

SMALL BUSINESS INNOVATION RESEARCH

PROGRAM SOLICITATION

Closing Date: March 1, 1995



MASTER

U.S. Department of Energy
Office of Energy Research
SBIR Program Manager
Washington, D.C. 20585

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DOE PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1. PROGRAM DESCRIPTION

1.1 INTRODUCTION

The Department of Energy (DOE) invites small business concerns to submit grant applications under this thirteenth annual solicitation for the Small Business Innovation Research (SBIR) program. Firms with strong research capabilities in science or engineering in any of the topic areas described in Appendix I are encouraged to participate. DOE will support high-quality research or research and development (R&D) on advanced concepts concerning important energy related scientific or engineering problems and opportunities that could lead to significant public benefit if the research is successful.

Objectives of this program include increasing private sector commercialization of technology developed through DOE-supported R&D, stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal research and R&D needs, and improving the return on investment from Federally funded research for economic and social benefits to the Nation.

1.2 THREE-PHASE PROGRAM

This program solicitation is issued pursuant to the Small Business Research and Development Enhancement Act of 1992, Public Law 102-564. Under Phase I, DOE anticipates making approximately 200 grant awards from this solicitation during fiscal year 1995 to small businesses in amounts up to \$75,000 for a project period of about 6 months. Phase I is to evaluate, insofar as possible, the scientific or technical merit and feasibility of ideas that appear to have commercial potential, submitted under the SBIR program. The grant application should concentrate on research that will contribute to proving scientific or technical feasibility of the approach or concept and would be a prerequisite to further DOE support in Phase II. The successful completion of Phase I objectives will be a prerequisite to a Phase II grant application, and the proposed Phase II studies must be in the same technical topic and subtopic as the Phase I studies.

Only those Phase I grantees selected through this solicitation will be eligible to compete for the subsequent Phase II continuation of their Phase I projects.

Phase II awards are expected to be made during fiscal year 1996 to firms with approaches that appear sufficiently promising as a result of the Phase I effort. Phase II grant awards are expected to be in amounts up to \$750,000 and to cover a period of up to 24 months. It is anticipated that one-third to one-half of Phase I awardees will receive Phase II awards, depending on Phase I results and availability of funds. Phase II is the principal R&D effort. Instructions for the preparation of the Phase II grant application will be provided to all Phase I grantees at the time of the Phase I award.

Under Phase III, it is intended that non-Federal capital be used by the small business concern to pursue commercial applications of the R&D. Also, under Phase III, Federal agencies may award non-SBIR funded follow-on grants or contracts for (1) products or processes that meet the mission needs of those agencies, or (2) further research or R&D. This follow-on work results from SBIR projects that were competitively selected in Phases I and II by scientific/technical review criteria. The work proposed for Phases I and II, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phase III.

This solicitation is for Phase I grant applications only, but it describes some aspects of Phase II grants as reference information. Further information will be provided to Phase I grantees on how to apply for Phase II.

1.3 FOLLOW-ON FUNDING

An important goal of this program is the commercialization of DOE-supported research or R&D. The DOE program includes an incentive for applicants to obtain a contingent commitment prior to Phase II to continue

the innovation process where the research or R&D also has commercial potential. (See Phase II Evaluation Criterion 6c in Section 4.3.) SBIR funding pays for research or R&D meeting DOE objectives (Phases I and II); private capital provides follow-on developmental funding to meet commercial objectives (Phase III).

Following the start of Phase I, applicants whose research or R&D has identifiable potential to meet market needs should seek commitments from private sector or non-SBIR funding sources for both Phases II and III. (See Evaluation Criterion 6 in Section 4.3.) The commitments should be obtained prior to the Phase II grant application submission. The commitment for Phase III may be made contingent on the DOE-supported research or R&D meeting some specific technical objectives in Phase II, which, if met, would justify funding to pursue further development for commercial purposes in Phase III.

1.4 ELIGIBILITY AND LIMITATIONS

In addition to the instructions given in Section 3, the following eligibility conditions and limitations apply:

Multiple Applications—Each grant application must be submitted to **only one topic** and, **within it, to only one subtopic** described in Appendix I. **Duplicate** grant applications will be rejected without review. However, there is no limitation on the number of **different** grant applications that a small business may submit under this solicitation, even to the same subtopic.

Similar Applications—Grant applications that are **similar** to each other may be submitted, but **no more than one** such grant application will be funded as a result of this solicitation.

Responsiveness—To be considered responsive, a grant application must fall within the description of the subtopic, and also satisfy any conditions contained in the introductory section of that topic. **The language in both the topic introductions and the subtopics should be taken literally. Applications that do not directly address the subtopic statement will be declined for non-responsiveness.**

Choice of Topic and Subtopic—DOE will not assign a topic and/or subtopic to grant applications; this must be done by the applicant. When a grant application

has relevance to more than one subtopic, the **applicant must decide** which subtopic is the most relevant and submit the grant application under that subtopic only.

Grant Applications Being Considered for Other Funding—If a grant application that is substantially the same as the one submitted in response to this solicitation has been previously funded, or is pending at, or about to be submitted to another Federal agency, or to other DOE programs as a separate action, the applicant must so indicate and provide the information required by Section 3.4.2.j. If an award is made pursuant to a grant application submitted under this SBIR solicitation, the grantee will be required to certify that neither the grantee organization nor any of its employees have previously been, nor are currently being paid for essentially equivalent work by an agency of the Federal Government.

Qualifying as a U.S. Small Business Concern—Each concern submitting a grant application must qualify as a small business for research or R&D purposes as defined in Section 2.3. Also, for both Phase I and Phase II, the research or R&D work must be performed in the United States. "United States" means the 50 states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Trust Territory of the Pacific Islands, and the District of Columbia.

1.5 PRINCIPAL INVESTIGATOR

The Principal Investigator (PI) should be knowledgeable in all technical aspects of the grant application and be capable of leading the research effort.

The PI's primary employment must be with the small business at the time of award and during the conduct of the proposed research. Primary employment means that more than one-half of the PI's time, but no less than 20 hours (average) per week, is spent in the employment of the small business during the conduct of the project. Primary employment with a small business precludes full-time employment with another organization. In addition, the PI is expected to devote to the project a considerable part of his or her time, and in no case less than 5 hours (average) per week for the duration of the project. Before the grant is awarded, the PI will be required to sign a statement certifying adherence to all of the above requirements.

In order to ensure appropriate technical guidance for the project, only one PI will be accepted per project; co-PIs will not be accepted.

Grant applications will be evaluated against *all* of the criteria listed in Section 4.2. Since the qualifications of the PI play an important role in Criterion 3, the following rules shall apply to any substitution in PI after the closing date of the solicitation: (1) After the closing date but prior to the award selection, no substitution in PI will be considered. (2) For grant applications selected for funding, but prior to grant award, any proposed substitution in PI will be viewed as a substantial change in the original grant application, and no award will be issued unless DOE expressly approves the substitution. (3) During the term of the grant, any change in the PI will require prior written approval by DOE.

1.6 CONTACT WITH DOE

Questions about the DOE SBIR program may be addressed to Mrs. Kay Etzler, Program Spokesperson, c/o SBIR Program Manager, ER-16, U.S. Department of Energy, Washington, D.C. 20585, telephone (301) 903-5867. Requests for copies of the solicitation may be addressed to the SBIR Program Office at the above address [telephone (301) 903-5707]. For reasons of competitive fairness, communications with any Federal Government personnel regarding this solicitation are limited to non-technical matters during the grant application preparation period. Interpretations of the technical topics in Appendix I will not be given. However, the staff of DOE national laboratories or other contractor-operated laboratories may provide assistance, or may even enter into an agreement to participate in a grant application, as described in Section 1.7 below.

The selection of grant applications for awards will be completed approximately four months after the closing date of the solicitation. Grant awards will be completed approximately two months thereafter. No information on grant application status will be available until the final selections have been made. However, if a grant application acknowledgement with an assigned grant application number is not received from DOE within three weeks of the closing date, the applicant should telephone (301) 903-5867.

1.7 SUPPORT FROM NATIONAL LABORATORIES AND UNIVERSITIES

In the last few years, more than half of the successful applicants to the DOE SBIR program have arranged for support from a DOE national laboratory or a university in their SBIR project.

The DOE national laboratories' technical expertise and equipment may be available to you under existing DOE approved mechanisms for providing services and materials to non-Federal entities. Your company must have the necessary expertise to direct the entire project, because a laboratory will not perform tasks beyond your technical understanding. If you are not cognizant of the appropriate person or department at a laboratory, you may telephone the FLC Locator of the Federal Laboratory Consortium for Technology Transfer on 206-683-1005 to obtain the name of an appropriate contact, or write to Dr. Andrew Cowan, Manager, FLC Locator, P.O. Box 545, Sequim, WA 98382.

A minimum of two-thirds of the funded research or analytical effort during Phase I (or one-half during Phase II) must be performed by the applicant organization (see Section 5.5). Work done by a national laboratory will be considered as external to the applicant organization.

Similar support may be obtained from a university. Inquiries can be made at one nearby, or at a local library, to locate the supporting expertise or facilities needed for your project.

2. DEFINITIONS

The following definitions apply for purposes of this solicitation:

2.1 RESEARCH OR RESEARCH AND DEVELOPMENT

Research or R&D is any scientific or engineering activity which is (1) a systematic, intensive study directed toward greater knowledge or understanding of the subject; (2) a systematic study directed specifically toward applying new knowledge to meet a recognized need; and/or (3) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

2.2 INNOVATION

Innovation is the process of introducing new ideas into use, or the process of introducing novel uses of existing ideas.

2.3 SMALL BUSINESS CONCERN

A small business concern is one that at the time of award of Phase I (and of Phase II, if awarded):

a. is independently owned and operated, is not dominant in the field of operation in which it is proposing, has its principal place of business located in the United States (as defined in Section 1.4), and is organized for profit;

b. is at least 51 percent owned, or in the case of a publicly owned business has at least 51 percent of its voting stock owned, by United States citizens or lawfully admitted permanent resident aliens; and

c. has, including its affiliates, a number of employees not exceeding 500 and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than licensed investment companies or state development companies qualifying under the Small Business Investment Act of 1958, 15 U.S.C. 661 et seq., are affiliates of one another when either, directly or indirectly, (1) one concern controls or has the power to control the other, or (2) third parties

(or party) control or have the power to control both. Control can be exercised through common ownership, common management, and contractual relationship. The term "affiliates" is defined in greater detail in 13 CFR 121.3-2(a). The term "number of employees" is defined in 13 CFR 121.3-2(t). Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association, or cooperative.

2.4 SOCIALLY AND ECONOMICALLY DISADVANTAGED SMALL BUSINESS CONCERN

A socially and economically disadvantaged small business concern is one:

a. that is at least 51 percent owned by (i) an Indian tribe or a native Hawaiian organization, or (ii) one or more socially and economically disadvantaged individuals; and;

b. whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals. A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent Asian Americans, other groups designated from time to time by the Small Business Administration (SBA) to be socially disadvantaged, or any other individual found to be socially and economically disadvantaged by SBA pursuant to section 8(a) of the Small Business Act, 15 U.S.C. 637(a).

2.5 WOMEN-OWNED SMALL BUSINESS CONCERN

A women-owned small business concern is a small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management.

2.6 SUBCONTRACT

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by the primary recipient of a Federal Government grant, calling for supplies or services required solely for the performance of the original grant award.

2.7 JOINT VENTURE

A joint venture is an association between two or more firms to participate jointly in a single business enterprise. There must be a community of interests, a sharing of profits and losses, and, for the purposes of this solicitation, the new entity must qualify as a small business concern as defined in Section 2.3.

3. APPLICATION PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 GRANT APPLICATION REQUIREMENTS

The purpose of a grant application to DOE under the SBIR program is to provide sufficient information to convince DOE, and members of the research community who review the grant application, that it is responsive to the subtopic under which it is submitted, that the proposed work represents a sound approach to the investigation of an important scientific or engineering question, and that it is worthy of support under the stated criteria. Experts at institutions such as colleges, universities, and DOE contractor operated national laboratories may be consulted during the preparation of the grant application. The grant application should concentrate on research that will contribute to proving scientific or technical feasibility of the approach or concept and would be a prerequisite to further DOE support in Phase II. Where the scientific or technical merit of the innovation or its essential feasibility has already been established, the work will not be considered for SBIR funding.

The quality of the scientific or technical content of the grant application will be the principal basis on which applications will be evaluated. The work proposed for Phase I, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phases II and III. A grant application should be self-contained and written with the care and thoroughness accorded papers for publication. Each Phase I grant application should be reviewed carefully by the applicant to ensure inclusion of data essential for evaluation using the checklist provided in Appendix G.

Appendix I lists 44 technical topics, in an arbitrary order, numbered 1 through 44. Each technical topic is subdivided into no more than 4 subtopics; each is

designated by a letter a, b, c, or d. **A grant application must respond to only one technical topic and, within it, to only one subtopic.** (See the limitations given in Section 1.4.). Both the topic number and the subtopic letter **must be entered in the appropriate spaces** on the cover page (Appendix A). Failure to identify both the topic and subtopic, or failure to respond, in the subject matter of the grant application, to the subtopic (within a topic) identified on the cover page by the applicant, will cause the grant application to be declined without further review.

The proposed research must be responsive to the DOE program objectives, and should also serve as the base for technological innovation and new commercial products, processes, or services. Grant applications must be confined to advanced concepts in energy-related scientific or engineering research which may be carried out through fabrication and evaluation of a laboratory prototype where necessary. Phase I research can include innovative design of hardware or software, and the evaluation or optimization of such design, where this is specifically invited under the subtopic description. Specifically excluded from this solicitation are grant applications principally for literature surveys, for compilations of the work of others, for technical assessments, or for technical status surveys. Grant applications primarily for the development of already proven concepts should not be submitted, because such efforts are considered the responsibility of the private sector. Commercialization is the objective of Phase III, where the research or R&D supported by DOE under Phases I and II can be continued using non-SBIR funding.

All consultants, instrumentation, and physical facilities identified in the grant application must be available for the research or R&D project. **The consultants who are identified in the grant application must have**

agreed to serve in the manner and to the extent described in the application, and the application must contain a specific statement to that effect (see Section 3.4.2.i.). If the instrumentation, equipment, and physical facilities to be used are not the property of the applicant, and are not to be purchased or leased for this project, their source must be identified and their availability specifically confirmed in the grant application (see Section 3.4.2.h.). Statements certifying to consultant availability and salary, and national laboratory (or other source) facilities or instrumentation and rental terms, must be signed by a principal and submitted with the grant application. If the grant application is selected for an award, the grant may not be awarded unless all of the above are available.

3.2 PROTECTION OF GRANT APPLICATION INFORMATION

DOE's policy is to use data included in grant applications for evaluation purposes only and to protect such information from unauthorized use or disclosure. Protection of trade secrets or other information that is commercial or financial and confidential or privileged is discussed in Section 5.4.a.

In addition to government personnel, scientists and engineers from outside the Government may be used in the grant application evaluation process. The decision to obtain outside evaluation will take into consideration requirements for the avoidance of organizational conflicts of interest and the competitive relationship, if any, between the applicant and the prospective outside evaluator. The evaluation will be performed under an agreement with the evaluator that the data contained in the grant application will be used only for evaluation purposes and will not be further disclosed.

3.3 GENERAL CONTENT

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal grant application. Those who wish to respond should submit a research grant application of **no more than 25 consecutively numbered pages** stapled together, including cover page, project summary page, main text, references, resumes, budget, and any other enclosures or attachments. **The pages must be of standard 8 1/2" x 11" size (21.6 cm x 27.9 cm). For**

proportionally-spaced fonts, the type can be no smaller than 12 point, and for non-proportionally-spaced fonts, the type can be no smaller than 12 characters per inch (elite). Exceptions will be permitted for legends on reduced drawings but not tables. Margins are not to be less than 1 inch (2.5 cm). Video tapes or computer disks will not be accepted.

The grant application should be direct, concise, and informative. Promotional and nonproject-related discussion is discouraged. To meet DOE requirements, all items listed in Section 3.4 are to be covered fully and in the order set forth, but the space allocated to each will depend on the research project chosen and the Principal Investigator's approach. All information required by Section 3.4 must be included in the 25 pages except for the listing of multiple Phase II awards which may be required by Section 3.4.4. Appendices E and F are for information only, and should not be submitted with a grant application. By signing the grant application cover page and marking Y in the third certification, the applicant agrees to the conditions in Appendices E and F. **Grant applications containing more than 25 pages will not be considered for review or award.**

3.4 PHASE I GRANT APPLICATION FORMAT

3.4.1 Introductory Pages

a. **Cover Page**—Complete the form identified as Appendix A in the solicitation. Detailed instructions are provided on the back of the form. This is to be the cover page on each of the required 8 copies of your grant application. No other cover page is permitted. For multiple applications, photocopy the cover page form before using it.

b. **Project Summary**—Complete the project summary form identified as Appendix B. Detailed instructions are on the back of the form. This form is page 2 of your grant application. The project summary should include a brief description of the research that will be performed in Phase I. Three additional photocopies of the completed Appendix B should be included separately with your complete submission. For multiple applications, photocopy the project summary form before using it. **The project summary**

page (Appendix B) must not contain proprietary information.

3.4.2 Primary Content

a. **Identification and Significance of the Problem or Opportunity**—(Begin on page 3 of your grant application.) Define the specific technical problem or opportunity addressed by your application and its importance.

b. Background, Technical Approach, and Potential Uses

1. **Indicate the overall background and technical approach** to the problem or opportunity and the part that the proposed research plays in providing needed results.

2. **State the anticipated results** of the approach, with special emphasis on **commercial potential**, if the project is successful and is carried over into Phases II and III. This should address the technical, economic, or other benefits to the Nation. Identify any specific groups in the commercial sector, the Federal Government, or other individuals that might be expected to use the projected results. Please bear in mind that Phase III must address either the development of commercial applications, the development of products or processes for use by the Federal Government, or non-SBIR Federally-funded research or R&D for concepts developed under Phases I and II. Therefore, in Phase II, it is important to show that the approach will bring the product, process, research, or R&D to suitable readiness for Phase III.

3. **Discuss the significance of the Phase I effort** in providing a foundation for the Phase II research or R&D effort.

c. **Phase I Technical Objectives**—State the specific objectives of the Phase I effort, including the questions it will try to answer to determine the feasibility of the proposed approach.

d. **Phase I Work Plan**—Provide an explicit, detailed description of the Phase I research approach and work to be performed. The plan should indicate not only what is planned but how the

work will be carried out. The Phase I effort should attempt to determine the technical feasibility of the proposed concept, and if successful should provide a firm basis for the Phase II grant application.

The work plan should be linked with the objectives and the questions that the Phase I effort is designed to answer. **The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total grant application.**

e. **Phase I Project Description**—The Project Description must summarize items c. and d. above by very briefly stating the principal project objective(s), identifying the tasks to be performed, and listing the performance schedule. It also should identify the final report as the **only deliverable under Phase I**. A sample Project Description is included as Appendix C. In Phase II the project description will cover the principal research or R&D necessary to prepare the product or process for a Phase III effort.

f. **Related Research or R&D**—Describe significant research that is directly related to the grant application, including any conducted by the Principal Investigator or by the applicant organization. Describe how it relates to the proposed effort and any planned coordination with outside sources. The applicant must convince reviewers of his or her awareness of key recent work conducted by others in the specific area of the proposed project.

g. **Key Personnel and Bibliography of Directly Related Work**—Identify the Principal Investigator and other key personnel involved in Phase I, including their directly related education, experience, and bibliographic information. When vitae are extensive, summaries that focus on the most relevant experience or publications are desired, and such brevity may be necessary to meet the grant application size limitation (see Section 3.3). It is important that the requirements described in Section 1.5 concerning the Principal Investigator be met explicitly.

h. **Facilities/Equipment**—Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased or leased (as detailed in Appendix D) must be justified under this Section. If the equipment, instrumentation, and facilities are not the property of

the applicant and are not to be purchased or leased, **the source must be identified and their availability specifically confirmed in this section.** A principal of the organization, such as a national laboratory or university, that owns or operates the facilities/equipment must certify regarding the availability and cost of facilities/equipment and any associated technician cost; a copy of this certification must be submitted as part of the grant application.

Only American-made equipment and products should be purchased with financial assistance provided under both Phase I and Phase II awards to the extent possible in keeping with the overall purposes of the program.

i. **Consultants and Subcontractors**—Involvement of university or other consultants in the planning and research stages of the project is permitted subject to Section 5.5 limitations. If such involvement is intended, it should be described in detail and included in Appendix D (if appropriate). If consultants or subcontractors are to be used and are identified, this section must contain a **specific statement** that they have agreed to serve in the manner and to the extent described in the grant application. A statement signed by the consultant certifying his/her availability and salary must be submitted as part of the grant application.

j. **Similar Grant Applications, Proposals, or Awards**—If a proposal or grant application, whether SBIR or not, is substantially the same as the one submitted in response to this solicitation and has been previously funded or is either funded, pending, or about to be submitted to another Federal agency or to the DOE in a separate action, the applicant must provide the following information:

1. The name and address of the agency(s) to which a proposal or grant application was submitted, or will be submitted, or from which an award is expected or has been received.
2. The date of submission or the date of award.
3. The title of the grant application.
4. The name and title of the project manager or Principal Investigator for each proposal or grant application submitted or award received.

5. The number and date of the solicitation under which the application or award was received.

6. The title of the specific research topic to which the application or award was submitted.

3.4.3 Budget

Complete the SBIR Grant Application Budget form, Appendix D, for the Phase I effort only. (For multiple applications photocopy the budget form before using it.) Incorporate the copy of the budget form that bears the original signature into the copy of the grant application that bears the original signatures on the cover page. No other budget form is permitted.

Under Phase I, a minimum of two-thirds of the funded research or analytical effort must be performed by the proposing firm. Under Phase II, a minimum of one-half of the funded research or analytical effort must be performed by the proposing firm. To satisfy this criterion for Phase I, at least two-thirds of the funding requested in the grant application budget (line L of Appendix D), excluding any purchased or leased equipment, materials, and supplies, must be allocated to the proposing small business. On a separate "Budget Explanation Page", identify costs for purchased and leased equipment, materials, and supplies for each subcontractor using the following table:

Cost (in dollars)		
	Subcontractor #1	Subcontractor #2
Purchased Equipment		
Leased Equipment		
Materials and Supplies		
Total		

Other budget considerations are as follows:

a. In Section F, include only items which are to be acquired from outside the small business. On line F5,

identify the amount of subcontract work necessary for the proposed project. The detailed budget for each subcontract should be described on a separate "Budget Explanation Page".

b. Phase I (and Phase II) grants may include a profit or fee for the applicant (line J of Appendix D). A profit or fee may also be paid to a subcontractor, that provides goods or services under a subcontract with a grantee.

c. If the total cost of the project (Line I plus Line J) exceeds the amount requested on the cover page, the grant application must contain information on who will contribute the difference. This difference should be reported on Line K as cost sharing. Line L must match the amount requested on the cover page.

d. Equipment budgets may be included under Phase I (and Phase II). The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research or R&D proposed. Equipment is defined as an article of tangible personal property having a useful life of more than two years and an acquisition cost of \$500 or more. Title to equipment will be vested with the grantee.

e. Budgets for travel funds must be justified and related to the needs of the project.

