grants and Contracts Division, SC-64, 19901 Germantown Road, Germantown, MD 20874-1290, ATTN: Program Notice 00-09. This address must also be used when submitting applications by U.S. Postal Service Express Mail or any other commercial overnight delivery service, or when hand-carried by the applicant.

FOR FURTHER INFORMATION CONTACT: Dr. John Houghton, Environmental Sciences Division, SC-74, Office of Biological and Environmental

Research, Office of Science, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290, telephone: (301) 903-8288, E-mail: john.houghton@science.doe.gov, fax: (301) 903-8519. The full text of Program Notice 00-09 is available via the Internet using the following web site address: http://www.sc.doe.gov/production/grants/grants.html.

SUPPLEMENTARY INFORMATION: Predictions of global energy use in the next century suggest a continued increase in carbon emissions and rising concentrations of carbon dioxide (CO2) in the atmosphere unless major changes are made in the way we produce and use energy – in particular, how we manage carbon.

One way to manage carbon is to use energy more efficiently to reduce our need for a major energy and carbon source – fossil fuel combustion. Another way is to increase our use of low- carbon and carbon-free fuels and technologies, such as nuclear power and renewable sources such as solar energy, wind power, and biomass fuels.

The third and newest way to manage carbon, capturing and securely storing carbon either from the global energy system or directly from the atmosphere, is relatively new. Although many options exist to capture and sequester carbon dioxide, the focus of this solicitation is fundamental research that would enable: a) the operation of the terrestrial biosphere in such a way to enhance the absorption and retention of atmospheric carbon; b) the operation of the ocean surface biota also to enhance the absorption and retention of atmospheric carbon; and c) the use of the deep ocean to store carbon dioxide that has been already separated, captured, and transported. The result of carbon retention by terrestrial and oceanic systems is commonly termed "carbon sequestration."

Any viable system for sequestering carbon must have a number of characteristics. It must be effective and cost-competitive with alternative means, such as renewable energy. It must have environmentally benign consequences, at least compared to alternative solutions, including no action. It must be able to be monitored and verified, because contributions to carbon sequestration almost certainly need to be measured. Research sponsored by this program could contribute to any of these goals.

This solicitation invites applications for individual projects on carbon sequestration in the terrestrial biosphere and in the oceans. The proposed research should be fundamental in nature. We are not accepting applications that test demonstrations of engineered technologies. Principal Investigators may consider the two existing DOE carbon sequestration research centers, CSITE (Carbon Sequestration in Terrestrial Ecosystems), and DOCS (DOE Center for Research on Ocean Carbon Sequestration), and the ways in which their research can complement programs there in the Centers.

Technical Areas of Interest:

A. <u>Sequestration in the Terrestrial Biosphere</u>: Carbon pools in the natural biogeochemical cycle are immense and quantitative estimates of the natural sequestration of carbon in various locations of the terrestrial biosphere are improving in accuracy. The feasibility of various options for enhancing sequestration, however, is only beginning to be explored. The DOE "Carbon Sequestration Research and Development Report" (available at http://www.sc.doe.gov/production/ober/carbseq.html) identifies potential opportunities for sequestering carbon in many ecosystems using a variety of mechanisms. The scientific foundation of different potential approaches needs to be developed. In particular, better estimates of biological fixation and metabolism of carbon are needed, along with improved data on the quantities of carbon sequestered. The intent is to develop techniques that increase fixation and alter carbon metabolism to enhance sequestration. Advanced research is encouraged that will elucidate ways of modifying natural biological and physical processes in terrestrial ecosystems to enhance carbon sequestration rates and capacities.

In general, the research should consider mechanisms and processes that can be manipulated in terrestrial ecosystems to enhance net uptake and sequestration of atmospheric carbon dioxide. Field tests are encouraged that consider feasibility and effectiveness of applying new approaches with managed and/or unmanaged terrestrial ecosystems, and which will focus on those processes or properties of ecosystems for which alteration or management will offer significant potential for enhancing the net sequestration of carbon.

The following examples are illustrative of technical areas relevant to carbon sequestration research involving the terrestrial biosphere:

1. Increasing the net fixation of atmospheric carbon dioxide by terrestrial plants with emphasis on physiology and rates of photosynthesis of vascular plants, retention of carbon by ecosystems and enhancing the translocation of carbon to soil. Research might focus on:

- intrinsic rates of carboxylation and changes in carbon balance of vascular plants.
- native plant species that exhibit rapid growth under a wide range of environmental conditions.
- ways that above- and below-ground partitioning of fixed carbon can generate long-lived sequestered products through the manipulation of nutrients, water and other environmental variables. This would include biotechnological

approaches to increase the availability or supply of nutrients from natural sources that otherwise limit plant productivity.
- understanding root architecture for optimal below-ground productivity and transformation of plant biomass, including lignified materials, into soil organic matter.

2. Reducing the emission of CO2 from soils due to heterotrophic oxidation of soil organic carbon. Research might focus on:

- defining and producing optimal mix of organisms and substrates for slowing oxidation of plant residues in soil.
- isolating and defining the environmental and biochemical factors that control the oxidation rate of soil carbon and how these factors could be modified to slow the rate.

3. Developing and demonstrating new, novel techniques for measuring changes of the quantity of carbon in biomass and soil of terrestrial ecosystems. Research might focus on:

- non-invasive methods that can measure carbon changes over time. The desired resolution would imply the ability to measure changes during a three year period of as little as 50g per square meter (0.5 tonnes per hectare) for biomass or 100g per square meter (1.0 tonnes per hectare) for soil.
- in situ devices for producing time series measurements for a given location, where detection is the same resolution as above.
- remote measurement devices for detecting relative changes of carbon source or sink strength of terrestrial ecosystems at same resolution as stated above.