3.4.4 Addendum: Documentation of Multiple Phase II Awards

A small business concern that submits a Phase I grant application and has received more than 15 Phase II SBIR awards, as totaled from all Federal agencies with SBIR programs, during the preceding five fiscal years, must document the extent to which it was able to secure Phase III funding to develop concepts resulting from previous Phase II awards. Accordingly, such small business concerns shall submit, for each Phase II award, the name of the awarding agency, the date of the award, the funding agreement number, the funding amount, the topic or subtopic title, the amount of follow-on funding, the source and the date that the follow on funding was provided, and the current commercialization status. **This required information will not be counted toward the grant application limitation of 25 pages, and should be prepared on a separate page with the heading**

"Addendum--Phase II History." Only one copy is necessary, and it should be attached to the original application.

3.4.5 Certifications

a. **Regarding Lobbying, Debarment, Suspension, and Other Responsibility Matters—Appendix E.** By signing the grant application cover page and marking Y in the third certification, the applicant agrees to these conditions, so Appendix E should not be signed or submitted with the application.

b. **Certification Regarding Drug-Free Workplace Requirements—Appendix F.** By signing the grant application cover page and marking Y in the third certification, the applicant agrees to these conditions, so Appendix F should not be signed or submitted with the application.

3.4.6 Checklist

Complete the Checklist in Appendix G and submit one copy with the grant application. The Checklist will not be counted in the 25-page limitation of the grant application.

3.4.7 Statistical Information

Complete the statistical information form (bottom of Appendix G) and submit one completed form with your grant application. This information is required by the Small Business Administration for statistical purposes, will not be revealed to the reviewers, and will play no role in the grant application award process. This form will not be counted in the 25-page limitation of the grant application.

4. METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 INTRODUCTION

Phase I grant applications will be judged on a competitive basis in several stages. All will be screened initially by DOE to ensure that they (1) meet stated solicitation requirements, (2) are responsive to the topic and subtopic entered on the cover page (see definition of responsiveness in section 1.4), (3) contain sufficient information for a meaningful technical review, (4) are for research or for research and development, (5) do not duplicate other previous or current work. Grant applications found to be in compliance with those requirements will be evaluated technically by scientists or engineers to determine the most promising technical and scientific approaches. In the evaluation and handling of grant applications, every effort will be made to protect the confidentiality of the grant application and any evaluations. Each grant application will be judged competitively against the Phase I evaluation criteria (see Section 4.2) on its own merit. Final decisions will be made by DOE based on the evaluation criteria and consideration of other factors, such as (1) the amount of Phase III funding received for previous DOE SBIR Phase II projects, and (2) program balance and needs.

If a written request for a debriefing is received by the SBIR Program Manager within 30 days after the announcement of the final selections, an oral debriefing of the grant application will be provided to the small business concern. Neither the identity of reviewers nor their verbatim comments will be disclosed.

Phase II grant applications will be subject to a technical review process similar to Phase I. Grant applications will be judged against Phase II criteria on a competitive basis. Final decisions will be made by DOE based on the evaluation criteria (see Section 4.3) and consideration of program balance and needs.

4.2 EVALUATION CRITERIA—PHASE I

DOE plans to select for award those grant applications judged to be of the highest overall merit, with approximately equal consideration given to each of the following criteria:

1. **The scientific/technical quality of the research** in the Phase I grant application.

2. **The degree of innovation** demonstrated by the grant application. Innovation is defined as the process of introducing new ideas into use, or the process of introducing novel uses of existing ideas.

3. **The qualifications** of the Principal Investigator, other key staff, and consultants, if any, and the level of adequacy of available or obtainable instrumentation and facilities.

4. **The anticipated benefits**, technical and/or economic, of the proposed research (Phase I and Phase II), if successful, with special emphasis on the likelihood that the project will attract further funding for product or process development after the SBIR support expires.

5. **The soundness and level of adequacy of the Phase I proposed work plan** to show progress toward proving the feasibility of the concept.

In preparing grant applications, applicants should present sufficient evidence to ensure that each criterion is well addressed. Technical reviewers will **base their evaluations only on information contained** in the grant application. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any experiments referred to, but not described, in refereed professional journals (i.e., those in which the articles have been subjected to peer review). Relevant journal articles should be identified in the grant application.

4.3 EVALUATION CRITERIA—PHASE II

Detailed instructions regarding Phase II grant application submission will be sent by DOE to all Phase I award winners. Listed below are some of the principles on which those instructions can be expected to be based.

A Phase II grant application can be submitted only by a DOE Phase I awardee. It must contain enough information on progress accomplished under Phase I by the time of Phase II grant application submission to enable an evaluation of the project's promise if continued into Phase II. The Phase II grant application will be evaluated for scientific and technical merit and commercial potential based on the

criteria below. Each item will receive approximately equal weight, except for item one, which will receive twice the value of any other item:

1. The **scientific/technical quality** of the proposed research or R&D with special emphasis on its degree of **innovation**.
2. The **qualifications** of the Principal Investigator and other key personnel to carry out the proposed work and the level of adequacy of available or obtainable instrumentation and facilities.
3. The **anticipated benefits**, technical and/or economic, of the proposed research, with special emphasis on the likelihood that the project will attract further funding for product or process development after the SBIR support expires.
4. The **degree** to which the **Phase I objectives were met** at the time of Phase II grant application submission.
5. The soundness and **level of adequacy of the Phase II proposed work plan** to meet the problem or opportunity.
6. The **commercial potential** of the proposed research or R&D as evidenced by (a) the small business concern's record of commercializing SBIR or other research, (b) the existence of Phase II funding commitments from private sector or non-SBIR funding sources, (c) the existence of Phase III follow-on funding commitments for the subject of the research, and (d) the presence of other indicators of commercial potential of the idea.

If the small business concern submits a Phase II funding commitment, the commitment should be an additional 20 percent or more of the Phase II funding requested from the DOE in order to receive full credit for criterion 6b. Smaller commitments will receive partial credit. The commitment must be provided either to or by the small business concern during the Phase II project period.

The Phase III follow-on funding commitment must provide that a specific amount of Phase III funds, comparable to that requested from DOE for Phase II, will be made available to or by the small business concern. Smaller commitments will receive partial credit. Commitments must indicate the dates the funds will be made available and contain specific technical objectives which, if achieved in Phase II, will make the commitment exercisable by the small business concern. The terms cannot be contingent on obtaining a patent because of the length of time this process requires. Both the Phase II and Phase III commitments must be submitted with the Phase II grant application.

Indicators of commercial potential in evaluation criterion 6d above include evidence that a market exists for the proposed product or process and the extent to which the proposed product or process would exceed the capabilities or value of other products or processes on the market.

Evaluation of the Phase II grant application may include on-site evaluations of the Phase I effort. The reasonableness of the proposed costs, vis-a-vis the effort to be performed, will be examined.

5. CONSIDERATIONS

5.1 AWARDS

From this solicitation, DOE expects to award approximately 200 firm, fixed-price Phase I research grants ranging up to \$75,000 to small business concerns in fiscal year 1995. Awards are expected to be made no later than September 1, 1995. DOE will announce the names of those firms receiving awards, and successful applicants will then have about six

months after award to carry out their proposed Phase I effort.

This solicitation does not obligate DOE to make any awards under either Phase I or Phase II. Awards under the program are subject to the availability of funds. For those grant applications chosen for awards, recipients may incur pre-award costs up to ninety days prior to the effective date of the award; but any pre-

award expenditures are made at the recipient's risk. Approval of pre-award costs by the Contracting Officer or incurrence by the recipient does not impose any obligation on DOE if an award is not subsequently made, or if an award is made for a lesser amount than the recipient expected.

It is anticipated that one-third to one-half of the Phase I awardees will receive Phase II awards, depending on the results of the Phase I effort and the availability of funds. The total amount requested must not exceed \$75,000 for Phase I and \$750,000 for Phase II.

Phase II is to further develop ideas originated under Phase I. Specific instructions for the preparation of Phase II grant applications will be sent to Phase I awardees by the DOE at the time of award. Those Phase II applicants who wish to maintain project continuity must submit grant applications no later than 45 days prior to the expiration of the Phase I grant. Successful Phase II applicants may then be issued a grant modification covering a four-month interim period of performance while the Phase II effort is being negotiated. This modification can be expected to become effective at the completion of Phase I or as soon thereafter as possible. Funding for this interim period is intended to cover the start-up costs of the Phase II effort, and will not exceed a proration of the Phase II effort as determined by the SBIR Program Manager.

Phase II applicants will be requested to provide an estimate of the amount of funding required to cover this interim period as part of their Phase II grant application. Should the two parties fail to agree on terms covering the Phase II effort, allowable costs experienced during the four-month interim period will be paid in accordance with Federal and DOE commercial cost principles. (See FAR, Part 31, and DEAR, Subpart 931.)

The final date for receipt of Phase II grant applications will be May 1, 1996. The period of performance under Phase II will depend on the scope of the effort, but normally will not exceed 24 months. Phase II award decisions will be based on the Phase II grant application and on the evaluation of progress attained under Phase I.

Phase II awards will be in amounts up to \$750,000, depending on the scope of research or R&D. Prior to Phase II, the DOE Contracting Officer may request

certain organizational, management, and financial information for administrative purposes to assure that the applicant adheres to certain standards applicable to Federal research grants.

5.2 REPORTS AND PAYMENTS

Three copies of a final report on the Phase I project must be submitted to DOE within 90 days after completion of the Phase I effort. The final report should include a single-page project summary as the first page (use form, Appendix B) identifying the purpose of the research, a brief description of the research carried out, the research findings, and the anticipated results/potential commercial applications of the research in a final paragraph. The summary may be published by DOE and should not contain proprietary information. The remainder of the report should indicate in detail the project objectives, work carried out, results obtained, and estimates of technical feasibility.

To avoid duplication of effort, language incorporated in a Phase II grant application to report Phase I progress may be used verbatim in the final report, with changes only to accommodate results obtained after the Phase II application submission and modifications required to integrate the final report into a self-contained, comprehensive, and logically structured document.

Details of payment procedures will be disseminated by the DOE Contracting Officer if a grant is issued.

5.3 RESEARCH INVOLVING SPECIAL CONSIDERATIONS

If the proposed research activities will involve human subjects at risk or vertebrate animals, the following regulations become effective. Thus, additional information will be required from the applicant.

a. **Human Subjects**—Guidelines to be used in safeguarding the rights and welfare of human subjects used in research supported by the Department of Energy are contained in Ch. 10, Part 745 of the Code of Federal Regulations (CFR).

b. **Animal Welfare**—Research work funded by the Department of Energy must be in compliance with the Animal Welfare Act of 1966, as amended (7 U.S.C. 2131 et seq), (9 CFR Part 1, 2, and 3).

Additional information and certification forms are required if the proposed scientific research involves human subjects or vertebrate animals. You must contact the SBIR Program Office, ER-16, U.S. Department of Energy, Washington, D.C. 20585 [telephone (301) 903-5867] by February 1, 1995, to request these forms.

5.4 INNOVATIONS, INVENTIONS, AND PATENTS

a. Proprietary Information. Information contained in unsuccessful grant applications will remain the property of the applicant. The Government will retain one file copy of each grant application and destroy the remainder. Grant application copies will not be returned to the applicant, but they will be destroyed. Public release of information in any grant application submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by an applicant in a grant application that constitutes a trade secret, confidential personnel information, or proprietary commercial or financial information, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the applicant with the term "Confidential Proprietary Information" and provided appropriate page numbers are inserted into the legend printed at the bottom of the cover page (Appendix A). The Government will limit dissemination of such information to within official channels. Any other legend may be unacceptable to the Government and may constitute grounds for removing the grant application from further consideration and without assuming any liability for inadvertent disclosure.

Submissions incorporating data affecting the national security will not be accepted for evaluation.

b. Rights in Data Developed Under SBIR Funding Agreements. Rights in technical data, including software developed under the terms of any funding agreement resulting from grant applications submitted in response to this solicitation, shall remain with the grantee, except that the Government shall have the limited right to use such data for Government purposes and shall not release such proprietary data outside the Government without permission of the

grantee for a period of not less than four years from completion of the project from which the data were generated. However, effective at the conclusion of the four-year period, the Government shall retain a royalty-free license for Government use of any technical data delivered under an SBIR award whether patented or not and shall be relieved of all disclosure prohibitions.

c. Copyrights. With prior written permission of the Contracting Officer, the awardee may copyright and publish (consistent with appropriate national security considerations, if any) material developed with DOE support. DOE receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgement and disclaimer statement.

d. Patents. Small business concerns may retain the principal worldwide patent rights to any invention developed with Federal support. The Government receives a royalty-free license for Federal use, reserves the right to require the patentholder to license others in certain circumstances, and requires that anyone exclusively licensed to sell must normally manufacture it domestically. Information regarding patent rights in inventions made with Federal funding by small business concerns can be found in the Code of Federal Regulations, 37 CFR Part 401.

5.5 COST SHARING, JOINT VENTURES, AND IN-HOUSE WORK

Cost sharing is permitted for grant applications under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I grant application. Federal funding will not exceed \$75,000 or \$750,000 for Phase I and Phase II projects, respectively. The amount listed on line L of the budget summary (Appendix D) cannot exceed these amounts. If the cost of the project (lines I+J) exceeds these limits, the applicant must explain who will contribute the difference indicated on line K.

Joint ventures are permitted, provided the entity created qualifies as a small business concern in accordance with the definition included in this solicitation (Section 2.3).

During Phase I, a minimum of two-thirds of the funded research or analytical effort must be performed by the applicant organization. During Phase II, a minimum of one-half of the funded research or analytical effort must be performed by the applicant organization.

For both Phases I and II, funded research or analytical effort is defined as the total amount of funding designated in the grant application budget (line L of Appendix D) excluding any purchased or leased equipment, materials, and supplies procured by the small business and its subcontractors.

5.6 NONDISCRIMINATION IN FEDERALLY ASSISTED PROGRAMS

In accordance with Title VI of the Civil Rights Act of 1964, P.L. 88-352, the applicant organization responding to this solicitation must agree to ensure that no person in the United States shall, on the grounds of race, color, national origin, sex, age, or handicap, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity in which the applicant receives Federal assistance from the Department of Energy.

5.7 GRANTEE COMMITMENTS

On award of a grant, the grantee will be required to make certain legal commitments through acceptance of numerous provisions in the Phase I grant. The outline that follows is illustrative of the provisions that will be included in the Phase I grant. This is not a complete list of provisions to be included nor does it contain specific wording of these clauses.

a. **Standards of Work.** Work performed under the grant must conform to high professional standards.

b. **Inspection.** Work performed under the grant is subject to Government inspection and evaluation at all reasonable times.

c. **Examination of Records.** The U.S. Comptroller General (or a duly authorized representative) shall have the right to any directly pertinent records of the grantee involving transactions related to this grant.

d. **Suspension and Termination.** The Government may suspend or terminate a grant for cause on the basis of noncompliance or debarment of the awardee.

e. **Disputes and Appeals.** Any dispute concerning the grant which cannot be resolved informally shall be decided by the Contracting Officer with right of appeal.

f. **Affirmative Action for Veterans.** The grantee will not discriminate against any employee or applicant for employment because he or she is a disabled veteran.

g. **Officials Not to Benefit.** No member of or delegate to Congress shall benefit from the grant.

h. **Covenant Against Contingent Fees.** No person or agency has been employed to solicit or secure the grant upon an understanding for compensation except bona fide employees or commercial agencies maintained by the grantee for the purpose of securing business.

i. **Gratuities.** The grant may be terminated by the Government if any gratuity has been offered to any representative of the Government to secure the grant.

5.8 ADDITIONAL INFORMATION

a. This solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR award, the terms of the award shall control.

b. Before issuing an SBIR award, the Government may request the applicant to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

c. Unsolicited grant applications will not be accepted under the SBIR program in either Phase I or Phase II.

6. SUBMISSION OF GRANT APPLICATIONS

6.1 NUMBER OF COPIES

The following must be submitted:

- 1 original application which includes:
 - a. Cover Sheet (Appendix A),
 - b. Project Summary (Appendix B),
 - c. Main Text as required in Section 3.4.2,
 - d. Budget Form (Appendix D),Note: Signatures are required on the Cover Page (Appendix A) and the Budget Form (Appendix D).
- 7 additional copies of the application
- 3 additional copies of the Project Summary (Appendix B)
- 1 completed Checklist and Statistical Information form (Appendix G)
- 1 addendum, "Documentation of Multiple Phase II Awards" (if appropriate)

Grant applications submitted as **First Class, Registered Mail, Certified Mail, or Two-Day Priority Mail** through the U.S. Postal Service, must be addressed to:

SBIR PROGRAM MANAGER (ER-16)
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20585

Please use the following address when submitting grant applications **by any other method including Overnight Postal Service:**

SBIR PROGRAM MANAGER (ER-16)
U.S. DEPARTMENT OF ENERGY
INTERSTATE 270 AND ROUTE 118
19901 GERMANTOWN ROAD
GERMANTOWN, MD 20874
(301) 903-5867

Phase I grant applications hand carried by the applicant may be delivered to: U.S. Department of Energy, 19901 Germantown Road, Germantown, MD.

Applications will not be accepted by the Department at its Independence Avenue SW, Washington, D.C. address.

If a grant application acknowledgement with the grant application number endorsed on it is not received from

DOE within three weeks following the closing date of this solicitation, the applicant should telephone the SBIR Program Office promptly at (301) 903-5867.

6.2 DEADLINE FOR RECEIPT OF GRANT APPLICATIONS

a. Any grant application received after 5:00 p.m. EST on Wednesday, March 1, 1995, will be considered late unless it was sent by the U.S. Postal Service's registered or certified mail not later than February 22, 1995. Since the postmark will be the evidence on which the decision is made, it is incumbent on applicants to assure themselves that the postmark is clear and easily legible; hand cancellation is suggested. All other methods of delivery of grant applications will be considered late if they are received after 5:00 p.m. EST on Wednesday, March 1, 1995. **Late grant applications will not be eligible for award and will be declined without a review.** Applications may not be submitted by telefax.

b. Modifications to grant applications that are intended to be incorporated in the review/award process will be accepted **only if received by the deadline**, and are clearly marked as modifications.

c. Modifications by successful applicants during the process of negotiation will be considered only if it is determined that they make the grant application more favorable to the Government.

d. Grant applications may be withdrawn by a written notice received at any time prior to award. The Government will retain one file copy.

6.3 PHYSICAL PACKAGING

Do not use special bindings or covers. Staple the pages in the upper left hand corner of each grant application. Secure packaging is mandatory. The Department cannot be responsible for the processing of grant applications damaged in transit.

7. SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Applicants may want to obtain scientific and technical information related to their proposed effort as background or for other purposes. Sources of this information are listed in the bibliographies of each topic in Appendix I.

7.1 NATIONAL TECHNICAL INFORMATION SERVICE

Reports resulting from Federal research and those received from exchange agreements with foreign countries and international agencies are available to the public in both paper copy and microfiche through the National Technical Information Service (NTIS). They may be ordered by telephone for dispatch through regular mail for a nominal fee from:

NTIS
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

For expedited service, call toll-free 1-800-553-6847. Rush service (dispatched within 24 hours by First Class Mail), second day air, and express service are each available for an additional cost.

Alternatively, microfiche of unclassified, unlimited DOE reports is available for use by the public free of charge in Government Printing Office depository collections. More than 1,400 public, college, and university libraries around the country are designated as U.S. Depository Libraries. Check with a local public library. Most libraries participate in an inter-library loan service whereby one may request copies of an unavailable publication from another library.

7.2 DOE OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION

DOE maintains an Office of Scientific and Technical Information (OSTI) which collects and disseminates both DOE-originated and worldwide scientific and technical literature in subjects of interest to DOE researchers. This information is available to the general public.

The Energy Data Base, containing over 2 million scientific and technical references, is available from:

DIALOG Information Services, Inc.
1-800-334-2564

STN International
1-800-753-4227

In addition, OSTI has developed an on-line Superconductivity Information System (SIS) which includes a bulletin board and three data bases - Preprints Database, Work-in-Progress Database, and Energy Database. SIS provides information and real-time communications for government program offices, researchers, industry, and academia on a daily basis. SIS is accessible through:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831

7.3 OTHER SOURCES

Literature and database searches for abstracts, publications, patents, lists of Federal research in progress (the FEDRIP database), and names of potential consultants in the specific research area can be obtained at good technical libraries (especially those of universities), from some state organizations, and from the organizations listed below.

Rural Enterprises, Inc.
1-800-658-2823

Mid Atlantic Technology Applications Center
1-800-257-2725

NASA/Far West Regional Technology
Transfer Center
1-800-642-2872 in California
1-800-872-7477 outside California

Southern Technology Applications Center
1-800-472-6785 in Florida
1-800-225-0308 outside Florida

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH
SOLICITATION NO. DOE/ER-0629

APPENDIX A
DOE USE ONLY

95-I

COVER PAGE

NOTICE FOR HANDLING GRANT APPLICATIONS. "This submission is to be used only for DOE evaluation purposes. All government and non-Government personnel handling this submission shall exercise extreme care to ensure that the information contained herein is not duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate the submission, without the written permission of the offeror (except that if a grant is awarded on the basis of this submission, the terms of the grant shall control disclosure and use). This is a Government notice, and shall not by itself be construed to impose any liability upon the Government or Government personnel for any disclosure or use of data contained in this submission."

Topic No. (1-44)

Subtopic (a-d)

AMOUNT REQUESTED:

\$ _____
(Not to exceed \$75,000.)

PROJECT TITLE: _____

FIRM NAME: _____

MAILING ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

(Please provide extended zip code.)

ANSWER
Y (YES) OR N (NO)

CERTIFICATIONS AND QUESTIONS

- ☐ The above applicant organization certifies that it is a small business and meets the definition stated in Section 2.3.
- ☐ A minimum of two-thirds of the funded research or analytical effort will be performed by the applicant organization (see Section 5.5).
- ☐ The applicant small business will comply with the provisions regarding: (1) lobbying, (2) debarment, suspension, and other responsibility matters, and (3) drug-free workplace requirements. (See Appendix E and Appendix F.) Inability to certify to any or all statements requires explanation.
- ☐ The applicant small business has provided the necessary information requested in Section 3.4.4 if it has received more than 15 Phase II SBIR awards in the preceding five fiscal years.
- ☐ The applicant small business has sent or plans to send this application or a similar one to another Federal agency. If "yes", the application includes the required information requested in Section 3.4.2.j.
- ☐ If the proposed project does not result in an award, the applicant organization permits the government to disclose the title and technical abstract of the application, and the name, address, and telephone number of the business official to any inquiring parties.

Principal Investigator (See Requirements in Sec. 1.5)

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

Title: _____

Telephone No. _____

Signature _____ Date: _____
of Principal Investigator

Corporate/Business Certifying Official

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

Title: _____

Telephone No. _____

Signature _____ Date: _____
of Corporate/Business Certifying Official

PROPRIETARY NOTICE (IF APPLICABLE, SEE SECTION 5.4)

For any purpose other than to evaluate this submission, these data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a funding agreement is awarded to this applicant as a result of or in connection with the submission of these data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data in this submission subject to this restriction are contained on pages:

INSTRUCTIONS FOR COMPLETING APPENDIX A

1. **Topic Number**—Provide the appropriate numerical designator of the technical topic (one of the 44 listed in Appendix H) to which you are submitting your grant application.
2. **Subtopic**—Provide the appropriate alphabetical character designating the subtopic, within the technical topic, to which you are submitting your grant application.
3. **Amount**—Must not exceed \$75,000. Grant applications requesting more than \$75,000 will be **declined without further review**.
4. **Project Title**—Should reflect the substance of the project and must be limited to 120 characters and spaces. Do not use the solicitation's topic or subtopic title.
5. **Firm Name**—Enter the name of the company or individual submitting the grant application. If a joint venture, enter the name of the company chosen to negotiate and receive the grant. If the name exceeds the space provided, please abbreviate it.
6. **Mailing Address**—Enter mailing address.
7. **State**—Enter two-letter state abbreviation.
8. **Zip Code**—Enter nine-digit code.
9. **Certifications and Questions**—Enter Y for yes and N for no in response to each of the statements or questions on the cover page.
10. **Endorsements**—Must be completed and signed by both the Principal Investigator and the Corporate/Business Official empowered to make contractual commitment on behalf of the firm. Both entries must be completed and signed even if the functions of the Principal Investigator and the Corporate/Business Official are performed by the same individual. Designate one copy of the grant application as the original and have original signatures appear on the cover page (Appendix A) and the budget summary (Appendix D) of that copy.
11. **Proprietary Notice (bottom of cover page)**—Should be completed, if applicable.

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
PHASE I - FY 1995-I
PROJECT SUMMARY

APPENDIX B
DOE USE ONLY

95-I

Topic No. (1-44)

Subtopic (a-d)

FIRM NAME, ADDRESS, TELEPHONE NUMBER:

TITLE OF PROJECT:

NAME AND TITLE OF PRINCIPAL INVESTIGATOR:

TECHNICAL ABSTRACT (Limit to space provided.):

KEY WORDS:

ANTICIPATED RESULTS/POTENTIAL COMMERCIAL APPLICATIONS as described by the applicant. (Limit to space provided).

INSTRUCTIONS FOR COMPLETING APPENDIX B

1. **Name, Address, and Telephone Number of Applicant**—Enter the firm name, the mailing address, and the telephone number as entered on the grant application cover page, Appendix A.
2. **Title of Project**—Enter the same title as entered on the grant application cover page, Appendix A.
3. **Name and Title of Principal Investigator**—Enter the same name and title as shown on the grant application cover page, Appendix A.
4. **Technical Abstract**—Provide a summary of your proposed project. It should be a concise statement of the proposed effort for Phase I, limited to the space provided.
5. **Key Words**—Provide key words descriptive of the project and useful in identifying the subject matter of the technology, research thrust, or potential uses of the proposed effort.
6. **Anticipated Results/Potential Commercial Applications**—Summarize the results and commercial applications that can be anticipated if the project is carried over into Phase II and beyond. Limit to the space provided.

SAMPLE PROJECT DESCRIPTION

1. Project Objective

The applicant shall investigate the electrocatalytic production of styrene from ethylbenzene in solid electrolyte fuel cells. The effort is directed toward defining optimal operating conditions for achieving high yields of styrene with simultaneous electric energy generation.

2. Project Description

The work to be performed consists of the following tasks:

- 2.1 Construction of tubular zirconia fuel cells with a platinum cathode and an iron oxide or platinum anode. Both anode materials are quite promising and a decision between the two will be made after preliminary runs.
- 2.2 Measurement of the styrene cell activity and yields as a function of velocity, temperature, and inlet concentration of ethylbenzene and external resistive load.
- 2.3 Measurement of the cell electric power output and overpotential as a function of the operating parameters described in 2.2.
- 2.4 Preliminary engineering and economic analysis according to the results of 2.2 and 2.3.
- 2.5 Final Report Preparation.

3. Performance Schedule

Task 2.1 completed two months after start of work.

Task 2.2 and 2.3 completed four months after start of work.

Task 2.4 completed five months after start of work.

Task 2.5 completed six months after start of work.

4. Reporting Requirement

The applicant shall provide a Final Report containing the data from the experiments performed according to Tasks 2.2 and 2.3 along with analyses and conclusions based on these data.

U.S. DEPARTMENT OF ENERGY
**SMALL BUSINESS INNOVATION RESEARCH (SBIR)
GRANT APPLICATION BUDGET**
(Please Print or Type)

ORGANIZATION:					
A. PERSONNEL (Employees) NAME	ROLE IN PROJECT Principal Investigator	EST. HOURS	HOURLY RATE	FRINGE BENEFITS	TOTAL COST
B. CONSULTANTS NAME	ROLE IN PROJECT	EST. HOURS	HOURLY RATE		
C. LEASED EQUIPMENT (Specify Time and Rate, or Other Basis) ITEM					
D. PURCHASED EQUIPMENT ITEM					AMOUNT
E. TRAVEL					
F. OTHER DIRECT COSTS 1. Materials and Supplies..... 2. Publication Costs..... 3. Testing Services (Including work at Government Installations)..... 4. Computer Services..... 5. Subcontracts..... 6. Other..... TOTAL OTHER DIRECT COSTS.....					
G. TOTAL DIRECT COSTS (A. through F.)					
H. INDIRECT COSTS (Specify Rate and Base) TOTAL INDIRECT COSTS					
I. TOTAL COSTS (G. plus H.)					
J. FEE OR PROFIT					
K. APPLICANT'S COST SHARING (If Any)					
L. TOTAL AMOUNT OF THIS REQUEST (Item I. plus J. minus K.)					
M. Has any executive agency of the United States Government performed any review of your accounts or records in connection with any other grant or contract within the past year? ☐ Yes ☐ No. If Yes, give name and address of reviewing office and official:					
N. BUSINESS OFFICIAL — TYPED NAME AND SIGNATURE					DATE:

INSTRUCTIONS FOR SBIR GRANT APPLICATION BUDGET

1. General

- a. Each grant application must contain a completed and signed budget form.
- b. If the information requested does not fit in the spaces provided, use an additional page and give it the heading "Budget Explanation Page".

2. Budget Line Items

The following is a brief outline of the information required:

Lines A and B, Labor: List the key personnel and consultants by name and function or role in the project. Other direct personnel need not be named, but their role, such as "technician", and total hours should be entered. Support personnel should be included in line H. Fringe benefits should be calculated to cover all direct labor overhead costs, including Social Security, pensions, and insurance, and entered as a total dollar amount. You can use an established labor overhead rate if you have one.

Lines C and D, Equipment: Items costing over \$500 and exceeding 2 years of useful life should be listed. Lesser items can be shown in line F.1.

Line E, Travel: Itemize by destination, type, period, and cost for both staff and consultants.

Line F, Other Direct Costs: Entries exceeding \$500, and other items requiring an explanation, should be detailed on a "Budget Explanation Page". If a subcontract includes costs for equipment, materials, or supplies, these should also be noted on a "Budget Explanation Page." (See Section 3.4.3.)

Line G, Total Direct Costs: Enter the sum of lines A. through F.

Line H, Indirect Costs: If you have an established G&A (General and Administrative) rate you may cite it. Otherwise you should include all indirect costs such as facilities, shared equipment, utilities, property taxes, and support staff for the period of the project.

Line I: Enter the total amount of the proposed project.

Line J: Self-explanatory.

Line K: Enter the amount which the applicant or other private sector or non-SBIR sources are committing to the project. For Phase II, this amount, if any, will be used to evaluate criterion 6b in Section 4.3 of the solicitation.

Line L, Total amount of the request: This amount cannot exceed \$75,000 for Phase I or \$750,000 for Phase II.

Line M, Federal Audit: If DCAA or another Federal agent has audited your accounts in connection with a Federal grant or contract, please enter the information requested, and use the established rates in lines A. and H.

Line N, Business Official: A signature of someone with the authority to commit the company must be given.

OMB Disclosure Statement

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of Information Resources Management Policy, Plans, and Oversight, AD-241.2 — GTN, Paperwork Reduction Project (1910-1400), U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, DC 20585; and to the Office of Management and Budget (OMB), Paperwork Reduction Project (1910-1400), Washington, DC 20503.

CERTIFICATION REGARDING LOBBYING

By signing and submitting this application the organizational applicant certifies to the best of its knowledge and belief, that it and its principals believe that:

- 1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- 2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the organizational applicant shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying" in accordance with its instructions.
- 3) The organizational applicant shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

**CERTIFICATION REGARDING DEBARMENT, SUSPENSION, AND
OTHER RESPONSIBILITY MATTERS - PRIMARY COVERED TRANSACTIONS**

By signing and submitting this application—

- 1) The organizational applicant certifies to the best of its knowledge and belief, that it and its principals:
 - a. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
 - b. Have not within a three-year period preceding this application been convicted or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State anti-trust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;
 - c. Are not presently indicted or otherwise criminally or civilly charged by a government entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph 1.b. of this certification; and
 - d. Have not within a three-year period preceding this application had one or more public transactions (Federal, State, or local) terminated for cause or default.
2. Where the Prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this application. (The explanatory attachment will not be counted in the 25-page limitation.)

CERTIFICATION REGARDING DRUG-FREE WORKPLACE REQUIREMENTS

This certification is required by the Drug-Free Workplace Act of 1988 (Pub. L. 100-690, Title V, Subtitle D) and is implemented through additions to the Debarment and Suspension regulations, published in the *Federal Register* on January 31, 1989.

By signing and submitting this application the **organizational applicant** certifies that it will provide a drug-free workplace by:

- (a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;
- (b) Establishing a drug-free awareness program to inform employees about—
 - (1) the dangers of drug abuse in the workplace;
 - (2) the grantee's policy of maintaining a drug-free workplace;
 - (3) any available drug counseling, rehabilitation, employee assistance programs; and
 - (4) the penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;
- (c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);
- (d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will—
 - (1) abide by the terms of the statement; and
 - (2) notify the employer of any criminal drug statute conviction for a violation occurring in the workplace not later than five days after such conviction;
- (e) Notifying the agency within ten days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction;
- (f) Taking one of the following actions, within 30 days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted—
 - (1) taking appropriate personnel action against such an employee, up to and including termination; or
 - (2) requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;
- (g) Making a good faith effort to maintain a drug-free workplace through implementation of paragraphs (a), (b), (c), (d), (e), and (f).

An **applicant who is an individual** certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant.

CHECKLIST

Applicant:

Project:

Please complete the checklist and paper clip (one copy only) to the cover sheet of the original (signed) copy of the grant application.

DOES THE APPLICATION SATISFY THE FOLLOWING REQUIREMENTS:

	Yes	No
✓ One, and only one, topic from Appendix I identified on the cover page.	☐	☐
✓ One, and only one, subtopic from Appendix I identified on the cover page.	☐	☐
✓ Both endorsements on cover page completed and signed.	☐	☐
✓ All certifications and questions on cover page marked <u>YES</u> or <u>NO</u> .	☐	☐
✓ Amount requested not in excess of \$75,000; if total of lines I and J in Appendix D exceeds \$75,000, the application must explain who will contribute the difference.	☐	☐
✓ Abstract contains no proprietary information and does not exceed space provided on the Project Summary Page (Appendix B).	☐	☐
✓ Main text (technical content) is included as requested in Section 3.4.2.	☐	☐
✓ Application, including all enclosures, not more than 25 pages. However, Appendix G and the Documentation of Multiple Phase II Awards (Section 3.4.4) will not be included in the 25-page count.	☐	☐
✓ No pages other than 8 1/2" x 11".	☐	☐
✓ No type smaller than (1) 12 point for proportionally spaced fonts and (2) 12 characters per inch (elite) for non-proportionally spaced fonts (except as legends on reduced drawings, but not tables).	☐	☐
✓ A minimum of 2/3 of the research or analytical effort will be performed by the small business. (See Sections 3.4.3 and 5.5).	☐	☐

ATTENTION: GRANT APPLICATIONS NOT MEETING ALL OF THE ABOVE REQUIREMENTS WILL BE DECLINED WITHOUT FURTHER ACTION.

STATISTICAL INFORMATION

	Yes	No
The proposing firm certifies that it is a socially and economically disadvantaged small business concern. (See Section 2.4.)	☐	☐
The proposing firm certifies that it is a woman-owned organization small business concern. (See Section 2.5.)	☐	☐

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TECHNICAL TOPIC DESCRIPTION

The technical topic descriptions for this solicitation are given below. The text in the first section of each topic gives general and background information for the topic. Within a topic, where there are subtopics, a grant application must respond specifically to the description given in one subtopic and not just to the general description at the beginning of the topic; it must comply, however, with any restrictions and exclusions contained within that general description.

1. NOVEL MATERIALS FOR SUSTAINABLE ENERGY DEVELOPMENT

This topic provides small businesses with an opportunity to propose substantially novel research in advanced materials for use in two areas that could directly influence the Nation's energy resources and utilization. DOE is interested in novel, energy-related ideas that are substantiated by proven scientific principles, and that indicate clearly that the idea has a reasonable chance of success either in demonstrating the validity of a pre-commercialization technology or in succeeding as a commercially viable commodity or process. The idea must be environmentally acceptable. **Before submitting a grant application under this topic, applicants should consider other technical topic descriptions, such as those under *Chemical Sciences Research, Improved Materials for the Pulp and Paper Industry, Measurement and Characterization of Materials in Civilian Nuclear Reactors, Improved Technology for Obtaining Recyclable Materials from Municipal Solid Waste, High Temperature Superconductivity for Energy Applications, and Lightweight Composite Materials for Automotive Structures*, to assure that the application is submitted to the most appropriate technical topic.**

Grant applications are invited only in the following subtopics:

a. Novel Materials for Direct Energy Applications or for Replacement Products or Components—Materials research is rapidly producing new materials, such as sophisticated thermal management materials, catalysts, or membrane technology for direct methanol fuel cells, as well as new approaches to synthesizing and processing materials, and designing single or composite materials with characteristics tailored to specific energy-related applications. Such methods open up an arena for innovation and discovery for new energy-efficient synthesis and processing and for novel ideas to fabricate new or substitute products or components for energy applications such as for energy storage or conversion. Some novel materials can be derived from renewable resources. Reference 3 describes a broad survey of needs and opportunities for innovation, including materials directly applied to energy generation, storage, conversion, delivery, and use. This subtopic focuses only on materials for direct energy-related applications.

Grant applications are solicited for novel approaches to create: (1) materials or surfaces applied to specific replacement parts or components that demonstrably and significantly improve energy efficiencies or reduce environmental impacts in the generation, conversion, delivery, and use of energy; and (2) synthesis, processing, or fabrication methods for the production of such energy-related materials or components for which the method would increase the energy efficiencies significantly or demonstrably reduce environmental impacts. Grant applications should explicitly focus on the design or processing of materials or components for a particular application to replace a specified process, product, or component that presents a limiting factor in current processes or technology. For example, new thermoelectric materials could be fabricated in multilayered arrangements for significantly enhanced figures of merit and applied to a cooling component or unit; or superplastic forming could drastically reduce energy and time costs of a specific fabrication method of energy-related parts or components. Grant applications that fall within the description of topic 6, High Temperature Superconductivity for Energy

Please note: (1) The technical topics are to be interpreted literally; DOE personnel are not permitted to elaborate on the language in the technical topics. (2) The award selection process is extremely competitive. Last year, only 1 out of 11 grant applications was awarded. Only those applications with the highest scientific/technical quality will be competitive.

Applications, should be submitted under that topic. Grant applications involving high temperature superconductors in other ways should be considered for submission under this subtopic.

Applications that are oriented toward research that would yield small or incremental improvements will not be considered under this subtopic, regardless of their inherent technical or scientific merit. Grant applications must clearly define and document, where possible: (a) the energy advantages; (b) the novelty as well as realization potential, and (c) a favorable outlook for economic benefit by the year 2000. The grant application must be based on normally-accepted laws of nature or sound engineering principles.

b. Designing Novel Nanoscale Electronics Capability

Grant applications for novel research are sought on advances in electronic signal processing, based on electronic properties of nanoscale size electronic materials, such as clusters, quantum dots, or single molecules. The objective is to develop new approaches for electronic switches, connections, transmission pathways, and other signal processing aspects for further miniaturization of electronics beyond the current microchip scale. Approaches of interest include application of new knowledge in nanocrystalline solids; monolayer films (e.g., self-assembled monolayers); and organic, organometallic, molecular, and bio-based processes for designing electronic signal processing elements or components.

Grant applications are sought to discover and develop molecule-based electronic mechanisms for efficiently processing ultra-low energy signals on a dimensional scale in which the bulk material properties, on which semiconductor technology is based, are no longer valid. Grant applications are also invited to create new electronics technology, using scientific advances in the following areas: electronic polymers, biosensors, quantum dots, fabrication of nanostructures, nanometer molecular lithography, and ultrathin films. Also of interest is the design of new signal processing devices that assemble elemental nanoscale electronic processes. One issue in this subject area is the need to develop mechanisms to interconnect possible new molecular switches or other nanoscale electronic discoveries. Hence, hybrid technologies that integrate such novel electronic device materials with more traditional electronic systems are also sought.

Miniaturization of traditional semiconductor technology and computer modeling are excluded from this subtopic. The novelty must be in the generation or application of new electronic materials, components, or mechanisms, at nanoscale or molecular dimensions, for the ultimate purpose of designing new communications and signal processing. The results at the end of Phase II should indicate a novel molecular or nanoscale electronic signal processing mechanism. Grant applications submitted to this subtopic must present a novel idea for an electronic component or a novel method of integrating newly-developed components into a larger circuit system. Projects are not expected to yield a marketable product in the near term. However, a reasonable plan for developing a marketable product or other follow-on funding should be included in the Phase II grant application.

Bibliography

1. Carter, F. L., et al, eds., Molecular Electronic Devices, Proceedings of the 3rd International Symposium on Molecular Electronic Devices, Arlington, VA, October 6-8, 1986, New York: Elsevier Science Publishers, 1988 (ISBN 0-444-70547-3).*
2. Horton, L. L., ed., Innovation in Materials Processing and Manufacture: Exploratory Concepts for Energy Applications, Oak Ridge, TN, March 11-12, 1993, Oak Ridge National Laboratory, 1993 (NTIS Order No. DE93017674).**
3. O'Neil, M. P., et al, "Picosecond Optical Switching Based on Biphotonic Excitation of an Electron Donor-Acceptor-Donor Molecule," Science, 257(5066):63-65, July 3, 1993 (ISSN 0036-8075).
4. Waldeck, D. H. and D. N. Beratan, "Molecular Electronics - Observation of Molecular Rectification," Science, 261(5121):576-577, July 30, 1993 (ISSN 0036-8075).
5. "Advanced Energy Projects FY 1994 Research Summaries," U.S. Department of Energy, September 1994, Report No. DOE/ER-0617.***

* Available from Elsevier Science Publishing Co., Inc. P.O. Box 882, Madison Square, New York, NY 10159

** See Section 7.1

*** Available from U.S. Department of Energy, Division of Advanced Energy Projects, ER-16, Washington, D.C. 20585

2. ADVANCED INSTRUMENTATION TO EXPLOIT NEUTRON AND PHOTON SOURCES

DOE supports a number of large-scale user facilities that provide intense beams of neutrons or photons. Almost every experiment could use a greater flux of neutrons or photons to carry out experiments more quickly and with greater resolution in energy or momentum in order to make measurements more precisely. The development of improved instrumentation, such as monochromators, high heat load mirrors, microfocussing optics, more efficient x-ray and neutron detectors, and beam guide tubes, will multiply the effective strength of every source in a most cost-effective manner. Grant applications are invited only in the following subtopics:

a. High Heat Load Optical Elements—Grant applications are sought for the development of mirrors to focus and crystals to monochromatize the very intense x-ray beams, generated by new synchrotron sources, that can maintain their shape (focus) under conditions of extreme power loads of up to 150 watts per mm². These x-ray beams are very small (approximately 0.2 mm²) and have an extremely high energy density. The following should be considered: the reflectivity and thermal conductivity of the surface material (e.g., silicon carbide, silicon crystals, isotopically pure diamond, or multilayers), the means of cooling the mirror or crystal surface (e.g., liquid gallium or liquid nitrogen), whether to use laminar flow or turbulent flow in cooling, and the geometry of the optical systems. Other factors to consider are the mechanical and thermal stability: vibrations and thermal gradients should be minimized.

b. Microfocussing Optics for Neutrons and X-Rays—Grant applications are sought for the development of improved microfocussing optics for both neutron and x-ray beams. Recent experiments have shown that it is possible to increase substantially the focussing of neutron and x-ray beams using tapered glass tubes so that the beam of neutrons or x-rays does not exceed the critical angle. This has been done with glass pipettes drawn out under heat to create a very narrow aperture that can be directed at an experimental sample. Such devices would be extremely useful in the analysis of very small parts of a sample which could be scanned across the beam. For other

applications, there is a need to make these tapered glass tubes in a reproducible way so that when several of them are bundled together, there is a uniform output from each tube. This is especially important in imaging. There is also the possibility of using Ni⁵⁸ on the interior of such glass tubes for neutron microfocussing applications.

c. High Count Rate Detectors—Grant applications are sought for the development of improved high-efficiency neutron and x-ray detectors and of the electronic components that process the raw signals. It is very cost-effective to increase the rate at which data can be obtained through the development of detectors that are more efficient. The limiting factors in handling such large count rates often appear to be in the electronics that processes the raw signals. Improvements in the state-of-the-art in this area might include, for example: parallel processing of detector signals, even to the extent of each pixel in a two-dimensional detector having its own memory; materials which respond to neutrons or x-rays with an improved fast recovery; and two-dimensional detectors with increased spatial resolution.

Bibliography

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2. Freund, A. K. and D. M. Mills, "Summary of Satellite Workshop on Thermal Problems of Synchrotron Radiation Optics," Review of Scientific Instruments, V63:N1Pt.11B(1623-1624), January 1992 (ISSN 0034-6748).
3. Gruner, Sol M., "Time-Resolved X-Ray Diffraction of Biological Materials," Science, V238:N4825(305-312) (ISSN 0036-8075).
4. Hyncek, J., "Virtual Phase Technology: A New Approach to Fabrication of Large-Area CCDs (Imager Applications)," IEEE Transactions on Electron Devices, V38:N5(483-489), May 1991 (ISSN 0018-9383).*
5. Lander, G. H. and V. J. Emery, eds., *Scientific Opportunities with Advanced Facilities for Neutron Scattering Workshop, Shelter Island, NY, October 23, 1984*, 170-186, CONF-8410256 (NTIS Order No. DE85012113).**
6. Macrander, A. T., et al, "High Heat Load Performance of an Inclined-Crystal Monochromator with Liquid Gallium Cooling on the CHESS-ANL Undulator," Nuclear Instruments and Methods in Physics Research, (Section A-Accelerators, Spectrometers, Detectors and

Associated Equipment) *Seventh National Conference on Synchrotron Radiation Instrumentation*, Baton Rouge, LA, October 28-31, 1991, VA319:N1-3(188-196) (ISSN 0168-9002).

7. McBee, M. R., et al, ed., *Proceedings of the Oak Ridge National Laboratory/Brookhaven National Laboratory Workshop on Neutron Scattering Instrumentation at High Flux Reactors*, Oak Ridge, TN, June 5-7, 1989, CONF-8906311 (NTIS Order No. DE91001003).**
8. McGrath, R. D., "Radiation Effects in a Virtual Phase CCD Imager," *IEEE Transactions on Nuclear Science*, V28:N6(4028-4032), December 1981, (ISSN 0018-9499).
9. "Neutron Sources for America's Future: Report of the Basic Energy Sciences Advisory Committee Panel on Neutron Sources," January, 1993, Report No. DOE/ER-0576P (NTIS Order No. DE93007386).**

* Available from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 (Telephone 800-678-4333)

** See Section 7.1

3. CERAMIC FIBERS AND FIBER COATINGS FOR HIGH TEMPERATURE APPLICATIONS

This topic provides small businesses with an opportunity to carry out substantially novel research in synthesis and processing of fibers for advanced ceramic composites. Fiber reinforced ceramic matrix composite materials offer desirable properties for high temperature environments including high strength, corrosion resistance, and low density. Their use in engine components such as heat exchangers, combustion liners, turbine tip shrouds, and other structural elements could potentially lead to reduced energy usage and cost, and lower nitrogen oxide and carbon dioxide emissions. Limitations in the current technology include high cost, thermal instability, and fabrication complexity of the fibers used as reinforcing agents. A grant application should be submitted for consideration under this topic only if the research represents significant advances in materials or in processing that will lead ultimately to higher quality fibers than those currently available. Grant applications limited to a simple incremental improvement will be declined. Grant applications for a study that would yield results limited to a single commercial material will be declined. **Grant applications are invited only in the following subtopics:**

a. Fiber Synthesis and Processing—Grant applications are invited on new synthesis and processing schemes for the production of oxide or silicon carbide ceramic fibers for advanced continuous ceramic matrix composites that will have the properties of high strength, thermal stability, oxidation resistance, and creep resistance. Especially needed are fabrication routes that would lead to reduced cost (less than \$200/lb) and would deliver reproducible and reliable fiber products in quantities suitable for new applications.

b. Fiber Coating Development—Grant applications are invited on new synthesis and processing schemes for fiber coatings that will provide good debonding behavior and low sliding resistance to the fiber in a ceramic matrix composite. The coating should also prevent strength degradation of the fiber. The issues of fiber reliability, reproducibility, and cost-effectiveness are germane to the development of processing routes, and must be discussed in the grant application.