4. Assessing the beneficial and adverse side effects of enhancing sequestration in the natural terrestrial biosphere. Research might focus on:

- certain management practices, such as low tillage agriculture, may enhance carbon sequestration. What secondary impacts affect the soil and runoff as a consequence of these practices, such as soil fertility, erosion control, and possible increased use of pesticides?
- how would altering the carbon cycle affect the biogeochemical cycling of other elements?
- what might be the impact of enhancing the carbon content of soils on the structure and function of ecosystems including biodiversity?

B. <u>Sequestration in the Oceans</u>: The ocean represents a large current sink for the sequestration of anthropogenic CO2 emissions as well as a large potential for further

enhancement. Two strategies for enhancing carbon sequestration in the ocean have been proposed. One strategy is the enhancement of the net oceanic uptake from the atmosphere by fertilization of phytoplankton with micro- or macronutrients. A second strategy is the direct injection of a relatively pure CO2 stream to ocean depths greater than 1000 m. Sources of CO2 might include power plants, industries or other sources. The long term effectiveness and potential environmental consequences of ocean sequestration by either strategy, however, are as yet unknown.

Examples of relevant research areas to the issue of enhanced carbon sequestration by the oceans.

1. Environmental consequences of long term ocean fertilization. Research might focus on:

- examining changes in structure and function of marine ecosystems including community structure of phytoplankton and zooplankton, ocean food webs and trophodynamics, resulting from ocean fertilization.
- examining changes in natural oceanic biogeochemical cycles (carbon, nitrogen, phosphorus, silicon, and sulfur) resulting from carbon sequestration.

2. Effectiveness of ocean fertilization on a large scale. Research might focus on:

- understanding the biological pumping of carbon to deep waters, the export of particulate organic carbon and particulate inorganic carbon to the deep sea, and mineralization or dissolution of all forms at depth.
- determining how micronutrients (such as iron) and macronutrients (such as nitrogen and phosphorus) regulate the biological pump in the ocean.
- determining to what extent increased carbon fixation in surface waters will result in an increase in carbon sequestered in the deep ocean, and how long it will remain sequestered. One approach might be the use of coupled physical, chemical and biological models.

3. Environmental consequences of direct injection of CO2 into the ocean in midwater or deep sea habitats. Research might focus on:

- understanding the effects of sustained release of concentrated CO2 on biogeochemistry and ecosystem structure and function.
- determining the effects of changes in pH and CO2 on organisms from midwater and deep sea habitats.
- understanding the longer-term fate of carbon, which is added to the ocean including the carbonate chemistry of mid- and deep-ocean water.

4. Effectiveness of direct injection of CO2 for carbon sequestration. Research might focus on:

- addressing weaknesses in Ocean General Circulation Models (OGCMs), specifically western boundary currents, ocean bottom currents and sub-grid scale processes, and test models using natural or experimental tracers.
- coupling near-field with far-field effects of CO2 injection, for example, couple plume modeling with basin and global scale ocean circulation models.

Collaboration

Applicants are encouraged to collaborate with researchers in other institutions, such as: universities, industry, non-profit organizations, federal laboratories and Federally Funded Research and Development Centers (FFRDCs), including the DOE National Laboratories, where appropriate, and to include cost sharing and/or consortia wherever feasible. Additional information on collaboration is available in the Application Guide for the Office of Science Financial Assistance Program that is available via the Internet at: http://www.sc.doe.gov/production/grants/Colab.html.

Program Funding

It is anticipated that up to a total of $2,000,000 will be available for awards in this area during FY 2000, contingent upon availability of appropriated funds. Multiple year funding of awards is expected, and is also contingent upon availability of funds, progress of the research, and continuing program need.

Preapplications

A brief preapplication may be submitted. The preapplication should identify on the cover sheet the institution, Principal Investigator name, address, telephone, fax and E-mail address, title of the project, proposed collaborators, and the technical area of scientific research (i.e. A. Sequestration in the Terrestrial Biosphere or B. Sequestration in the Oceans). The preapplication should consist of a two to three page narrative describing the research project objectives and methods of accomplishment. These will be reviewed relative to the scope and research needs of the Carbon Sequestration Research Program.

Preapplications are strongly encouraged but not required prior to submission of a full application. Please note that notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d):

1. Scientific and/or Technical Merit of the Project,
2. Appropriateness of the Proposed Method or Approach,
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources,
4. Reasonableness and Appropriateness of the Proposed Budget.

The evaluation will include program policy factors such as the relevance of the proposed research to the terms of the announcement and the agency's programmatic needs. Note, external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Information about the development and submission of applications, eligibility, limitations, evaluation, selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Science Financial Assistance Program. Electronic access to the Guide and required forms is made available via the World Wide Web at: http://www.sc.doe.gov/production/grants/grants.html. DOE is under no obligation to pay for any costs associated with the preparation or submission of applications if an award is not made. The research project description must be 15 pages or less, exclusive of attachments and must contain an abstract or summary of the proposed research. On the SC grant face page, form DOE F 4650.2, in block 15, also provide the PI's phone number, fax number and E-mail address. Attachments include curriculum vitae, a listing of all current and pending federal support, and letters of intent when collaborations are part of the proposed research. Curriculum vitae should be submitted in a form similar to that of NIH or NSF (two to three pages), see for example: http://www.nsf.gov:80/bfa/cpo/gpg/fkit.htm#forms-9.

The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CFR Part 605.

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Acting Associate Director of Science
for Resource Management

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