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4. CHEMICAL SCIENCES RESEARCH

Research in the chemical sciences can contribute to the advancement of virtually all sectors of the economy through new developments important to areas of energy generation, conversion, and storage, and to environmental remediation and waste minimization. This topic singles out and is limited to four specific subtopics in this broad field: analytical sensors, membrane separations, catalytic conversions, and advanced battery research and development. **Before submitting a grant application to this topic, applicants should consider other technical topic descriptions, such as those under topic number 1, *Novel Materials for Sustainable Energy Development*; and topic number 28, *Characterization, Monitoring, and Sensor Technologies for Radioactive and Hazardous Waste*, to assure that the application is submitted to the most appropriate technical topic. Grant applications are invited only in the following subtopics:**

a. Advanced Sensors for Analytical Chemical Measurements—Determination of chemical composition is being done increasingly on line, in real time, without removal of samples of a material for subsequent analysis. The components of interest may be unstable, or immediate feedback on changes in composition may be required to keep manufacturing or waste streams under control. Progress has been made in developing a variety of optical and electrochemical sensing devices for analytical purposes. However, these allow measurement of only a small number of chemical species and often are limited to a restricted range of operating conditions. **In the context of this subtopic, a sensor is defined as a miniature, in-situ probe which, by itself, indicates the presence and/or concentration of one or more chemical species. Specifically, it does not include an off-line spectroscopic device which, by itself, is used to indicate the presence of the chemical species. Additionally, fiber-optic materials by themselves are not considered sensors and thus are excluded.**

Grant applications are sought on advanced sensors that will provide one or more of the following capabilities: highly localized sensing (micron-size scale, if possible), operation in extreme temperature and/or pressure environments, and rapid response. In

all of the above cases, the interest is in the sensing or analysis of chemical species. While such devices will undoubtedly have applications in energy technologies, the proposed research should not be targeted to a specific application, but should seek understanding of principles of operation and the broadest possible range of operating capabilities. The interest is in novel types of sensors, and not in research leading to incremental improvements in existing devices.

b. New Materials for Enhanced Selectivity and Efficiency in Membrane Separations—Membranes currently in use incorporate a variety of substances for separation of raw materials or waste streams into their chemical components. Grant applications are sought on substances that employ novel concepts for obtaining greater selectivity and/or higher fluxes than can presently be achieved for the isolation of valuable components from complex mixtures. This subtopic is limited to new chemical compositions and/or new macro- or micro-structures for membranes. Plans for testing the new materials for selectivity and efficiency should be incorporated into the grant application. Grant applications should not emphasize a specific separation, but should describe fundamental research into the relationship between the novel chemical or physical structures and their separation properties, leading to potential applications in the separations field, possibly in Phases II or III.

c. Catalytic Reduction of Nitrogen Oxides under Oxidizing Conditions—While catalysts have contributed substantially to the reduction of pollutants from automobile exhaust, existing catalyst technology will not meet future environmental requirements. A persistent problem in the use of the internal combustion engine is the formation of nitrogen oxides from nitrogen in the air. Catalytic reduction for the removal of oxides of nitrogen, as opposed to redesign of the engine to prevent their formation, is a desirable strategy.

Grant applications are sought for the characterization of heterogeneous redox catalytic processes at temperatures relevant to the problem of nitrogen oxide emissions from internal combustion engines. Applications should clearly demonstrate the feasibility and means of achieving NO_x reduction and should result in an improved understanding of the relationship between the adsorbate reactions and any oxidation and reduction reactions of the surface.

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d. Advanced Battery Research and Development—Batteries are a mainstay of contemporary electronic and information industries. The performance of batteries is often the limiting factor that hinders the development of improved portable devices such as cellular telephones, laptop computers, hand-held tools, and other consumer products. Stringent environmental requirements impose restrictions on the use of battery materials and components deemed to be harmful to the environment or human well-being.

Grant applications are invited for research related to the development of new or significantly improved battery technology for a wide range of applications, with particular emphasis on improvement in battery size, weight, life, and recharge cycles for non-automotive applications. Batteries for transportation and fuel cells are specifically excluded from consideration. Appropriate topics for research include: electrode research including investigations of graphitized and composite electrodes for lithium ion cells, metal hydrides, bifunctional air electrodes, composite electrode structures, failure and degradation of active electrode materials, and thin-film electrodes. Electrolyte studies could include ionic conducting polymers and room temperature molten salt. Consideration will also be given to research on the problems of overcharge/overdischarge, power capability, and cyclability of anodes in lithium cells, oxidative degradation of electrolytes by high voltage cathodes, and highly conductive thin-film ceramic electrodes. Appropriate topics in the area of characterization and methodologies include problems of electrode morphology, corrosion, separator/electrolyte stability, and stable microelectrodes. Other topics of interest include novel battery systems, separators, and transport properties of electrode and electrolyte materials. The interest is in novel research and technology development, and not in research leading to incremental improvements in existing devices.

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*** Available from Elsevier Science Publishing Co., Inc. P.O. Box 882, Madison Square, New York, NY 10159

**** Available from the U.S. Department of Energy, Office of Basic Energy Sciences, Chemical Sciences Division, ER-14, Washington, D.C. 20585

5. INFORMATION INFRASTRUCTURE FOR THE NATIONAL INFORMATION INITIATIVE

Historically, communication and computing technology, i.e., leading edge information technology, has been a powerful instrument of change in our society. The civilian National Information Infrastructure (NII) program will help transform the Department of Energy and present a new and more open DOE interface to the public. It will create new collaborative environments by integrating the Department's diverse components, academia, and industrial partners. It can also provide new and innovative capabilities for performing the Department's technical missions. Through the development of information infrastructure, DOE will transform itself, especially with respect to its ability to operate in an open, collaborative, and efficient fashion, by using leading edge digital communication and computation to serve the public interest and accomplish its missions. For the development of this new information infrastructure, **grant applications are invited only in the following subtopics:**

a. Wide Area Network (WAN) Based Hierarchical, Distributed Database and Data Storage Technologies and Techniques—The advances in high performance computing and communications, combined with the enhanced sophistication of both Grand and National Challenge applications, have accelerated the need for distributed, fast, interoperable, and scaleable technologies and techniques for storing, manipulating, and querying large data sets. Grant applications are sought for the development and implementation of technologies and techniques for managing large datasets using WAN based storage and database tools and protocols. Applicants are expected to demonstrate familiarity with the current state of the art in these areas.

b. Wide Area Network (WAN) Based Collaboration Technology and Application Development—The need to efficiently share information and unique facilities remotely, in addition to the growing requirement for telepresence and telecommuting capabilities, demands enhanced collaborative technologies and techniques such as packetized video/audio streams and multimedia conferencing, shared whiteboards, and concurrent editing/markup capabilities.

Grant applications are sought for the development and implementation of WAN based technologies and techniques for providing real-time and interactive voice, video, and data exchange across the Internet and other large distributed, heterogeneous networks. Applicants are expected to demonstrate familiarity with the current state of the art in these areas.

c. Wide Area Network (WAN) Authentication and Security—The growth of networking, as evidenced by the increased useage of the Internet and the attention devoted to the NII, will continue at its current rapid pace. The components of large, interconnected networks (local networks, hosts, computers, information, data, applications and users) all require some level of security. As the number of individuals, businesses, schools, and other entities using networks grows, so does the need for more sophisticated authentication and security tools. Grant applications are sought for the development and implementation of WAN based security tools, systems, metrics, and protocols in the areas of application and user interfaces, information search and retrieval, and data storage and transmission that can operate across the Internet and other large distributed, heterogeneous networks. Applicants are expected to demonstrate familiarity with the current state of the art in these areas.

d. Wide Area and Distributed Network Based Technologies to Support Energy Demand and Supply Management—The electric and power utilities are using and deploying telecommunications to support their principal business of managing and providing energy to their customers. However, the evolving nature of the corporate utility business demands the development of novel distributed network technologies to enhance the existing capabilities of utilities in the area of real-time energy demand and supply management. The technologies and infrastructures that support energy utility consumers and providers may be leveraged to accommodate other utilities and service providers. Grant applications are sought for the development and implementation of both wide area based and distributed network tools and protocols that enable energy utilities to improve efficiency, conservation, billing, and customer service. Applicants are expected to demonstrate familiarity with the current state of the art in these areas, especially with regard to how the consumer interfaces and connects to both the utility and the NII.

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6. HIGH TEMPERATURE SUPERCONDUCTIVITY FOR ENERGY APPLICATIONS

High temperature superconductivity (HTS) for energy applications is classed as a critical technology by the 1991 National Critical Technologies Panel. In addition, the Energy Policy Act of 1992 has assigned DOE the responsibility for the development of HTS electric power equipment technologies. Research and development on this topic therefore supports national and DOE goals.

HTS was discovered recently, in the late 1980s, and major barriers still remain to its practical use. For example, while HTS wires are now available that satisfy basic application performance needs, costs must be lowered and performance raised before use becomes widespread. For example, HTS wires must be economically manufactured in kilometer lengths, with the ability to carry large currents in magnetic fields greater than 2 Tesla. This would allow the manufacture of useful components such as motor coils and transmission cables. These components can then enable a new era of advanced electric power equipment that can lower the cost and pollution associated with electricity generation, delivery, and use.

A world-wide market of several billion dollars per year for superconductivity products has been predicted for the year 2000, with wire-using products comprising the largest market share. Continued innovation is needed to overcome the existing technical and economic barriers to exploiting this tremendous commercial potential. Incremental advances to current HTS technology will not be considered. **Grant applications are invited only in the following subtopics:**

a. HTS Wire and Coil Manufacture—Grant applications are sought for the development of innovative processes and process quality management technologies for manufacturing HTS wires that will (1) lead to manufacturing costs comparable to that of low temperature superconducting wire (presently around \$30/kAmp-meter for Nb₃Sn composite conductors), or (2) improve HTS wire performance in areas such as: uniformity of long wires, current carrying ability (above 100 A/sq mm), operating temperature ability, operating magnetic field ability, flexibility, and durability. Grant applications are also sought for the development of innovative HTS coil manufacturing processes and process quality management technologies that will lower costs or improve HTS coil performance in areas such as: durability, operating magnetic field ability, and efficient alternating current operation.

b. HTS Electrical Device Development—Grant applications are sought for development of HTS electrical devices, with presently achievable HTS performance, that can improve the efficiency and economics of electrical generation, delivery, or use. These may be innovative designs for familiar electrical devices such as generators and motors, or proposed new inventions which are enabled by HTS. Grant

applications for device-associated coil protection measures are also sought.

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7. IMPROVED MATERIALS FOR THE PULP AND PAPER INDUSTRY

DOE is supporting research on materials technologies that can have significant impact on increasing energy efficiency, productivity, and environmental compliance in the pulp and paper industry. In pulp and paper processes, nearly every form of wear may be encountered, including abrasive and erosive wear, wear by slurries, cavitation wear (in pumps), sliding wear, and impact wear. Corrosion issues are also encountered in the processing of wood fiber to make pulp and pulp to make paper, and in the management of waste streams at the source. Corrosion problems will probably increase as facilities move toward the "closed mill" cycle concept.

The focus of this topic is the development of improved or new materials applicable to the unit operation processes involving pulping and bleaching, paper-making, and chemical recovery. Consideration will be given to suitability for potential applications, including improved materials properties and performance, cost-effectiveness, and the ability to manufacture parts of requisite sizes and shapes. **Grant applications are invited only in the following subtopics:**

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a. Materials for Improved Pulping and Bleaching—The objective of the pulping process is to separate cellulose fibers from the other components of wood. The processes include mechanical grinding, mechanical refiner pulping, thermomechanical pulping, and chemical pulping. Improved materials needs vary with the type of pulping addressed. Mechanical or refiner pulping includes wear from abrasion and erosion of components, whereas chemical pulping can result in exposure of materials to corrosive and erosive wear from solutions/slurries. For mechanical grinding, wear resistance is the main property in need of improvement. Grant applications are solicited for materials with at least 50% increased wear resistance for use as the rotating grindstones used to reduce the size of logs for further processing.

For mechanical refiner pulping, pulp quality and process efficiency are affected by corrosion associated primarily with presteaming, by condensates containing sulfur-bearing acids and chlorides, and by wear of refiner plates. Rounding of refiner plate bar edges results in lessening the refining capability of the system. Pitting of the bars by cavitation erosion influences a materials response in refiners. Dashing of plates, which occasionally come in contact due to minimal clearances, is also a significant issue. Grant applications are solicited for lighter, stronger refiner materials suitable for high speed operation, and for surface treatment or new materials to improve wear resistance, cavitation resistance, and toughness of refiner plates.

There are various methods for chemical pulping; the predominant process in the U. S. is the Kraft process, which includes the digester, the evaporator, and the chemical recovery system. The design of the digester can cause significant changes in materials behavior and requirements. Corrosion and erosion of metallic components, including pipes, valves, and pumps, by sodium/sulfite slurries also occur. Grant applications are solicited for development of materials to minimize caustic stress corrosion in digesters; preferably, development should be coupled with modeling to optimize design operating parameters.

b. Materials for Improved Papermaking—In the papermaking unit process, pulp fibers in suspension are concentrated to the desired level and routed through the papermaking machine to form a dry paper sheet at the dry end of the machine. Materials problems involve corrosion and erosion/abrasion, as the

solution carrying cellulose fibers still contains some chloride or other oxidant. Grant applications are solicited for materials improvements in papermaking machines, specifically and only for improved metallic alloys for suction rolls and granite rolls, and for improved ceramic coatings for rolls having similar sticking and release characteristics as granite.

c. Materials for Chemical Recovery Systems—Chemical recovery processes vary with the type of pulping process used. In the Kraft process, a boiler is used to incinerate black liquor while providing steam for cogeneration and plant processes. Black liquor gasification is a new process, whereby the black liquor is pyrolyzed and reacted with steam to form fuel gas and inorganic salts. Valuable fuel gases are formed, and inorganic chemicals are recovered in solid form. Materials problems in chemical recovery systems are primarily related to corrosion, especially in the boiler, where high temperatures are involved and black liquor combustion takes place. It is critical that boiler tube materials not leak any water coolant as water reacts with the molten smelt in the boiler. Grant applications are solicited for materials with improved resistance to sulfidation and/or alkali corrosion/erosion for tubes, including materials and inexpensive coatings for enhancement of operational lifetimes at temperatures of about 1500°F.

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*** See Section 7.1

8. ADVANCED DRILLING TECHNOLOGY

Drilling technology has evolved during this century into a complex set of processes for breaking and removing rock to provide access to a target region in the subsurface. The United States has been a leader in worldwide drilling technology; however, to remain competitive, it will be necessary to develop new advanced systems to reduce both drilling time and costs. The National Research Council of the National Academy of Sciences (NAS) recently completed a study of "Advanced Drilling and Excavation Technologies for the Future" which identified promising areas for major technical improvements. The NAS study recommends establishment of a national research and development program that focusses on a smart drilling system. This system will be capable of sensing and optimizing drilling operating parameters as well as evaluating and adapting to formation parameters in order to reach desired targets. Development of a smart drilling system will depend upon major advances in several key elements of the drilling process. Four of these key

elements are described below. Research and development projects in grant applications should be designed to ultimately lead to drilling hardware that could be incorporated into a smart drilling system. **Grant applications are invited only in the following subtopics:**

a. Drill Bit Sensing and Evaluation—Measurements of limited drilling parameters are typically made at the surface during drilling. Current state-of-the-art downhole technology supports measurement of some drilling parameters at the bit-rock interface. Included are rate of penetration, weight on bit, torque, and rotation rate. Grant applications are sought to expand these downhole measurements to include either: (1) sensing bit wear in order to warn of impending failure or other need for replacement, or (2) sensors that measure drilling mud properties at the bit to improve borehole quality and mud conditioning. Downhole sensors should be compatible with existing or advanced techniques for transmitting data to the surface.

b. Formation Properties Sensing and Evaluation—Downhole measurement of formation properties during drilling is an active, expanding field. Significant new advances have been made during the past ten years. Grant applications are sought for the development of improved capabilities to make measurements around and ahead of the bit. At least one of the following three areas must be addressed: (1) fracture detection away from the bit based on electromagnetic, acoustic, or other innovative methods, (2) advanced formation evaluation based on sensor measurements, or (3) high-resolution imaging capabilities.

c. Drill Bit Positioning and Steering—Position and steering systems are commercially available based on gyro, accelerometer, magnetic, and electromagnetic technology. Development of the smart drilling system will require advances in current positioning and steering systems. Grant applications are invited for the development of new sensing systems capable of determining bit position in three-dimensional space within an accuracy of one foot and/or determining bit direction and the resultant forces to optimize steering.

d. Borehole Stabilization—Stabilization of the borehole while drilling is important to prevent loss of drilling fluid or caving of the wellbore wall. Grant applications are invited for new downhole sensing systems that can determine borehole stability during

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drilling. Examples of stability-related parameters include measurements of friction between the drill string and the formation, stress state in the wall rock, and loss of drilling fluid near the bit.

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* Available from The Society of Petroleum Engineers, Richardson, TX 27505 (Telephone 214-952-9393)

9. ADVANCED ENVIRONMENTAL MONITORING TECHNOLOGY

Characterization of subsurface, atmospheric, and oceanic environments is a key element of several DOE research efforts designed to analyze the transport, fate, and human and environmental health effects of energy materials and wastes. This topic concerns innovative technologies to advance environmental monitoring capabilities. Monitoring in this context means long-term measurement of biological and physicochemical properties of natural systems with low-maintenance or autonomous sensors and equipment. Monitoring will be a critical assessment and control activity in designing for sustainable development, as well as for future, pollution-free, zero-discharge, environmentally benign energy systems. Subtopics a and b relate specifically to the monitoring and remediation of the subsurface environment, while subtopics c and d concern environmental monitoring in general.

Grant applications must include bench tests of critical technologies. Critical technologies are those components, materials, equipment, or processes that significantly limit current capabilities in the specific subtopic area. Applications that propose only incremental improvements or enhancements to existing technologies will not be considered. Grant applications in all subtopics must describe in the technical approach or work plan the purpose and benefits of any proposed teaming arrangements with government laboratories or universities. Applications for all subtopics should provide information supporting claims of commercial potential for proposed technologies (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). **Grant applications are invited only in the following subtopics:**

a. Supercritical Fluid Extraction—Supercritical fluids (SCFs) are fluids that are at a state above the critical temperature and critical pressure of that fluid. Several SCFs have desirable physicochemical properties at moderate pressures and temperatures that make them well suited for environmental monitoring and remediation applications. Supercritical carbon dioxide (CO₂), for example, is an environmentally benign solvent that dissolves nonpolar species and can be substituted for solvents in the synthesis of polymers and other organic materials. Addition of small amounts of an entrainer allows polar molecules to dissolve in the supercritical CO₂ as well. Therefore,

supercritical CO₂ can be used in a host of chemical processes, replacing or reducing the amounts of organic solvents used. Supercritical fluid extraction (SFE) (the use of supercritical fluids in an extraction process) can be used to remove inorganic and organic compounds and contaminants from subsurface matrices and also as a solvent substitute in chemical processing of wastes. SFE is being used in applications ranging from the analysis of phospholipid fatty acids (PLFA) (which are short-lived molecules found only in living cells) to the separation of metal ions from soils and groundwater.

Grant applications are sought in one of the following three areas: (1) Development of extraction methods, processes, materials, or equipment for removing inorganic or organic compounds from complex subsurface matrices using SFE. Examples of critical technologies include, but are not limited to, extractors, recirculation pumps, compressors, and adsorbent beds. (2) Development of components, materials, systems, and subsystems for field-portable analytical instrumentation that uses SFE in conjunction with a suitable detection system including (but not limited to) spectroscopic and/or chromatographic detectors. The primary interest is in simple and rapid field-survey instrumentation that provides universal detection for a wide range of pollutants at ppm to ppb sensitivities. (3) Development of methods, materials, or equipment that substitute supercritical fluids for organic solvents leading to a more environmentally benign process. All technologies proposed for this subtopic must rely primarily on the use of supercritical fluids, reduce the use of organic solvents, be significantly faster than standard extraction methods, and be achievable at moderate pressures and temperatures. Critical technologies proposed for this subtopic must be novel with regard to SCF, sample handling, or extraction control, and functionally indispensable for an SFE operation. Minor adaptations of readily available hardware for use in an SFE system are not responsive to this subtopic.

b. Remediation Analysis—Subsurface remediation technologies have expanded steadily and improved over the last decade. Soil washing, solvent extraction, bioremediation, vapor extraction, chemical treatment, and forms of thermal treatment have grown by 44 percent at Superfund sites since 1982. However, the effectiveness of these technologies often cannot be assessed in a timely manner because of inadequate site analysis prior to remediation, lack of sensing and

process-control techniques, and difficulty in obtaining uncompromised samples from remediation sites, especially subsurface ones. Grant applications are sought to develop: (1) Innovative methods, processes, materials, and/or equipment for assessing the efficacy of remediation actions. The proposed technologies should indicate the effectiveness of remedial activities in relation to natural recovery processes occurring at untreated sites with comparable environmental insults. (2) Process control systems, materials, components, or equipment that will improve remediation effectiveness. The proposed technologies must significantly reduce remediation duration and/or costs through advancements in the methodologies used to monitor, analyze, or control the remediation process. (3) Novel methods, field-data display techniques, three-dimensional imaging equipment, and software, to precisely determine, display, and/or track operations to allow discrimination between closely spaced but geologically dissimilar samples.

Techniques proposed for this subtopic should not require regulatory approval for implementation. Minor adaptations of readily available materials or hardware for such use are not responsive to this subtopic.

c. Biosensors and Genetic Probes—There is a need for sensitive, accurate, and real-time monitoring of biological organisms and processes and physicochemical parameters in the environment. Uses for such environmental measurement capabilities range from bioremediation of subsurface hazardous waste sites to waste-water analysis. Many new technologies in biomolecular and gene probe based assessment have been created in the laboratory; yet, beyond the clinical environment, few have reached the standardized, instrumented, or automated state required for environmental applications. Grant applications are sought to develop: (1) Robust but sensitive biosensor devices (devices employing biological molecules or systems in the sensing elements), or critical technologies for them, that can be used for field-monitoring of environmental processes or parameters. Also of interest are integrated biosensing and controller/signal processing systems for autonomous or unattended measurement applications. Sensors and systems proposed must be able to detect geological, biological, chemical, or physical processes that transport, disperse, and transform energy-related materials in the atmosphere or the terrestrial or marine ecosystems. Grant applications should address the environmental significance of the parameter to be

monitored by the biosensing system. Biosensing systems may incorporate (but are not limited to) whole cell biosensors (chemoluminescent or bioluminescent systems), enzyme or immunological linked detection systems, membrane lipids, or DNA/RNA probe technology with enzyme amplification of target signals. (2) Enhanced sample purification methods/techniques for biomolecules which will minimize the required sample size and permit in-situ detection. Examples of purification processes currently used are centrifugation, precipitation, and agarose gel electrophoresis, depending on the intended test. (3) New gene probes for specific environmental bacterial species. The cloned DNA sequences should be developed with closely located markers to prevent separation. In addition, the gene selected for the probe must discriminate between species but not be so specific that minor base pair mutations will cause bacteria to be overlooked. Minor adaptations of readily available materials or hardware for such use are not responsive to this subtopic.

d. Fiber Optic, Solid-State Chemical, and Silicon Sensors

Fiber optic sensors (classified as intensity-based, wavelength-based, or phase-based sensors) offer several advantages over conventional sensors including inherently high sensitivity, large dynamic range, intrinsic immunity to electromagnetic interference, geometric flexibility, and light weight. Solid-state chemical sensors and silicon micro-machined sensors also offer several advantages over conventional sensors due to their small size, relatively low cost in production quantities, linearity, and rapid response time. The benefits of small-scale monitoring devices include simpler deployment in remote locations, potential cost advantages, and enhanced access to the monitoring site. Sensors and systems proposed must be able to detect geological, biological, chemical, or physical processes that transport, disperse, and transform energy-related materials in the atmosphere or the terrestrial or marine ecosystems.

Grant applications must address the environmental significance of the parameter to be monitored by the proposed sensing devices. Grant applications are sought to develop: (1) robust but sensitive fiber optic, solid-state chemical, or silicon micro-machined sensors, or critical technologies for them, for field-monitoring of environmental processes or parameters (atmospheric, oceanographic, or terrestrial), or (2) integrated sensing and microprocessor/signal processing systems for autonomous or unattended measurement applications which utilize fiber optic, solid-state chemical, or silicon

micro-machined sensors (either a single sensor or a suite of sensors). Innovative integration of components such as micro-machined pumps, valves, and micro-sensors into a complete sensor package is considered responsive to this subtopic. Minor adaptations of readily available materials or hardware for such use are not responsive to this subtopic.

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10. HUMAN GENOME

DOE supports research to stimulate the acquisition of knowledge regarding the molecular structure of the human genome and to make this information and related biological, chemical, and physical resources readily available to interested users. Such knowledge will (1) markedly improve the ability to estimate risks to humans exposed to low levels of radiation and chemicals by clarifying the basis for variation in human susceptibility to such exposure, (2) form the basis for individualizing radiation protection and monitoring needs, and (3) facilitate the identification and isolation of genes involved in human diseases and disorders. There is also the potential of diagnosing early disease correlates years before clinical symptoms appear. Areas of interest include developing more efficient DNA-sequencing technologies, improving computational capabilities for acquiring, storing, and analyzing human chromosome DNA-sequence data, and disseminating new information with appropriate learning aids. Close interactions with one of the DOE laboratories can be beneficial in the development of a grant application.

Grant applications are invited only in the following subtopics:

a. Development of Improved DNA Sequencing Technologies—Increased use is being made of DNA sequencing in biotechnology, cancer research, genetic toxicology, and molecular genetics. Data derived by DNA sequencing have wide application in a variety of research areas including: design of improved vectors for gene cloning and expression, analysis of the genetic organization of eukaryotic chromosomes, and assessment of environmentally induced DNA damage. Grant applications are sought for improvements in techniques and instrumentation to substantially augment present capabilities in DNA sequencing technologies. Innovative new approaches to increasing the speed of sequencing by orders of magnitude, error-free performance, and low cost per base are of interest. Developments might include: (1) new automated instrumentation for DNA preparation and amplification; (2) improved and novel sets of labels and/or complementary instrumentation for quantifying and distinguishing co-resolved labels in sequencing instruments; and (3) new approaches to sequencing (chemical, enzymatic, or physical).

b. Improved Systems for Management and Interrogation of DNA Clone Libraries—Grant applications are sought for innovative approaches for the maintenance and interrogation of libraries of DNA clones for the discrimination between, and isolation of, sought library members. Applications must propose technologies or approaches that will enhance the capacities of small laboratories to process large libraries, or to enable much more cost effective library processing services by private sector organizations. Coupled improvements are sought, for example, in the massively parallel growth of clones and/or amplification of clonal DNAs, automation of pooling strategies for polymerase chain reaction screening, or miniaturization of DNA dot blots for subsequent interrogations with DNA probes.

c. Rapid and Automated Methods for Polymorphism Screening—Grant applications are sought for innovative approaches that could rapidly screen for the presence of mutations or polymorphisms in selected genes of a large number of individuals. Applications should propose technology that can quickly and efficiently process many DNA samples. Also, applications should use technologies that can be automated. The proposed approach should address screening of multiple genes simultaneously from one DNA sample. Approaches that are amenable to the integration of several complementary techniques are encouraged. Issues that should be considered must include one or more of the following: (1) heterozygosity (detecting only one mutant copy of a gene or polymorphism of a heterozygote is important); (2) sample heterogeneity (biological samples, e.g., tumor biopsies, may contain cell subpopulations with different somatic mutations, and it is important to detect alterations in only a fraction of the DNA in the sample); (3) small DNA sequence changes, e.g., point mutations and small deletions (techniques are also needed to accurately determine the exact DNA sequence of the variants); or (4) gene amplifications and deletions (techniques are needed to detect more rapidly and efficiently these larger alterations in DNA).

d. Educational Materials and Information Technologies—Information from the Human Genome Project is expanding rapidly and has the potential to affect our everyday lives in many ways. Educational materials are necessary to aid and facilitate use of this expanding knowledge resource. Grant applications are sought for the development of innovative materials or

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information dissemination techniques that will help to inform the public about the benefits and challenges arising from this program. Applicants should have sufficient knowledge and expertise to allow them to communicate with scientists working on the project and to rapidly and efficiently research the appropriate literature sources needed to form the basis for developing high quality communication vehicles. The materials and techniques to be developed by these projects in Phase II could be designed for use at the high school, undergraduate college, or graduate level (e.g., biological, physical, and social sciences), or by the lay public, including politicians and the legal and medical professions. The products, to be commercialized in Phase III, would support the dissemination and use of the information arising from the project and would include all types of educational media (e.g., printed, audio and video tapes, films, and computerized tutorials). Areas of interest include molecular biology, human genetics, computational biology, automation, and robotization. Also of interest are topics involving ethical, legal, and social issues, especially those dealing with the privacy and confidentiality of genetic information.

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* See Section 7.1

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11. COMPUTERIZED PROCESSING OF BIOLOGICAL DATA

DOE supports biological research programs and research infrastructure that require the application of innovative database and software engineering to problems of biological data and computational biology. These programs involve human genome research, health effects of radiation and environmental agents, structural biology infrastructure and research, bioinformation infrastructure, and the development of advanced biomedical technologies. Research and development in these areas will require software tools for the management of laboratory systems and information, data analysis, and information retrieval and navigation. In addition, improved scientific databases and associated resources will be required. These tools should address the major challenges facing

biology today, particularly in the analysis of structure and function of genomic DNA sequences and proteins.

Grant applications are invited only in the following subtopics:

a. Development of Improved DNA Sequence Data Acquisition, Analysis, and Processing—As detailed in the goals for the human genome program, advances in DNA sequencing technologies are increasing the volume of data generated from DNA sequencing systems. After these DNA sequencing technologies are implemented at genome research sites, it is anticipated that these sequencing technologies will also be widely adapted for use at other sites in routine medical diagnostics, biotechnological applications, and biomedical research. Increasingly automated procedures and integration of steps in handling data and materials will be needed. Grant applications are sought for innovative design, evaluation, or optimization of software and related developments that will significantly improve, integrate, and automate two or more processes associated with large-scale DNA sequencing efforts. Such processes include: (1) determination of appropriate sequencing templates from the physical map of a genomic region; (2) automation of handling and processing of sequencing templates; (3) automation of handling and processing of the results from the DNA sequencing instruments; (4) prediction of meaningful sequence similarities between newly discovered sequences and the sequences of previously characterized genes; (5) automation of sequence data analysis and annotation; and (6) submission of sequence and associated data to community databases. Applicants must describe the user community that will be the initial target for these innovations and how they will interact with members of that community to determine users' needs.

b. Software to Facilitate Access to Public Databases—Large, complex public databases and data resources now play an increasingly important role in biological research, and access to these databases is important for human genome research, structural biology research, environmental research, and many other fields. Examples of these public data resources include the Genome Sequence Data Base (GSDB), the Genome Data Base (GDB), and the Protein Data Bank (PDB). The public databases are, for the most part, available on-line over the Internet via documented application programming interfaces. Software tools are needed that can facilitate access to distributed,

heterogenous data bases; extract data for use by local desktop-based or remote compute server-based analytical tools; maintain connectivity and interoperability in the face of diverse software, hardware, and data schemes at different sites; and buffer against the effects of local system modifications and upgrades. Recently, generic Internet client-server software such as Mosaic and World Wide Web that access text and other file-based information through the Internet have proven very useful.

Grant applications are sought for innovative design, evaluation, or optimization of software to facilitate the analysis and handling of data held in public biological data resources. This includes: (1) vector graphics displays of genomic maps and other biological data; (2) improved ability to direct ad hoc structured queries against underlying public biological databases; (3) improved ability to execute queries that are the equivalent of true and outer joins against data distributed at multiple sites; (4) integration of local laboratory data with data from networked public databases; and (5) optimization of improved data annotation, data curatorship, and data submission tools to one or more of these public databases. Applications must: be based on the use of Internet (the only exceptions are CD-ROM-based applications, assuming that use of the latter mode of distribution is justified and the issue of semi-annual updates to the data is adequately addressed), demonstrate familiarity with previous and current work in the area, develop interactions with one or more sites already active in computational biology or biological data resources, describe the user community that will be the initial target for their innovations, and communicate with members of that community to determine the users' needs.

c. Software for Acquisition and Analysis of X-ray Spectroscopy Data—X-ray spectroscopy is playing an increasing role in providing key data about metal ions in molecules of biological importance. Information on structural parameters as well as on the oxidation state of these ions can be obtained with x-ray spectroscopy, and such data are often not accessible by other techniques. An obstacle to the widespread use of this technique is the difficulty in obtaining consistent, reproducible analyses of the spectral data collected. Grant applications are solicited for the development of software that will facilitate accurate, reproducible interpretation of electronic structure data from x-ray spectroscopy experiments on biological molecules and

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environmental contaminants. The software must address integration of data collection and data analysis.

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* Available from Human Genome Management Information System, Oak Ridge National Laboratory, 1060 Commerce Park, MS-6480, Oak Ridge, TN 37831 (Telephone 615-576-6669)

** See Section 7.1

*** Available from the Structural Biology Synchrotron Users Organization, Department of Biological Sciences, Purdue University, West Lafayette, IN 47907

**** Available from the Office of Science and Health Reports, NCCR/NIH, Westwood Building, Room 850, Bethesda, MD 20892 (Telephone 301-594-7938)

12. ATMOSPHERIC MEASUREMENT AND SAMPLING TECHNOLOGIES

World-wide energy production is modifying the chemical composition of the atmosphere and is linked with

environmental degradation and human health problems. The radiative transfer properties of the atmosphere may be changing as well. Various technological developments are needed for the long-term monitoring of these changes to support a strategy of sustainable and pollution-free energy development for the future. The following four subtopics focus on these needs. Subtopic a concerns gas-phase absorption measurement in the 8- to 14-micron band. Subtopic b concerns the development of improved radiometric instruments, and subtopics c and d concern the application of unmanned aerial vehicles (UAVs) for high-altitude measurement and sampling.

Grant applications must propose Phase I bench tests of critical technologies. Critical technologies are those components, materials, equipment, or processes that significantly limit current capabilities in the specific subtopic area. For example, grant applications proposing only computer modeling without physical testing will be considered non-responsive. Grant applications should also describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities in the technical approach or work plan. Applications for all subtopics should support claims of commercial potential for proposed technologies, (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). **Grant applications are invited only in the following subtopics:**

a. Mid-Infrared Range Absorption—Grant applications are sought to develop sensitive methods of measuring absolute absorption losses in gas phase samples in the infrared region, specifically the 8- to 14-micron region. The proposed technologies should have significantly improved performance characteristics over existing field transportable monitoring devices. The method must be absolute and cannot rely on a calibration measurement because operations at a remote site may limit access to the instrumentation. Applications should discuss how the technology can be adapted for autonomous operation at remote sites on battery power. Phase I must experimentally demonstrate a capability to meet all the above requirements, address potential sources of instrument error associated with self-calibration, and develop design features to enable operation at a remote site for as long as one year. In Phase II, the proposed apparatus must be constructed, and its capabilities must be demonstrated. Applications that make only incremental advances to existing technologies will be declined.

b. Radiometric Instrumentation—Measurements of column-integrated shortwave solar radiation (0.3 to 3.0 micrometers) and thermal radiation (3 to 100 micrometers) provide valuable information about the chemical and physical state of the atmosphere as well as the skin temperature and reflectivity of the earth surface. Both direct and diffuse components of incident solar radiation are measured. Current instrumentation for broad-band solar radiation include pyranometers, pyrhemometers, and rotating-shadowband radiometers. Spectral measurements are typically made with scanning-filter photometers, rotating-shadowband spectrometers, and spectroradiometers. Broad-band precision infrared radiometers, interferometers, and grating instruments are used for measuring the thermal radiation from the earth surface and atmosphere. Grant applications are solicited for the development of novel radiometric instrumentation or radiometer components that (1) improve current performance (e.g., eliminate angle of incidence, temperature, pressure, and humidity effects on detectors, precision optical components, and windows), (2) reduce drift or calibration requirements, (3) significantly reduce the cost of ancillary equipment such as solar seekers and trackers without degrading performance, or (4) extend the range of low-cost spectral instrumentation into the ultraviolet-B (0.28 to 0.32 micrometers) and near infrared (2 to 50 micrometers) regions. Applicants may focus on critical components and ancillary equipment for radiometers including: detectors, radiation standards and calibration methods, filter systems and monochromators, and solar tracker/seekers. Applications that make only incremental improvements to existing radiometric devices will be declined.

c. Unmanned Aerial Vehicles Performance Enhancement—Significant advances in unmanned aerial vehicle (UAV) performance are required to achieve sustained flight at altitudes of up to 20 km. Grant applications are sought for novel technologies that enhance current flight duration and/or altitude capabilities of UAVs, improve in-flight safety and/or reliability, or reduce operating and/or construction costs. Also of interest are de-icing methods for UAVs that work at mid-altitude or in cirrus clouds with significant amounts of super-cooled water vapor. For de-icing methods, applications must include an analysis to determine where icing is likely to occur and techniques to detect the presence of ice in flight.

Proposed work must result in a significant capability enhancement. Technologies must be developed to the extent that they can be demonstrated in an unmanned aerial vehicle flight during Phase II. Phase I grant applications must identify unmanned aerial platforms to be used for this flight demonstration and include teaming agreements necessary for the flight demonstration. Phase I grant applications must also address the following design considerations (although the actual design work could be performed in Phase I or II): effects of pressure variations on system performance as the vehicle changes altitude, system reliability for unattended periods of operation ranging from several days to a week in duration, and system monitoring and control input requirements (i.e., temperature, pressure, and humidity). Applications that make only incremental improvements to existing technologies will be declined.

d. Sensors for Unmanned Aerial Vehicles—Unmanned aerial vehicle (UAV) systems used for atmospheric radiation measurement have special sensing requirements that are unique to their mission. Grant applications are sought for: (1) Sensing devices to accurately measure water vapor concentrations to altitudes of 20 km. Water vapor measurement should be accurate to within $\pm 10\%$ at an altitude of 20 km. (2) Compact devices for precisely determining the orientation of UAVs with respect to the sun. High accuracy measurements of the solar flux require knowing the instrument orientation with respect to the sun to 0.1 degree at 10 Hz. (3) Sensor stabilization systems to maintain sensor orientation relative to either a geo- or solar-referenced axis during flight. Systems should be capable of maintaining ± 0.5 -degree accuracy for 100-hour UAV flights. (4) Sensing systems to remotely detect and discriminate between liquid and solid aerosols in the flight path of a UAV. The system should provide information that will allow the vehicle to make avoidance maneuvers if necessary. Solid phase particles from plinian eruptions with particle diameters of between 5 and 50 microns at concentrations from .004 to 4 grams per cubic meter must be detectable.

System weight, power, and cost are critical design elements in each area. Estimates of weight, power, and cost for the proposed technology should be included in the grant application. An understanding of UAV design requirements must be clearly shown in the grant application. Applications that make only

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* See Section 7.1

13. MEDICAL APPLICATIONS

DOE is interested in innovative research involving nuclear medicine technologies to facilitate and advance the current state of diagnosis and treatment of human disorders. The DOE Medical Applications program covers a broad range of energy-related technologies

including nuclear medicine research. The current areas of research in nuclear medicine focus on the development of (1) radiolabeled molecular probes as radiotracers to study *in vivo* chemistry, metabolism, cell communication, and gene expression in normal and disease states; (2) new radionuclide-imaging systems; and (3) new boron-labeled compounds targeted for use in neutron capture therapy of cancer. **Grant applications are invited only in the following subtopics:**

a. Molecular Medicine Technologies—Grant applications are sought for the development of radio-labeled compounds that could have applications as radiotracers for (1) radionuclide imaging technologies such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) and (2) the development of boron-labeled compounds that are capable of concentrating in tumor cells *in vivo* and delivering lethal radiation after neutron irradiation. Radiochemical, synthetic, and molecular approaches should be given consideration in developing molecular medicine technologies capable of providing a product for nuclear medicine use.

b. Advanced Imaging Technologies—Grant applications are sought for new, sensitive, high resolution instrumentation for radionuclide imaging, which advances the application of radiotracer methodologies for imaging molecular biology including cell communication and gene expression *in vivo*. Development of new detector material, detector arrays for three-dimensional imaging, software development for rapid data processing, and image reconstruction is of interest.

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* See Section 7.1

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14. HIGH ENERGY PHYSICS EDUCATIONAL AND TEACHING AIDS

DOE supports an extensive program of basic research in high energy physics. An important adjunct to this field is the physics and technology employed for the production of the charged particle beams used in the research. Since the DOE mission encompasses not only research but also education in basic sciences, the high energy physics program is interested in stimulating the development of aids for teaching the science, technology, and research processes central to high energy physics and the physics of charged particle beams. The educational levels of interest are high school, junior and undergraduate college, or first- or second-year graduate level college. It is not required that grant applications target all of these levels; targeting one or two levels may be more appropriate for a proposed teaching aid. The student participation can range from totally student self-paced and interactive through complex demonstration devices to be operated by a lecture-demonstrator.

The teaching aids of interest may be laboratory or lecture demonstration hardware or software, student laboratory apparatus, or self-teaching kits or software for self-instruction in school, at workshops, or by individuals at home. The focus for developing hardware as teaching aids should be on highly innovative, safe, inexpensive, and simple devices. Interactive devices or software are desirable, but not exclusively so. Apparatus must be in compliance with applicable Federal, state, and local regulations regarding radiation and radiological safety. In order to be considered for funding, grant applications must explicitly show and demonstrate the relevance of the proposed work to education in high energy physics, particle astrophysics, or the adjunct physics and

technology of charged particle beams. **Grant applications are invited only in the following subtopics:**

a. Particle Detectors—Grant applications are sought for teaching aids that employ modern particle or radiation detection technologies in highly innovative and inexpensive educational demonstrations or projects illustrating how research is accomplished in high energy physics. Devices should be easy to use and maintain. Teaching aids in this area should include supporting electronics and, where applicable, software support. Interfaces to personal computers typically used in high schools and colleges are desirable, as is supporting software that can provide simple pulse analysis, histogram, track drawing, etc. Examples of educational devices that might be appropriate include, but are not limited to, scintillator telescopes, semiconductor detectors, NaI or other crystal detectors, and cosmic ray and wire chamber detectors, as well as associated experimental packages.

b. Electronics Used in High Energy Physics—Grant applications are sought for the innovative development of simple, inexpensive educational devices that demonstrate the principles of electronically processing data from particle detectors. For example, such devices might include pulse shapers, pulse-height analyzers, discriminators, and triggering circuits. Interfacing these devices to personal computers typically used in high schools and colleges is desirable as is computer software for displaying and analyzing outputs from the processing hardware. In addition, the development of software products for illustration and simulation of particle detection systems will be considered.

c. Apparatus for Teaching the Physics and Technology of Charged Particle Beams—Grant applications are sought for the development of novel and innovative educational tools to demonstrate the physics of charged particle beams and charged particle beam optical systems in devices such as charged particle accelerators, storage rings, linear colliders, beam transport lines, and charged particle sources. For example, these might include devices that integrate such elements as magnetic and electrostatic beam steering and focusing, beam position monitoring, beam imaging, and beam current monitoring, as are commonly found in electron/ion focusing and transport channels, accelerators, storage rings, electron microscopes, or television tubes.

Please note: (1) The technical topics are to be interpreted literally; DOE personnel are not permitted to elaborate on the language in the technical topics. (2) The award selection process is extremely competitive. Last year, only 1 out of 11 grant applications was awarded. Only those applications with the highest scientific/technical quality will be competitive.

d. Software Tutorials—Grant applications are sought for the development of creative and innovative multimedia products, integrating video, graphics, animation, sound, and interactive techniques, for direct use by students to better understand and learn key concepts in high energy physics, particle astrophysics, or the physics of charged particle beams. These educational products could be quizzes, "games", and/or simulated analysis of real physics results. Examples of educational tutorials that could be developed include the "Standard Model" of particle physics, and the history of this model; highlights of major research findings in particle physics over the past three decades; and the design, use, and "dissection" of particle detectors, charged particle optics systems (i.e., particle beam lines, electron microscopes, etc.), and various types of accelerators. Substantial video footage of detectors and accelerators is available from the Department of Energy national laboratories.

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* See Section 7.1

15. TECHNOLOGY AND INSTRUMENTATION FOR HIGH ENERGY ACCELERATORS

The DOE High Energy Physics program supports a broad research and development effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1) new concepts for acceleration, novel device development, and computer software that will contribute to overall advances in accelerator technology applicable to the High Energy Physics program, (2) high peak power radio frequency (RF) technologies, (3) advanced cryogenic, superconductor, and superconducting magnet technologies, and (4) special charged particle beam and high energy physics instrumentation. Relevance to applications in high energy physics must be explicitly described and will be a factor in selection. Advanced accelerator R&D more appropriate to applications in nuclear physics or heavy ion fusion is specifically excluded from this topic and should be submitted under Topics 18 and 22, respectively. **Grant applications are invited only in the following subtopics:**

a. Advanced Accelerator Concepts, Technology, and Related Software Development—Grant applications are sought to develop new or improved acceleration concepts and devices to provide very high gradient (>100 MeV/m for electrons and >10 MeV/m for protons) acceleration of intense bunches of particles. Stageability, beam stability, manufacturability, and high wall plug to beam power efficiency must be addressed in detail.

Grant applications are also sought for the development of permanent magnet, charged particle optical elements. Examples include, but are not limited to, dipoles, quadrupoles, higher order multipole correctors for use in small electron linear accelerators, and solenoids for use in electron-beam or ion-beam sources or for klystron or other RF amplifier tubes operating at wavelengths from 0.1 to 10 cm. Magnets made with very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest.

Grant applications are invited for development of new or improved computer software specifically for the design or study of charged particle beam optical systems, accelerator systems, or accelerator components. Such applications should incorporate the innovative development of user-friendly interfaces with emphasis on graphical user interfaces and windows. Grant applications are also solicited for the conversion of existing codes to incorporate such interfaces, provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate.

Also sought are grant applications for the design and prototype fabrication of small inexpensive (<\$1 million) electron sources for use in advanced accelerator R&D laboratory experiments. These sources should be in the energy range of 5 to 35 MeV, and provide on the order of 10^9 electrons in a bunch less than 5 picoseconds long. The normalized transverse beam emittance should be less than or equal to 5π mm-mrad, and the device should operate at greater than 10 Hz pulse repetition rate. RF photocathode sources (robust, with quantum efficiencies >0.1 %) operating at output electron beam energies >3 MeV and/or the required laser drive systems are included among these sources.

b. Radio Frequency Acceleration—Grant applications are invited for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >100 MeV/m for electrons and >10 MeV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes. Means for achieving unloaded voltage gradients >20 MeV/m in superconducting cavities are of interest, as are methods for reducing surface breakdown and multipactoring (such as surface coatings or special geometries) and for suppressing unwanted higher order modes. Grant applications should be for devices operating at wavelengths from 0.1 to 25 cm.

There is also interest in new concepts, approaches, and instrumentation for producing high peak power (>150 MW), narrowband, low duty-cycle, low pulse repetition frequency (approximately 1 kHz) pulsed RF amplifiers operating at 1.0 GHz or higher frequency for application in large electron/positron linear colliders. Potential electrical efficiencies greater than 45% are considered essential. Also sought are higher efficiency (>65%) 1.0 GHz or higher frequency sources with a few MW power, 2 msec (millisecond) pulse length, and 10-

100 Hz repetition rate. In addition, low-cost, very efficient, pulse power modulators in the 250 kV to 1 MV range are also sought for the above pulsed RF systems.

c. Cryogenic, Superconductor, and Superconducting Magnet Technology—This subtopic addresses only those cryogenic, super-conductor, and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems. Grant applications on new and significantly improved cryogenic devices and systems for helium service in the temperature range 2 to 20 K are sought, e.g., development of new or significantly improved heat exchangers and rotating machinery (turboexpanders, circulating pumps, and compressors).

Improved instrumentation directly applicable to the testing of superconducting magnets, including the measurement of local strain, temperature, and magnetic field, is sought.

New or improved materials and related processing techniques are sought for high critical-current, high critical-field conductors to produce low stabilizer (Cu, Al) to superconductor ratio, multifilamentary wire for use in very high-field magnets ($B > 8$ T). Examples of property improvements include higher critical-current densities, higher critical fields, reduced degradation of these properties as a function of applied strain, and process improvements which result in equivalent performance at reduced cost. Examples of materials of interest include: niobium-titanium, niobium-tantalum-titanium, the so called "A-15" compounds (e.g., niobium-tin), and Chevrel phase superconductors.

d. Special Instrumentation—Grant applications are invited on novel devices and techniques in the areas of beam monitors, beam optics, and instrumentation for high energy physics research, as specified below.

Novel charged particle beam monitors are sought to measure the transverse or longitudinal charge distribution in small radius (<5 mm diameter), short (<10 mm) relativistic electron or ion beams. Also sought are devices capable of measuring and recording the Schottky spectrum of these beams. Any proposed techniques should be nondestructive to the beams monitored and have computer-compatible readouts.

Novel experimental techniques, instrumentation, materials, and systems are sought that either extend basic high energy physics experimental research capabilities or result in less costly and less complex apparatus (e.g., improved or less costly calorimeters or vertex detectors).

Grant applications with a major emphasis on digital instrumentation, digital processing or data triggering, handling, or analysis techniques or hardware should be considered for Topic 16.

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16. HIGH ENERGY PHYSICS DATA PROCESSING AND DETECTOR INSTRUMENTATION

DOE supports research and development in a wide range of technologies essential to the conduct of experiments in high energy physics or to the operation of the accelerator complexes at the three major DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and for the recording, processing, and analysis of experimental data as well as for the monitoring and control of accelerator systems and devices are included. Principal areas of present interest include high-speed electronics instrumentation, data acquisition and analysis systems, special computer systems, computer-to-computer networks, computer peripherals, particle detectors and associated data read-out systems, and instrumentation and procedures for the operation and control of particle accelerators. Grant applications must clearly and specifically indicate their particular relevance to high energy physics programmatic

activities. Although particle physics detector instrumentation and data processing equipment development and construction are usually centered in large, collaborative efforts at major national particle accelerator centers, there are many developmental endeavors in collaborative or stand-alone efforts where small businesses can make creative and innovative contributions to the further development of the required advanced technologies. This is equally true for accelerator monitoring and control systems. **Grant applications are invited only in the following subtopics:**

a. High-Speed Electronic Instrumentation—This subtopic includes:

Components—Grant applications are invited for special purpose chips and devices for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, controllers, and communications interface devices.

Electronics—Grant applications are invited for circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, particle calorimeters, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters (>300 MHz), and time-to-amplitude converters. Compatibility with one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus) is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

Systems—Grant applications are invited for advanced, high speed logic arrays and microprocessor systems for fast event identification, event trigger generation, and data processing with very high through-put capability. Such systems should be compatible with or implemented in one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus).

Instrumentation Modules—Much of the electronics instrumentation in use in high energy physics is

packaged in one of the international module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus). Grant applications are invited for modules that will provide capabilities not previously available, for substantial performance enhancement to existing types of modules, and for components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

b. Special Computer Systems and Peripherals—Grant applications are invited for innovative software and hardware for applications in high energy physics experiments, data processing, accelerator control systems, and theoretical computations, including, for example, distributed microprocessor systems, pattern-recognition systems, database management systems, code development systems, emulators for high-speed computation, large scale parallel processors (100x to 1000x Cray-2 or IBM 3090 600E computational power) for large-scale simulation, and cost-effective, multiple-access, large-memory systems. Grant applications are also sought for hardware for local and wide area computer-to-computer networks, network switching devices, network monitoring and control instrumentation, cost-effective alternatives to magnetic tape or disk on-line storage, new approaches to very long-time or large-scale on-line data storage (e.g., optical disk), smart terminals, scientific work stations, and enhancements to CAD-CAM (computer-assisted design and manufacture) systems and devices. A current strong need is for improved devices using the tape cartridge format for digital storage.

c. Computer Software—Grant applications are invited for the production of computer software to meet identified computing problems. Areas of interest include (1) computer network management (e.g., for X.25, DECnet, and TCP/IP), interconnection, and control; (2) transition to ISO network protocols; (3) CAD-CAM conversion between dissimilar systems; (4) systems for the management of very large databases of the type created in connection with the operation of large detectors; (5) general purpose software for controlling and interfacing with large electronic systems; and (6) software for the control of large multiprocessor systems. Grant applications are also sought for software for controlling, data recording,

and/or data analysis for a major high energy physics detector system, or for an approach or system that will allow the control, data recording, and/or data analysis software for a large detector to be specified and produced commercially in whole or in part.

Grant applications are also sought for improved software for command and control functions, real time database management, and status display systems encountered in state-of-the-art approaches to accelerator control.

d. Novel Data Handling Techniques and Systems for Particle Detectors—Grant applications are invited for innovative approaches to data handling for existing or anticipated experimental techniques and devices that result in more cost-effective or less complex systems for digitizing, handling, or recording detector outputs.

Grant applications are also invited for improved solutions to the specialized local communications problems encountered internal to large modern particle detectors. Particular areas of interest include the need for ultra-speed highly parallel systems to connect detector device output signals to the external electronic processing site. Grant applications are also sought for improved solutions to the specialized local communication problems encountered in connection with accelerator control systems.

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17. NUCLEAR PHYSICS INSTRUMENTATION AND TECHNIQUES

DOE seeks innovative and novel approaches to technical problems encountered in basic research in nuclear physics. Measurements in this field are performed typically at the limit of technical feasibility. Hence, new capability will often generate important advances in scientific knowledge. DOE is particularly interested in supporting projects that may lead to advances in detection systems for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art and outside the usual scope of research and development

activities at the nuclear physics national accelerator facilities. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications with applicability to nuclear physics research clearly noted are invited only in the following subtopics:**

a. Particle and Photon Detectors and Detector Materials—Nuclear physics research has a need for devices for detecting and analyzing charged particles, neutrons, photons, and single atoms with improved energy, position and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, and background suppression. These devices include: solid-state devices such as silicon strip and silicon drift detectors; photosensitive devices such as photodiodes, single- and multi-anode photomultipliers; micro-channel plates; and gas-filled detectors such as proportional, drift, streamer, Cerenkov, micro-strip, and straw drift tube chambers; liquid argon and xenon ionization chambers, single-atom detectors using laser techniques, particle polarization detectors, and magnetic spectrometer components and systems. Grant applications are sought to develop: (1) thicker (over one mm) segmented silicon charged particle and x-ray detectors and associated compact (high density), high resolution electronics; (2) very high resolution particle detectors or bolometers based on semiconductor materials and cryogenic techniques; (3) cost-effective production of n-type and p-type silicon drift chambers with active areas $>16 \text{ cm}^2$; (4) detectors with high position resolution, high radiation hardness, small surface temperature gradients, and integrated calibration systems; (5) resistive materials and methods of production of large area ($>100 \text{ cm}^2$) conductive surfaces with resistivity in the range of 10^9 to $10^{12} \Omega\text{-cm}$ for electrodes in gas chamber counters, such as substrates in gas micro-strip counters; (6) high precision, low-cost time of flight detectors and efficient polarization-analyzing materials; and (7) large arrays of high-resolution, room-temperature HgI_2 x-ray detectors for use in nuclear spectroscopy. (To minimize Compton scattering of the reaction gamma rays in these detectors, it is of utmost importance that the masses of the detector packaging and the associated electronics be reduced as much as possible.)

b. Scintillators and Associated Materials—Grant applications are invited for research and development on new scintillators and new heavy crystals or glasses to serve as scintillators or Cerenkov materials for electromagnetic calorimeter applications. Calorimeter

materials in single block lengths of up to 20 radiation lengths, which could be produced in large quantities and at low cost, would be of interest. Grant applications are invited for innovative research on new Cerenkov radiator materials with indices of refraction up to 1.10 or greater, such as heavy gases, or materials like silica aerogel, with good optical transparency and long-term stability. New scintillating materials including composite materials with high radiation resistance would be of interest as well.

New scintillation materials are also needed for use in large intermediate-energy photon detector arrays. These materials should exhibit time and energy resolution comparable to BaF_2 but with faster scintillation decay time for use in extremely high-rate applications. It is essential that the materials have a density and mean nuclear charge such that the radiation length is less than 2 cm, and can be fabricated in large pieces (up to 20 radiation lengths) at reasonable costs.

c. Special Nuclear Targets—Grant applications are invited for the development of special nuclear targets only as they specifically address nuclear physics research needs. One category of special targets is polarized (with nuclear spins aligned) high-density gas or solid targets. Other special targets include: (1) windowless gas targets and supersonic jet targets, for use with very low energy charged particle beams, and (2) liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low emittance charged particle beams are used. There is also an interest in new technology for the production of films for targets, strippers, and detector windows.

d. Electronics Instrumentation and Data Systems—Grant applications are invited for special purpose custom designed integrated circuits and for circuits and systems for rapidly processing data from particle detectors used in nuclear physics experiments such as gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cerenkov counters. Representative circuits include low noise amplifiers, analog storage devices, analog-to-digital and time-to-digital converters, and time-to-amplitude convertors. Compatibility with one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus) is highly desirable, as would be low power consumption, advanced packaging, and/or adaptability to a large number of multiple channels.

Please note: (1) The technical topics are to be interpreted literally; DOE personnel are not permitted to elaborate on the language in the technical topics. (2) The award selection process is extremely competitive. Last year, only 1 out of 11 grant applications was awarded. Only those applications with the highest scientific/technical quality will be competitive.

Grant applications are also invited for research and development on devices and systems including bus systems, data links, event handlers, multiple processors, fast buffered time and analog digitizers, generalized software, and packages with improved graphics capabilities for the acquisition and analysis of data specifically addressing needs related to nuclear physics research and development.

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18. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

The Nuclear Physics program of the Department of Energy supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy ion, electron, and proton accelerators and associated systems. Research and development is desired that will contribute significantly to overall accelerator technology and applications tailored to nuclear physics scientific initiatives including the Continuous Electron Beam Accelerator Facility (CEBAF) for electron beam energies of up to 16 GeV, the Relativistic Heavy Ion Collider (RHIC) with heavy ion energies up to 100 GeV/amu for each beam, Gammasphere, and development of devices and/or methods which would be useful in the generation of intense accelerated beams of radioactive isotopes related to the Radioactive Ion Beam (RIB) facility. Relevance of applications to nuclear physics must be explicitly described. **Grant applications are invited only in the following subtopics:**

a. Radio Frequency Techniques—Grant applications are invited on the design and development of improved or advanced concept superconducting and room temperature materials or components, especially as applied to radio frequency (RF) accelerating cavities used in particle accelerators. Included in this area of interest are accelerating structures and cavities, and peripheral components such as ultra high vacuum seals, terminations, and cryogenic radio frequency windows. Termination materials for use at 2 to 4 K, compatible with the ultra high vacuum and dust-free environment, and capable of absorbing microwaves efficiently from 2 to 90 GHz (>12 dB return loss, 2 to 4 GHz, S-band waveguide, length <12 cm) are of particular interest. RF transmission windows for use in an ultra-high vacuum, dust-free environment, which have a low secondary emission coefficient, and which do not arc in the presence of incident ionizing radiation of 3×10^{-6} A/m², are of particular interest; such windows need to operate at 2 K, and to dissipate less than 10^{-4} of the transmitted power.

Methods of converting RF power, induced in superconducting cavities by decelerating beams, to direct current (dc) power are of interest. The RF power should be induced at a single frequency between 500 and 1500 MHz, and the conversion efficiency needs to be greater than 50%.

The avoidance of inclusions in the superconducting material and contamination on the surface of the superconductor is of extreme importance in minimizing field emission, quenches due to localized heat sources, and excessive global heat dissipation. Improvements to accelerating gradients and quality factor (Q) in cavities for both continuous wave and pulsed operation are also desired. Innovative concepts and designs addressing these performance improvements are solicited.

For the pre-acceleration of radioactive beams, it is desirable to develop superconducting structures which can operate in the velocity regime between 0.001 and 0.01 times the velocity of light, for ions with charge-to-mass ratios between 1/30 and 1/240. Structures with large acceptances and which maintain good beam quality in both longitudinal and transverse phase spaces are needed. The development of improved techniques for phase stabilization of low velocity ion acceleration structures is also of interest.

Grant applications are also solicited on methods of fabricating cavities with more than five cells while still providing moderate damping of all higher-order modes. More economical methods for the fabrication of cavities and their cryostats are also of importance. Innovative designs for hermetically sealed refrigerators and other cryogenic equipment that simplify procedures and reduce costs associated with reparability and modification are needed. Grant applications are requested as well for high duty factor, high power RF systems for RFQs and linacs.

b. Particle Beam Sources (including electromagnetic beams)—Grant applications are solicited for high-brightness electron beam sources utilizing continuous wave (CW) superconducting RF cavities with integral photocathodes operating at high acceleration gradients. Applications are also requested for particle beam ion sources having improved intensity, emittance, and range of species. Included are high-charge-state sources for heavy ions, sources for negative and light ions, and polarized sources for hydrogen ions and heavy ions. Power supplies to drive these sources are of interest as well.

Grant applications for the development of ion sources for radioactive beams are sought. Aspects to be emphasized are: high efficiency, high charge state ions, high temperature operation for coupling to high temperature production targets, and element selectivity, e.g., through the use of laser ionization. The development of methods to increase the charge state of ion beams, e.g., by the use of special electron-cyclotron-resonance ionizers or special stripping techniques, are of interest. Grant applications are also invited on the development of techniques for improving the high voltage stand-off and reducing the field emission from high voltage electrodes in the presence of work function lowering material (i.e., cesium) to improve the performance of photoemission electron sources.

Grant applications are also requested for the development of techniques and targetry materials for radioactive beam production. These targets must be capable of use with beams of protons, neutrons, or heavy ions, with beam power of 10-100kW, and must be configured for rapid release of isotopes and close coupling to an ion source to generate high intensity radioactive beams.

c. Accelerator Control and Diagnostics—Grant applications are invited for "intelligent" software and

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hardware developments which will facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research. Developments which offer generic solutions to problems in the initial choice of operational parameters and the optimization of selected beam parameters with automatic tuning are especially encouraged. Grant applications requested also include advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy. The use of advanced methods such as neural networks or expert systems is appropriate. It is especially of interest to develop techniques that are nondestructive to the beams being monitored. Examples of other nuclear physics research needs include increased sensitivity for non-intercepting current, position and profile monitors for ion beams, and methods for on-line monitoring of triggering from, and transient digitizing of, very short beam bunches (100 picoseconds or less). Measurements of dc charged particle average beam currents in the range 0.1 to 100 μ A to very high precision ($<10^{-4}$) are also needed.

d. High Power Solid State Devices—Grant applications are sought for the design and development of solid state devices to replace the currently available 5 kW, 1500 MHz klystrons. The gain should exceed 30 dB, and the device should exhibit long life, cost-effectiveness, reliability, and high electrical efficiency.

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19. PLASMA CONFINEMENT SYSTEMS TECHNOLOGY

DOE supports the operation of several different fusion plasma confinement devices as well as the design and development of future devices such as the International Thermonuclear Experimental Reactor and the Tokamak Physics Experiment. Because many common problems are encountered in these various devices, it is possible to identify specific technology areas where innovative research and development would benefit the entire fusion experimental program. All subsystems and technology proposed must be compatible with appropriate plasma conditions of temperature, radiation, stress, allowed impurity level, etc. Excluded from this topic is research pertaining to cold fusion, inertial confinement fusion, and other fusion energy concepts that are not based specifically on magnetic confinement of plasmas. Also excluded are theoretical studies and computer code development unless specifically associated with and needed for the design and development of components. **Grant applications pertaining to technology development are invited only in the following subtopics:**

a. Radio Frequency Plasma Heating Systems—In plasma heating, radio frequency (RF) heating is of particular interest. The relevant frequency ranges are 0.05 to 0.3, 1 to 6, and 30 to 600 GHz, and the required power levels are 0.5 to 5 MW. Many RF sources and components are not available in this range of power levels and frequencies, especially those at millimeter wavelengths. Grant applications are sought to develop transmission lines, low-loss windows, circulators, loads, calorimeters, vacuum feed-throughs, electron guns, power supplies, magnet systems, launching structures, Faraday shields, and insulating coatings compatible with a plasma environment. The application of concepts to solve special cooling problems of components is an example of possible innovative development.

In particular, two RF heating methods chosen for near term and future large and mid-size fusion applications are Ion Cyclotron Resonance Heating (ICRH) in the range of frequencies .05 to 0.3 GHz and Electron Cyclotron Resonance Heating (ECRH) in the range of frequencies 100 to 300 GHz. These systems are expected to operate at very high powers for long pulse lengths. Total system power of 10 to 50 MW and pulse length from 30 seconds to continuous operation are

under discussion. Grant applications are sought for: (1) antenna systems capable of launching 5 MW through a 1/4 square meter area port need to be developed (because of the limited number and size of access ports and the need to shield antenna components) and (2) other components of the system, many of which do not exist in the necessary parameter ranges, such as tuning capacitors, feed-through devices, coaxial cable, stub tuners, RF power amplifiers and tubes for ICRH, and mode converters, windows, output couplers, loads, and launching systems for ECRH.

High voltage, high current power supplies to operate RF sources are also required in three typical operating ranges: 1 to 2 kV at 10 to 100 kA, 50 to 100 kV at 0.1 to 1 kA, and 500 to 2000 kV at 10 to 20 A. The required waveforms are frequently neither AC nor DC, but rather follow a complex time history. Response times of order 0.5 ms are needed. Grant applications are sought on innovative microprocessor controllers for thyristor power supplies, gate-turn-off thyristors that exceed present performance, fast acting safety devices for thyristors, and fast-opening breaking switches that can interrupt hundreds of kiloamperes and withstand tens or hundreds of kilovolts. Switching power-supply technology appears ready for several of these applications that have heretofore used conventional transformer-rectifier systems.

b. Particle and Impurity Control—Desired particles are injected into the plasma by fueling, and undesired particles are removed by the vacuum generation process. Grant applications are sought to improve the performance and reliability of high velocity deuterium or tritium pellet injectors. Cost reductions compared to existing systems must be addressed. Grant applications are also sought for improvements to the following components of particle removal systems: high speed vacuum pumps and other hardware for continuous pumping as well as rapid evacuation of the chamber between pulses, seals designed to withstand unusual thermal and/or electrical stresses, water cooled bushings for high power feed throughs, electrically conducting quick disconnects for vacuum application, remote leak detection systems, and improved ultra-high vacuum valves. The extraction of energy from energetic particles leaving a fusion plasma is also of interest.

c. High Heat Flux Materials/Plasma Facing Components—This subtopic addresses plasma facing (non-structural) materials and components which must

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survive the large heat fluxes, plasma-induced erosion, and neutron damage expected in a fusion reactor. Surface heating conditions span the range of long pulse heat fluxes (0.1 to 1 MW/m²) on surface areas characteristic of first wall heat rejection components, long pulse heat fluxes (1 to 10 MW/m²) on divertor components, and short pulse heat fluxes (10 to 500 MW/m²) on surfaces appropriate to plasma disruptions (10⁻³ sec). Grant applications are sought for: (1) radiation resistant high thermal conductivity materials and techniques for the control of erosion and redeposition, for limiters, divertors, wall armor, and liners; (2) heat dissipating materials and techniques; and (3) brazing techniques for graphites and carbon/carbon composites and techniques for increasing thermal conductance at mechanical joints under high thermal loading (for braze joints, non-destructive evaluation techniques must be addressed).

d. Superconducting Magnets and Materials—

This subtopic addresses the design and development of new or advanced concept magnets for plasma fusion confinement systems; i.e., high field magnets (12 to 16 T) and low loss pulse magnets for tokamak systems. Grant applications are sought for: (1) innovative and advanced materials and manufacturing processes that have a high potential for attractive conductor performance and low fabrication costs; (2) cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance; (3) novel, low cost cable design and fabrication techniques which minimize conductor strain; (4) superconducting joints for high field and pulse applications; (5) thick (30 cm) weldable structural case materials with high strength and toughness at 4 K; (6) welding techniques for thick cryogenic structural materials; (7) radiation-resistant electrical insulators (e.g., wrapable inorganic insulators and low viscosity organic insulators); (8) non-destructive evaluation techniques for thick section steels and thick section weldments; and (9) low-cost, efficient, and reliable cryogenic support components (such as liquid helium pumps and cryogenic dewars).

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20. FUSION ENERGY SYSTEMS

Practical applications of magnetic fusion energy in the next century will require the successful development of materials, nuclear technologies, and maintenance/repair approaches for safe, reliable, and environmentally attractive operation of fusion power systems. The long-range technical problems posed by these challenges generate many research opportunities. Excluded from this topic is research pertaining to cold fusion, inertial confinement fusion, and other fusion energy concepts that are not based specifically on magnetic confinement of plasmas. **Grant applications are invited only in the following subtopics:**

a. Materials—Grant applications are invited for research that will lead to relaxation of operating limits on materials for fusion applications in three specific materials systems. These are vanadium alloys and silicon carbide/silicon carbide (SiC/SiC) composites for structural applications, and insulating ceramics for use in diagnostic or radio frequency power transmission components. All three materials require increased resistance to degradation under neutron irradiation. Additional limitations that could be addressed include relaxation of the protection requirements of vanadium alloys set by their sensitivity to the pick up of gaseous impurities, the limitations on SiC/SiC composites set by available production and joining processes, and the limitations on insulating ceramics set by the sensitivity of electrical properties to ionizing and displacing radiation fields. Additional information on the limitations of these three materials classes can be found in references (3-8).

b. Fusion Nuclear Technology—Grant applications are sought to develop concepts for a Volumetric Neutron Source (VNS) to test, develop, and qualify fusion nuclear technology components and materials combinations. VNS, as a possible strategic element of

an aggressive fusion program leading to demonstration power plant (DEMO) operation by 2025, would operate in parallel with the International Thermonuclear Experimental Reactor (ITER) and the International Fusion Materials Irradiation Facility to provide the nuclear technology data base for DEMO. VNS, which would screen candidate DEMO nuclear component concepts, verify performance of promising concepts, and provide for engineering development and reliability growth of leading concepts, should be a plasma-based device operating in a plasma-driven mode with deuterium-tritium fuel. The features required of a VNS to accomplish its mission include: (1) a DEMO-like nuclear operating environment within test spaces, (2) a plasma-facing surface area for testing greater than 10 m², (3) an average neutron wall load and heat flux on plasma-facing surfaces of test spaces greater than 1 MW/m² and 20 W/cm², respectively, (4) steady-state or high duty-cycle pulsed operation with a minimum burn time of 1000 seconds and a maximum dwell time of 100 seconds, and (5) duty cycle x availability greater than .3, with a cumulative fluence potential of at least 6 MW-yr/m². Evaluation criteria for VNS attractiveness include: (1) capital cost, which should be no more than 25% of ITER's cost, (2) fusion power, which should be less than 300 MW, (3) use of proven technologies, (4) site electrical power consumption, which should be less than 500 MW, (5) the ability to rapidly install and replace test articles, and (6) the ability to rapidly replace any failed device component. Grant applications must demonstrate that any planned concept for VNS will meet all the above feature requirements and must determine the extent to which the proposed concept satisfies the above evaluation criteria. Proposed VNS concepts must emphasize the potential for low capital cost, low fusion power, minimal use of unproven technology, low electricity consumption, and low installation/replace-ment/repair times.

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21. PLASMA DIAGNOSTICS

DOE is currently supporting several magnetic fusion related plasma experiments that require diagnostics for measurement of plasma parameters and analysis of plasma observations. Two new magnetic fusion devices are now in the design stage--the large International Thermonuclear Experimental Reactor and the advanced, long-pulse Tokamak Physics Experiment. The goals of this topic are to develop and demonstrate novel techniques and instrumentation that provide reliable, multidimensional spatial and temporal resolution for critical plasma parameters; to make previously proven techniques more available under new plasma conditions; and to provide components and systems to improve diagnostic reliability. Improvements to accommodate the access restrictions and long pulse (≥ 1000 seconds) requirements of the next step tokamaks are needed.

Areas of interest to DOE under this topic include complete diagnostic systems for measuring plasma parameters, individual components of these systems, improved performance of currently used systems, and improved capability for data analysis. Excluded from this topic are concepts and systems pertaining mainly to inertially confined plasmas which should be submitted under topic 22. **Innovative grant applications are invited only in the following subtopics:**

a. Plasma Parameter Measurement—Major parameters to be measured include plasma density, electron and ion temperature, plasma current and plasma current density, plasma position and shape, plasma impurity density, magnetic field strength, ambipolar potentials, and radiation from the plasma. These parameters require both good spatial and temporal resolution. Real time measurements of some plasma parameters, such as plasma position and shape and plasma current density, will be needed for active control of long-pulse plasmas. In addition, methods are desired for examining the edge plasma region and areas of high heat flux deposition on limiters or divertor plates. Finally, measurement of the properties of auxiliary plasma heating and non-inductive current drive is also desired. Grant applications are sought to develop techniques for measuring these parameters. Not only must absolute values be measured, but also small relative differences in those values in space and time. Instrumentation must be capable of a large dynamic range and be sensitive to small variations.

b. Particle Detection and Detector Systems—Grant applications are solicited for: (1) detecting and characterizing particles from RF heating including ions, electrons, neutrons, and photons; particles injected by neutral beams; and confined and escaping charged fusion products of deuterium-deuterium and deuterium-tritium fusion reactions; and (2) determining the energy spectra, spatial distribution, and time evolution of thermalized plasma particles, including impurities for which the charge state is also significant.

With regard to detector systems, grant applications are sought to develop: (1) improvements to increase accuracy and resolution of detector systems (e.g., increasing the signal-to-noise ratio in instrumentation or extending the range over which measurements can be made); (2) sources and calibration techniques in the microwave and far infrared regions for improvement of electron cyclotron emission, scattering, reflectometry,

and interferometry methods; (3) improvements to infrared surface temperature measurement techniques for fast time response and magnetic field compatibility; and (4) calibration techniques for neutron measurement systems with a very wide dynamic range.

c. Components for Special Environments—With the advent of tokamak operation with burning plasmas, there is a significant requirement for radiation hardened components. Grant applications are sought for hardware (such as vacuum components, optical components, fiber optics, and detectors) that can be used in a harsh fusion environment characterized by high vacuum, high radiation, high temperature, and high magnetic field. The environment may also include the soft x-ray and vacuum ultraviolet spectral ranges. Survivability, capability for calibration, and potential for handling by remote maintenance equipment should be considered. For spectroscopic devices, improvements in diffracting elements, gratings, spectrometers, windows, and monochromators are needed to ensure radiation resistance and ruggedness.

Grant applications are also sought to improve the resistance of diagnostic components such as fast gauges, coatings, probes, encoders, gratings, and windows to ultra-high vacuum environments (10^{-8} torr) with their attendant magnetic and electric fields, temperatures, and vacuum. High reliability feed-through techniques between vacuum and air are necessary, such as those for fiber optics and for transmitting linear or rotary motion. Surface treatment, repair techniques, and in-situ calibration techniques are needed.

d. Data Analysis and Processing—Data from tokamak diagnostics will increasingly be used for real-time control of the plasma. Grant applications are solicited for innovative algorithms and systems to speed up the data reduction process (i.e. the conversion of raw data into signals representing control variables and the determination of control commands from these signals).

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* See Section 7.1

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22. TECHNOLOGY AND INSTRUMENTATION FOR HEAVY ION FUSION ACCELERATORS

Through its programs in Heavy Ion Fusion Accelerator Research, DOE supports a broad research and development effort in the science, engineering, and technology of heavy ion accelerators and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1) new concepts for acceleration and novel device development that will contribute to overall advances in accelerator technology applicable specifically in the Heavy Ion Fusion Accelerator Research program, (2) charged particle beam instrumentation, (3) beam transport techniques, (4) high current ion sources, and (5) low-cost vacuum insulating materials. Relevance to applications in heavy ion fusion research must be explicitly described and will be a factor in selection. Advanced R&D more appropriate to high energy physics and not specifically to heavy ion fusion accelerators will not be considered responsive and should be submitted under Topic 15. **Grant applications are invited only in the following subtopics:**

a. Advanced Heavy Ion Accelerator Concepts—Grant applications are sought for advanced linear induction accelerator technology capable of providing kiloampere ion beams with 1 to 2 kA of pulsed power at 1 to 2 MV at repetition rates from a few Hz to 200 kHz, including the use of multiple beams in a single unit. Of particular interest are pulsed power systems based on fast, high current, solid state switching suitable for accurate, programmable pulse shaping, and economical high voltage energy storage systems. These systems should include pulse waveform diagnostics

with speed and accuracy comparable to the waveform generators.

b. Beam Transport and Control—Grant applications are sought for: (1) cost-effective devices that use electromagnetic, electrostatic, or plasma techniques to manipulate high intensity, high momentum, heavy ion beams; (2) methods for calculating the transport of high energy (1 to 10 GeV), heavy (100 to 200+ AMU), short-pulse (10 to 20 ns), high current (1 to 10 Ka) ion beams to focal points (<0.5 cm diameter) at a distance of about 5 meters from the final focus element under a range (0.0001 to 10 torr) of reactor chamber vacuum conditions; (3) advanced particle beam diagnostic concepts and devices that provide high speed computer-compatible measurements of particle beam intensity, position, emittance, luminosity, momentum, time of arrival, and energy; and (4) novel, effective techniques to measure the transverse or longitudinal charge distribution in small radius (<5 mm diameter), high current ion beams. Techniques proposed must be nondestructive to the beams being monitored and be less costly than currently used techniques.

c. Ion Sources—Grant applications are sought on particle beam ion sources that have improved intensity, emittance, range of species, and modest (1^+ to 3^+) charge state. In particular, sources for induction linacs are sought which may be laser driven and which have high current, modest (~ 10 Hz) repetition rate, and 1 to 20 μ s pulse lengths.

d. Materials—Grant applications are sought for low-cost insulating materials for high voltage accelerating columns greater than 20 inches inside diameter which are capable of having electrodes embedded during the manufacturing process and which also have low outgassing to maintain vacuums less than 10^{-8} torr. These insulators are needed for high voltage hold-off applications in injectors and accelerator modules.

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* See Section 7.2

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23. COST-EFFECTIVE METHODS FOR COATING POLYMERS

Replacement of metal automobile components with lighter-weight parts formed from structural polymers has contributed to substantially decreased fuel consumption over the past few decades. Other advantages of structural polymers include increased toughness, improved aqueous corrosion resistance, and net-shape formability. Methods developed to apply scratch-, UV-, or alcohol-resistant coatings to polymers (such as vacuum deposition, evaporation, sputtering, and chemical vapor deposition) tend to be expensive due to high capital equipment costs and/or low application rates. Also, complex shapes are difficult to coat with existing technologies. Development of more cost-effective coating methods, such as solution-based techniques for dipping or spraying, could lead to wider application of structural polymers in automobiles as well as in many other products. These coatings can be either previously known or innovative and can be comprised of single or multiple layers. In any case, the coating system must be expected to meet performance criteria appropriate for the proposed end-use application. **Grant applications are invited only in the following subtopics:**

a. Application of Scratch-Resistant and UV-Resistant Transparent Coatings—The replacement of glass by structural polymers is restricted due to lack of surface hardness and to deterioration caused by exposure to the ultraviolet (UV) portion of sunlight. Grant applications are invited for the development of a cost-effective process to apply scratch-resistant, optically transparent coatings to flat or moderately curved surfaces of acrylic or polycarbonate components. The system should also incorporate a UV blocker, whether it is included in the scratch-resistant coating, or in an intermediate coating. The final properties of the coated product should be consistent with its use as automotive windows or windshields. Projects should be designed so that they culminate in the development of industrial-scale equipment and processes for the cost-effective coating of polymer components.

b. Application of Scratch-Resistant Coatings to Complex Shapes—Many automotive components, which are not as gently curved as windshields, may have irregular shaped geometrics (including holes, sharp bends, and corners). Grant applications are

Please note: (1) The technical topics are to be interpreted literally. DOE personnel are not permitted to elaborate on the language in the technical topics. (2) The award selection process is extremely competitive. Last year, only 1 out of 11 grant applications was awarded. Only those applications with the highest scientific/technical quality will be competitive.

invited for the development of a cost-effective process to apply scratch-resistant coatings to complex-shaped polymer components. Projects should be designed so that they culminate in the development of industrial-scale equipment and processes for the cost-effective coating of polymer components.

c. Application of Alcohol-Resistant Coatings—

The use of polymers to replace metallic components that come in contact with (alternative) fuels is restricted due to chemical degradation by alcohol. Grant applications are invited for the development of a cost-effective process to apply coatings, resistant to automotive fuels containing several percent of methanol or ethanol, to complex-shaped polymer components. Projects should be designed so that they culminate in the development of industrial-scale equipment and processes for the cost-effective coating of polymer components.

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24. RESEARCH ON THE ELECTRONIC EXCHANGE OF SCIENTIFIC AND TECHNICAL INFORMATION AMONG ORGANIZATIONS

In 1990, DOE received legislative authority to use its resources to enhance mathematics and science education. Largely through the national laboratories, DOE developed and implemented a number of outreach programs that are recognized both for their quality and unique scientific expertise and resources. However, because of technological barriers to nationwide implementation, these programs have had primarily local impact. An architecture which makes educational outreach programs accessible nationwide is a necessary goal.

New standards and technologies emerging today allow DOE to take a much needed corporate approach toward accessing and integrating educational program resources in ways not previously imagined. Recently, DOE has adopted ISO Standard 8879, Standard Generalized Markup Language (SGML), as the standard for exchange of full text scientific and technical information. SGML handles full text as well as multimedia, an integral aspect of information developed for students and teachers. A non-proprietary architecture for capturing information electronically as well as for facilitating easy access and exchange of full text math and science documents and multimedia is essential in the future.

DOE intends to capitalize on standards, information technologies, and expertise to link its education materials programs through long distance learning systems to student and teacher populations in support of the Nation's future scientific and technical needs. In so doing, the need for well-educated, highly skilled scientific and technical personnel to carry out the DOE's basic research and development and operational missions will be addressed. **Grant applications are invited only in the following subtopics:**

- a. Collaborative Writing and Editing of Scientific and Educational Materials—Authoring and

editing of educational documents and multimedia output (e.g., graphics, pictures, voice) can occur in groups within sites, among groups within sites, and among organizations. This collaborative writing and editing process is currently cumbersome, untimely, and cost ineffective particularly in organizations which have related, but geographically dispersed sites. Grant applications are sought for developing a wide-area-network for collaborative writing and editing of scientific and technical education documents within and among geographically dispersed organizations. The network should include the use of ISO Standard 8879, SGML. It should reflect where and how the markup should occur and depict the use of SGML encoding in a simple, non-offending manner, particularly to the originating author(s). The network should be designed to: (1) demonstrate a wide-area-network pilot between the DOE Office of Scientific and Technical Information and at least three dispersed DOE contractor and educational sites, and (2) maximize access and utility by students meeting educational requirements for technical careers, and post-college occupational opportunities. Applicants are expected to be thoroughly familiar with the SGML and knowledgeable of the current state-of-the-art of methods and procedures for writing, editing, and electronic and multimedia publishing. A general knowledge and understanding of math and science education programs within the United States is expected as well.

b. Electronic Exchange Architecture—The exchange of electronically created full text scientific and technical educational documents and multimedia (e.g., graphics, pictures, voice) within and among organizations is currently very difficult or impossible. This situation results from the use of multiple types of electronic files, proprietary systems, mixed hardware and software platforms, etc. Grant applications are sought to develop an organization-wide, full text, electronic exchange architecture applicable for use by widely dispersed DOE sites, DOE contractors, and educational organizations. The architecture should include the use of the ISO 8879 SGML as the encoding standard for making the full text and multimedia data neutral and transferrable over time and across multiple organizations with mixed platforms. The electronic architectural exchange should reflect electronic exchange requirements for implementation both within and among at least ten multiple and geographically dispersed government, contractor, and educational sites. A description of required standards, technologies, organizational requirements, and related

costs for implementing the architecture should be included with the design in the grant application.

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* See Section 7.1

25. ELEMENTAL TRITIUM COLLECTION TECHNOLOGY

DOE has facilities that produce and use tritium. Tritium processes are typically contained in negative pressure, inert atmosphere gloveboxes, and other confinement systems designed to prevent releases into the work room or the environment. These tritium confinement systems use oxidation of elemental tritium to form tritiated water to capture and store the tritium from the exhaust stream on molecular sieves. This creates occupational and environmental health risks because the oxide is 25,000 times more radiologically hazardous than elemental tritium. The tritiated water must then be further processed to convert it back to the elemental form creating additional potential hazards.

The cessation of nuclear weapons production operations has resulted in large amounts of tritium on molecular sieves that require processing or recovery as a part of decontamination and decommissioning activities. Recent research has provided the theoretical background and materials to collect tritium from exhaust streams in its elemental form. This creates an opportunity for research and development on the

design, fabrication, and testing of metal hydride "getters" in process glovebox structures. If successful, the employment of this new getter glovebox cleanup technology at tritium facilities across the DOE complex would result in lower worker occupational dose, lower worker and public accidental dose, lower routine public exposure, and less production of waste. Additionally, a more tightly controlled glovebox atmosphere and an increase in productivity will result. The Department's goal is to make the DOE nuclear complex safer and also provide an excellent product for transfer to the private sector. **Grant applications are invited only in the following subtopics:**

a. Metal Hydride Tritium Collection Devices—Grant applications are sought for development of metal hydride elemental tritium collection devices for cleaning the exhaust gas from process gloveboxes. Phase I should include the fabrication of a prototype device and the conduct of experiments to describe specific performance data on the "getter" bed air cleaning system. Grant applications should describe capabilities to develop fully functional systems in Phase II.

b. Recovery of Tritium from Spent Molecular Sieves—Grant applications are sought for the application of metal hydride collection devices to the recovery of tritium from spent molecular sieves. Phase I should include the fabrication of a prototype device and the conduct of experiments to investigate specific performance data on the "getter" bed molecular sieve unloading system. Performance of this system should be evaluated under realistic flow and impurity concentration conditions. Grant applications should describe capabilities to develop fully functional systems in Phase II.

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* See Section 7.1.

26. TECHNOLOGY FOR SPACE NUCLEAR PROPULSION AND POWER

DOE supports research and development on technologies for the application of radioisotope and reactor energy to space missions of other agencies of the U.S. government. Potential mission requirements (References 1-11) are for spacecraft electrical power for deep space exploration missions, electrical power for communication and sensing satellites, electrical power for lunar and planet surface exploration and space resources processing and utilization, and nuclear propulsion for general use in space. The harsh environment of space and planetary atmospheres affects the utility of these systems, and ground testing requires special provisions, particularly for environmental and nuclear safety concerns. Thermal power levels are from half a watt to several thousand megawatts. Advanced concepts, fuels, power conversion, and materials will be required. Significant reductions in mass, increased efficiency, and increases in temperature, lifetime, and reliability are needed. **Grant applications are invited only in the following subtopics:**

a. Reactor Power Systems—Reactors can be used directly to provide heat energy for nuclear thermal propulsion (NTP) or indirectly, through static or dynamic conversion, to provide electric power for many space uses, including nuclear electric propulsion (NEP). For space reactor power systems and NEP, the specific mass (kg/kWe) and lifetimes of systems and components are key drivers (References 6, 8, and 11). For NTP, the specific impulse, with higher system temperatures, is the key driver, but mass is also of concern

(References 4, 5, 7, and 8). Grant applications are invited for concepts or technology development that achieve significant improvements in the key drivers for the above space reactor systems. Advances in the following areas are of particular interest: (1) innovative reactor and power system concepts including reactor and non-nuclear power systems combinations, reactor fuels, reactor materials and coatings, and reactor or auxiliary components, and (2) innovative and cost effective approaches in safety, safety systems and instrumentation, space nuclear test ground facilities, and effluent treatment systems (References 2, 7, 8, and 11). Nuclear concepts which combine NTP and NEP capabilities, including the option to provide electrical power, are sometimes described as bimodal systems and are also appropriate for consideration (Reference 11). Grant applications must show that proposed concept and technology advances will lead to significant improvements in the key drivers and mission capabilities for future space reactor power systems.

b. Power Conversion Systems—Grant applications are sought for innovative and/or advanced power conversion systems and components, suitable for use within space reactor electrical power systems, including improvements in materials, manufacturing techniques, efficiencies, lifetimes, and costs. Of particular interest are advances in thermoelectric, thermionic, and other static systems; dynamic systems; and advanced fuel cells coupled with static or dynamic systems. For thermoelectric conversion, an increase in device efficiency of at least 20% is sought for state-of-the-art type silicon-germanium or other thermoelectric couples, and improvements leading to an increased figure-of-merit, Z , in type p-n junctions for high temperature use are also of interest. For thermionic conversion, research interests include improved high temperature emitters, containment alloys, and other materials needed in thermionics. Other static and dynamic energy conversion concepts and technologies (including alpha and beta voltaic converters, AMTEC and HYTECH devices, advanced Brayton and Rankine dynamic systems, and hybrid systems for propulsion and power) that substantially improve system efficiencies and/or lifetimes will also be considered. Grant applications are also invited on improvements in heat transport and heat rejection because they are the key technologies which can be applied in the search for smaller systems.

c. Isotope Power Systems—Radioisotope Power Systems (RPS) employing thermoelectric conversion have been the sole spacecraft electric power source for deep space exploration and have been used in the moon and Mars surface missions (References 9 and 11). While thermoelectric RPS power systems have been extremely reliable with operational lives in excess of 12 years, the system efficiencies for these thermoelectric systems are low (typically 6.5 to 9%). For static systems, targeted conversion efficiency $\geq 16\%$ in power ranges of 40 to 150 watt electrical is desired. For dynamic systems, the target is $\geq 25\%$ in power ranges of 60 W to 5 kW electrical. Grant applications are sought for attaining or approaching these target conversion efficiencies in isotope power systems with mission lives in the range of 10 to 25 years. Approaches should employ conversion based on one of the following technologies: a new thermoelectric material and device, a thermo-photovoltaic system, or a dynamic Stirling system. In addition, an innovative device employing segmented thermoelectric legs comprised of silicon germanium/lead telluride (or equivalent) with a cold junction temperature from 50 to 250°C and hot junction of 1000°C is of interest. All thermal systems and materials must be compatible with a heat source based on the General Purpose Heat Source module (Reference 10). The maximum heat source steady state temperature is approximately 1330°C for the fuel clad surface, which for a vacuum system yields a module surface temperature of approximately 1100°C.

Grant applications are also invited on small isotope power sources with power levels in the 0.04 to 10 watt electrical range employing 238-plutonium dioxide or other isotopes and unique static conversion systems. Emphasis should be focused on high efficiency, long-lived, 10 to 20 year conversion systems including system packaging designed for the maximum requirements of launch safety.

d. Space Reactor Power Systems Surface Applications—The application of reactors on the surface of bodies for Lunar, Martian, and asteroid missions generates special requirements including protection from surrounding elements which may include oxidizing gases and dust. The surrounding environments may define special requirements and opportunities for heat rejection. The physical deployment of space reactor power systems either robotically or with manned support presents special challenges. In many cases, the system must be

deployed to minimize or shield radiation to surrounding manned operations. Grant applications are sought for innovative materials and concepts useful for adapting reactors to the above surface environments; approaches for deploying Lunar, Martian, and asteroid space reactor power systems that meet the above special needs; and unusual or innovative reactor systems for processing and/or utilizing space resources.

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* See Section 7.1

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27. MEASUREMENT AND CHARACTERIZATION OF MATERIALS IN CIVILIAN NUCLEAR REACTORS

The continued viability of nuclear power will require proper characterization and demonstration of materials performance for those systems, structures, and components considered critical for safe operation of a nuclear facility. DOE has identified a need to enhance present technologies through innovative technology-based research and development on approaches to: (1) measure the mechanical properties of nuclear reactor pressure vessel (RPV) materials, (2) enhance the capability of in-service inspection technology to verify the absence of service-induced defects in reactor pressure vessels, and (3) determine cable jacket and insulation properties for electrical cables. **Grant applications are invited only in the following subtopics:**

a. Measurement of Nuclear Reactor Pressure Vessel Mechanical Properties—The characterization of RPV integrity (through material property determination) is a critical safety assessment. Thermal annealing of RPVs may increase the amount of material property testing required. One means of characterizing the integrity of RPVs is to monitor mechanical property changes of materials susceptible to irradiation embrittlement. However, the fixed amount of available RPV material that can be incorporated into additional surveillance programs may not satisfy the increased level of testing required. Innovative mechanical property measurement techniques that

reduce the amount of material required will provide surveillance program options. Grant applications are sought to develop in-situ nondestructive evaluation technology which tests the minimal amount of material required to determine mechanical properties (Charpy impact, tensile and fracture toughness) of RPV materials subjected to irradiation embrittlement.

b. In-Service Inspection Technology—Regulations established by the Nuclear Regulatory Commission require nondestructive inspection of RPV beltline materials (material directly adjacent to the effective height of the nuclear fuel core) to ensure RPV integrity by verifying the absence of service-induced defects. Characterization of the inspection system performance parameters (probability of detection and sizing accuracy) is vital if the results of a vessel-specific, in-service inspection are to be used to provide a realistic assessment of RPV integrity. In addition, physical constraints in the RPV may preclude 100% inspection of the beltline region using available techniques. Previously, exemptions to a 100% inspection were allowed if physical constraints precluded inspection using available technologies. Recent regulatory changes no longer allow these exemptions and require inspection of over 90 percent of the examination volume. Grant applications are sought to develop: (1) innovative approaches to determine the probability of detection and the sizing accuracy for non-destructive inspection systems, and (2) innovative technologies that allow in-service inspections of those parts of the beltline region that are otherwise inaccessible using present techniques.

c. Electrical Cable Jacket and Insulation Properties—Electrical cables are subject to various types of environmental aging (e.g., thermal and irradiation aging). In critical applications, including civilian nuclear power plants, more precise measurements of the effects of environmental aging can be used to accurately predict the remaining qualified life of a cable. Electrical cable jacket and insulation material properties have been directly correlated to mechanical testing results, including elongation and tensile strength. Accurate measurements of electrical cable jacket and insulation materials, combined with the results obtained during the initial environmental qualification program, will help ensure that adequate safety margins are maintained. Grant applications are sought for technologies that will allow in-situ mechanical measurements of electrical cable jacket and insulation properties. Non-destructive techniques are

of primary interest; techniques that require small samples from the ends of a cable or very localized samples will also be considered.

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** See Section 7.1

28. CHARACTERIZATION, MONITORING, AND SENSOR TECHNOLOGIES FOR RADIOACTIVE AND HAZARDOUS WASTE

DOE is committed to the cleanup of radioactive, hazardous, and mixed waste at its facilities by the year 2019. A new approach to environmental research and technology development at the DOE was adopted in January 1994, with action plans to address the following focus areas: contaminant plume containment and remediation; high-level waste tank remediation; mixed waste characterization, treatment, and disposal; landfill stabilization; and facility transitioning, decommissioning, and final disposition. Characterization and monitoring technology is required for all five focus areas. Characterization/monitoring technology that is developed for addressing needs in one focus area can often be adapted to solve similar problems in others. However, this topic focuses on technology development

of particular relevance to high-level tank wastes, low-level mixed wastes, decontamination and decommissioning, and sensors for robotic applications.

Each grant application must include evidence of communication with and appreciation of the needs of prospective customers. The feature(s) to be characterized/monitored, the target limits of detection, accuracy, and precision, and the target measurement ranges must be clearly stated and must be consistent with the functional and operating requirements of the prospective customers. Information concerning the baseline technology (if any) and its performance must be provided so the potential value of the proposed technology development can be assessed. **Grant applications are invited only in the following subtopics:**

a. Characterization and Monitoring of High-Level Waste Tanks—Approximately 200 large underground storage tanks were used to capture, process, and store radioactive waste from weapons material production processes. These tanks contain highly radioactive sludge, saltcake, and supernatant liquid. The major chemical constituents are nitrates, along with hydrated metal oxides, phosphate precipitates, transuranics, and isotopes of strontium (^{90}Sr), iodine, cesium (^{137}Cs), and technetium (^{99}Tc). Characterization/monitoring technology improvements are needed to help address waste tank safety issues, including tank leak monitoring, and to help support the safe retrieval, pretreatment, and processing of tank waste. Grant applications are sought for the development of: (1) systems for in-situ determination of the following at various waste matrices (liquids, saltcake, and sludge) within the tanks: water content (weight percent), total organic carbon content (weight percent), fissile material (^{239}Pu) content ($\mu\text{g/g}$), and heat generation (^{90}Sr and ^{137}Cs) (Btu/hr-lb); and (2) systems for continuous, real-time detection of tank leaks during waste storage and waste retrieval operations. Devices and systems for in-situ deployment must be capable of performing in a caustic environment and a radiation field of 5,000 rad/hr for an accumulated dose of 10^7 rad.

b. Low-Level Mixed Waste (LLMW) Process and Effluent Monitoring—LLMW contains small amounts of radioactive material mixed with material that contains one or more hazardous chemicals. DOE's 107,000 m^3 LLMW inventory includes hundreds of different chemical and physical waste matrices. A variety of treatment and waste stabilization

technologies are under investigation and development. Incineration, plasma processing, and vitrification are examples of the former; polymer and grout encapsulation exemplify the latter. All LLMW treatment/stabilization processes require some characterization/monitoring to help ensure the production of acceptable final waste forms. Treatment of LLMW requires destruction of hazardous organic constituents and stabilization of hazardous inorganic constituents to comply with land disposal restrictions. In addition, effective removal of pollutants from off-gas effluent of the treatment processes needs to be accomplished and documented at levels that satisfy all applicable local, state, and federal requirements. Grant applications are sought to develop techniques for determining the presence and concentration of volatile metals (mercury, lead) and the total salt content (sodium chloride, potassium chloride, along with sulfates, nitrates, and some fluorides) in wet solids, heterogeneous dry solids, and homogeneous dry solids. Grant applications are also sought for the development of techniques for continuous, real-time monitoring of radionuclide, total organic carbon, and Resource Conservation and Recovery Act (RCRA)-listed heavy metal concentrations at various points in mixed waste treatment process streams.

c. Characterization Support for Decontamination and Decommissioning (D and D) Activities—

Many of DOE's nuclear materials processing facilities are contaminated with radioactive and/or hazardous materials. Examples include uranium, plutonium, and other special materials processing facilities, and reactors, hot cells, and irradiated fuel storage facilities. These facilities must be decontaminated and decommissioned, and valuable materials must be recovered. Extremely large quantities of materials will be targeted and generated by D and D activities. Recovery and reuse of some of these materials, including metals, concrete, and equipment, offer the possibility of large economic benefits. New technologies are needed to help characterize facilities and materials scheduled for D and D and to monitor the D and D processes to ensure safe operation, release of recovered materials for reuse, and appropriate control and disposition of secondary waste. Grant applications are sought to develop: (1) techniques that provide the capability of large area coverage with three-dimensional mapping to identify polychlorinated biphenyls, uranium, plutonium, fission products, and mercury in the near-surface layer of concrete (techniques capable of "seeing through" coatings such as paint and epoxy are of

special interest), (2) a real-time alpha sensor for determination of activities in solutions, ranging from Ci/L levels for flush solutions to $\mu\text{Ci/L}$ levels for final decontamination conditions (this sensor will help resolve criticality issues and provide information for evaluating the effectiveness of decontamination operations); and (3) technologies for the characterization of metal scrap volumetrically contaminated with ^{99}Tc and activation products such as ^{60}Co .

d. Sensors for Robotic Applications—

Robotic technology has potential for enhancing the safety of operations in many of the focus areas identified above. Current robotic development efforts address: (1) waste storage tank inspection, waste characterization, and retrieval; (2) buried waste characterization, retrieval, and remediation; (3) remote and automated inspection of interim stored waste; (4) contaminant analysis automation; and (5) mobile facility surveyors and decontamination platforms. Sensors are needed to help support the application of robotics for remote sensing, operation, and control of equipment; for minimization of worker exposure; and for enhancement of operational throughput. Grant applications are sought for the development of the following sensors with emphasis on minimization of weight, volume, power consumption, and supporting peripheral equipment requirements: (1) sensors for real-time determination of heavy metals and organic chemicals listed in the Resource Conservation and Recovery Act, and (2) miniature alpha/gamma radiation sensors for detection of mixed samples.

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* Available from Ames Laboratory, 107 Spedding Hall, Ames, Iowa 50011-3020

** See Section 7.1

29. IN-SITU TREATMENT OF METAL CONTAMINATED SOILS AND GROUNDWATER

DOE operates 18 research and production facilities throughout the United States. More than 3,000 inactive waste sites have been identified at these facilities, including both engineered disposal facilities and sites of unplanned releases. Metals, including radionuclides, were found to be among the most prevalent contaminants throughout the complex. Common contaminants include tritium and the metals lead, chromium, arsenic, zinc, copper, cadmium, nickel, mercury, uranium, barium, cesium, strontium, plutonium, thorium, and technetium. In many cases, sites containing these metals are also contaminated with organic acids, complexing agents, and organic solvents. These contaminants have migrated into the groundwater.

DOE is interested in the development of innovative technology systems for in-situ removal, extraction, or destruction of metal contaminants in the soil's vadose zone (the unsaturated zone between the ground surface and the water table) in order to eliminate the need for soil excavation for subsequent treatment and disposal.

Specific technology systems of interest are those that will either reduce the leachability of the metals in the soil (stabilization, chemical or electrochemical reduction, etc.) or increase the metal mobility to enhance recovery of the metals from the soil using an extraction well.

DOE is also interested in the development of systems for the in-situ treatment of metal contaminated groundwater. A technology must be developed to concentrate contaminants prior to extraction. This is necessary to either minimize or eliminate the volume of water recovered through an extraction well prior to above-ground treatment. Subsurface contaminated soils that are above the groundwater table are of particular concern. Of interest are specific technologies that will either permanently reduce the solubility of the metals in the groundwater in order to eliminate the need for their recovery, or would enhance metal mobility and/or concentration of the metals in the groundwater to improve the efficiency and effectiveness of pump and treat technologies.

Principal issues precluding demonstration of many of the physical, chemical, and biological treatment technologies include the lack of performance data specific to the contaminants at DOE sites and the need to demonstrate efficient dispersal and/or collection of chemical reagents in an in-situ application involving unsaturated soils. **Grant applications are invited only in the following subtopics:**

a. Stabilization of Metals in Vadose Zone Soils—Grant applications are sought for innovative processes that stabilize metals in subsurface vadose zone soils located above the groundwater zone. Stabilization involves technologies that reduce the mobility of contaminants in soils and sediments by physically or chemically binding them to the soil/sediment matrices. Techniques that may be employed in these processes include the addition of liquid or gaseous reagents to form insoluble precipitates, adsorbents to strongly adsorb soluble contaminants, or the addition of grout to form a monolithic material that has a low hydraulic conductivity and either physically or chemically binds the contaminants within the monolith. Other techniques that can be shown to achieve similar objectives will also be considered. Grant applications must: (1) consider the effects of gravity and soil heterogeneity on the movement of reagents in the soil within the contaminated zone, (2) account for the effect of reactions of reagents with the

soil and contaminants on the physical properties of the soil, (3) identify and integrate supporting technologies (i.e., drilling, mixing schemes, monitoring, etc.) to ensure that a treatment system will eventually be available for application, (4) show plans to demonstrate the effectiveness of the proposed technology in groundwater or soil spiked with metals, and (5) establish the bounds of effectiveness according to key parameters by the end of Phase II. The extent of development in Phase II must be sufficient to scale up to a small field test.

b. Enhanced Mobilization and Recovery of Metals in Vadose Zone Soils—Grant applications are sought for innovative processes that enhance the mobility of metals in vadose zone soils located above the groundwater zone and that subsequently recover these metals from the soils. Processes that may enhance metal mobility include those involving the addition of chemical agents such as complexing agents or surfactants, and/or enhanced ion transport using electrokinetic techniques. Research and development are required to demonstrate the delivery and uniform dispersal of reagents to the zone of contamination as well as recovery of metals and unconsumed reagents from this zone. Grant applications must: (1) consider the effects of gravity and soil heterogeneity within the contaminated zone on the movement of reagents and metals in the soil, (2) account for the effect of reactions of reagents with the soil or contaminants on the uniform dispersion of reagents, (3) identify and integrate supporting technologies such as containment barriers to ensure that the technology will be acceptable for field application, (4) show plans to demonstrate the effectiveness of the proposed technology in groundwater or soil spiked with metals, and (5) establish the bounds of effectiveness according to key parameters by the end of Phase II. The extent of development must be sufficient to scale up to a small field test.

c. Solubility Reduction of Metals in Groundwater—Grant applications are sought for innovative processes for stabilizing metals in groundwater including the sediments with hydraulic conductivities $<10^{-5}$ cm/sec. These sediments are generally not considered amenable to conventional pump and treat technologies. Research and development are required to demonstrate the proposed technology including the delivery and uniform dispersion of reagents throughout the treatment zone in a contaminated groundwater plume. Techniques that may be employed in these processes include the addition of liquid or gaseous

reagents to form insoluble precipitates, adsorbents to strongly adsorb soluble contaminants, or the addition of grout to form a monolithic material that has a low hydraulic conductivity and either physically or chemically binds the contaminants within the monolith. Grant applications must: (1) consider the effects of soil heterogeneity within the treatment zone on the movement of reagents in the saturated sediments, (2) account for the effect of reactions of reagents with sediments and groundwater contaminants on the physical properties of the sediments and on the mobility of the reacted contaminants, (3) identify and integrate supporting technologies (i.e., drilling, mixing schemes, monitoring, etc.) to ensure that a treatment system will eventually be available for application, (4) show plans to demonstrate the effectiveness of the proposed technology in groundwater or soil spiked with metals, and (5) establish the bounds of effectiveness according to key parameters by the end of Phase II. The extent of development in Phase II must be sufficient to scale up to a small field test.

d. Enhanced Mobilization and Recovery of Metals in Groundwater—Grant applications are sought for innovative processes that enhance the mobility of metals in groundwater and subsequently recover these metals using an extraction well. Processes that may enhance metal mobility include those involving the addition of chemical agents such as complexing agents or surfactants and/or electrokinetic techniques. Research and development are required to demonstrate the delivery and uniform dispersal of the required reagents to the zone of contamination as well as recovery of metals and unconsumed reagents from this zone. Grant applications must: (1) consider the effects of soil heterogeneity within the contaminated zone on the movement of reagents and metals in the soil, (2) account for the effects of reactions of the reagents with the soil or contaminants on the physical properties of the saturated sediments, (3) show plans to demonstrate the effectiveness of the proposed technology in groundwater or soil spiked with metals, and (4) establish the bounds of effectiveness according to key parameters by the end of Phase II. The extent of development must be sufficient to scale up to a small field test.

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30. CHEMICAL SEPARATION PROCESSES FOR WASTE TREATMENT

DOE's goals for waste management and environmental restoration are to: (1) reduce the volume of waste that must be disposed of in a geologic repository; (2) decrease the toxicity and minimize the quantity of low-level waste (LLW) that is disposed of near the earth's

surface; (3) minimize the volume of process, secondary, and decontamination and decommissioning wastes; (4) modify and apply separations methods developed for waste treatment to environmental restoration and waste management activities in remediating soils and groundwater; (5) identify high-value waste constituents for potential recycle; and (6) develop technologies for transfer to commercial use.

Separation technologies can remove radionuclides, hazardous materials, and chemicals from radioactive wastes (see note below), contaminated soils and groundwater, and waste streams resulting from the decommissioning and decontamination of facilities contaminated with hazardous and/or radioactive chemicals. Heavy metals, RCRA metals, organics classified as hazardous by the RCRA, and radioactive species are typical components of concern in DOE waste streams. Separation technologies must minimize the environmental impact, risk, and life cycle costs of waste treatment, waste disposal, and environmental restoration.

[NOTE: Radioactive wastes can include high-level wastes (HLW), low-level wastes (LLW), transuranic (TRU) wastes, and highly radioactive mixed wastes. HLW is defined as the highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation. TRU waste is defined as waste that is contaminated with alpha-emitting transuranic nuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste. LLW is defined as radioactive waste not classified as HLW, TRU, spent fuel, or by-product material. Mixed waste contains both radioactive and hazardous components, as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA).]

Grant applications, submitted in response to the subtopics listed below, should identify separation processes which are selective for specific contaminants of interest; produce low-volume secondary waste streams; and provide high loading capacities, high separation factors, and simplicity. Separation processes having commercial applications are strongly encouraged, but all grant applications should target a DOE problem. Enabling processes for separations (i.e.,

processes which transform the waste stream so that it becomes amenable to subsequent treatment by an established or innovative separation process) are also acceptable. In all cases, the flexibility of the technology is important; for example, a technology that addresses multiple contamination situations is preferable to a technology limited to a single situation. Grant applications should describe clearly the advantages of the proposed technologies over existing alternatives, if any.

For those applicants who do not have the facilities to perform research involving radioactive species, grant applications will be accepted in which an innovative separation technology is demonstrated on a nonradioactive substance; however, the approach, upon further development, must be relevant to radioactive species. **Grant applications are invited only in the following subtopics:**

a. Aqueous Waste Streams—Grant applications are sought for innovative ways to separate radioactive species from high ionic strength, multicomponent, aqueous solutions of salts dominated by species such as sodium nitrate, nitrite, carbonate, and phosphate. Related efforts include methods for the removal and/or destruction of non-radioactive but problematic compounds such as nitrates, nitrites, and organics (especially RCRA-related organics) in radioactive wastes. (Nitrates and nitrites constitute the largest fraction of wastes at some DOE sites, increase volume and cost requirements, increase safety risks, complicate waste processing, and can increase the leaching of other components from waste forms. Hazardous organics pose serious environmental threats and can reduce the effectiveness of some methods for removing metals from waste streams.) Treatment of both acidic (typically, up to several molar in nitric acid) and alkaline (up to several molar in hydroxide) aqueous solutions are of interest.

Grant applications are also sought for separation or enabling processes to remove contaminants and minimize waste streams from decontamination and decommissioning operations. Radionuclides and other materials under consideration for separation include transuranic (TRU) elements such as neptunium, plutonium, americium and curium, highly radioactive elements, strontium (^{90}Sr) and cesium (^{137}Cs), long-lived soluble fission products including technetium (^{99}Tc) iodine (^{129}I), and activation products such as tritium and carbon (^{14}C). In addition to radioactive elements,

contaminants on equipment and structural surfaces at DOE facilities also include common solvents such as trichloroethylene (TCE), polychlorinated biphenyls (PCBs), RCRA contaminants, and toxic metals such as mercury. Grant applications may focus directly on the decontamination process (for example, development of reagents or approaches to selective leaching) or on reduction of the waste streams that are generated by decontamination process reagents.

b. Sludges and Solid Wastes—Highly radioactive sludges are typically metal oxides with large amounts of potentially soluble materials such as sodium or aluminum. Only about 0.3 percent of the waste is radioactive. Grant applications are sought for the direct removal of the radioactive materials (e.g., selective leaching of transuranics and strontium) or for the removal of the bulk constituents (aluminum, sodium) to leave a smaller volume of high level waste. Methods such as bulk leaching, selective leaching, dissolution, and extraction will be considered.

Grant applications are also sought for high temperature and chemical methods to separate radionuclides and hazardous elements from solid (e.g. calcined) radioactive waste streams. Of particular interest are processes that separate species into concentrated product streams, can withstand a radiolytic environment, are economically viable, can be scaled up to processing rates of 2 to 30 gallons per minute, and are simple to construct and operate.

c. Glass and Vitrification Processes—Grant applications are sought for the removal of the following materials from borosilicate glasses and vitrification processes: (1) metals (such as aluminum, zirconium, and chromium) and anions (such as phosphates) that are deleterious to borosilicate glass; (2) species (such as halogens, volatile metals, and volatile metal oxides) which generate toxic, difficult-to-handle off-gas streams in the vitrification of mixed waste (note: volatile metals, both radioactive and RCRA-regulated, include cesium, lead, mercury, rubidium, bismuth, cadmium, silver, and arsenic); (3) sulfates which can separate out in a melter, producing a highly corrosive liquid; (4) technetium, which exists in a number of different valence states, distributes to different waste streams during processing, and has a high mobility in many waste forms; and (5) noble metals (particularly palladium, rhodium, and ruthenium) which have an adverse effect on the formation of borosilicate glass and can have significant economic value.

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d. Soil and Groundwater Treatment—There are a wide variety of radioactive, toxic, and heavy metal contaminants in the groundwaters and soils at DOE facilities. Some of the most common are uranium, technetium, trichloroethylene, and polychlorinate biphenyls. Grant applications are sought for innovative ways to remove contaminants selectively and efficiently from groundwater and soils while removing as little non-contaminant material as possible. Selective adsorbents or extractants with high capacity, good mass transfer rates and/or kinetics, and high selectivity could be used ex situ for treating groundwaters pumped from aquifers, and such adsorbents may find applications in situ as "adsorptive barriers" which prevent underground transport of radioactive and toxic contaminants. When the source of the contamination must be excavated and removed, processes such as selective leaching may be needed for species that cannot easily be washed or volatilized. Because all such processes generate secondary waste streams, grant applications must also develop techniques to separate and recycle process reagents from these waste streams.

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31. COMPUTER STORAGE AND ANALYSIS FOR NONPROLIFERATION DATA COLLECTION

Treaties to enforce international nonproliferation goals include the Nuclear Nonproliferation Treaty, Open Skies, and the pending Comprehensive Test Ban Treaty. The implementation of these treaties requires the utilization of sensor data from satellites, aircraft, and on-site inspections. Large amounts of imaging and multispectral data, as well as data from ground geographical positioning systems, are collected. Current techniques to compile, correlate, and analyze these data are so time consuming and cumbersome that often high confidence conclusions cannot be reached in the required decision time frames. The international community has a need for computer-based techniques which can communicate, store, and screen data, perform statistical analyses, and display high confidence results coordinated to the geographical positioning information in near real-time. **Grant applications are invited only in the following subtopics:**

a. Data Fusion and Statistical Analysis—The amount of data collected during treaty verification is overwhelming. If decisions based on these data are to be made in a timely manner, critical data must be extracted, integrated, analyzed, and presented to decision makers in real or near-real time. Grant applications are solicited for smart systems which are capable of automatically screening and analyzing data collected during treaty verification and presenting the pertinent results geographically.

b. Neural Networks—Grant applications are solicited for a practical and convincing demonstration which uses a neural network to analyze data collected during the implementation of arms control and non-proliferation treaties. The demonstration should be based on digitally stored data retrieved from multiple and independent sources (such as those listed in the introduction paragraph above) or on analytical data to indicate the presence of a signal in a variable noise background. The demonstration must clearly show the advantage of the proposed system over existing systems in terms of unit cost, processing, time, or analysis accuracy.

c. Digitizing Images and Data Base Storage—Much of the data collected by inspection is in forms which are not conducive to automated computer processing in a standardized data base (i.e. photographs, maps, site plans, still video, full motion video, analysis results, meteorological data, sampling conditions, time-lapse film and video). Grant applications are sought for innovative ways to transform these data to digital form with low error rates. Grant applications must show improvements over existing commercially available schemes and produce data bases in standard form which can easily be used in fusion and neural network algorithms.

d. Non-Keyboard Input—International Atomic Energy Agency inspectors rely on notebooks, sampling kits, imaging systems, and specialized instrumentation to gather data during field inspections of nuclear facilities. Grant applications are solicited for automated, man-portable systems to perform record keeping and process the instrumentation data in real time for transfer to, and later interpretation by, a host computer. Such systems would significantly reduce the time required for inspectors to be on site. Since manual and keyboard systems are too cumbersome for field use, other approaches such as voice digitization or touch screen entry are also sought.

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32. LASER TECHNOLOGY FOR CHEMICAL ANALYSIS FOR NONPROLIFERATION ACTIVITIES

Laser-based measurement technology has become an important tool to remotely analyze effluents for non-proliferation and environmental purposes. While the applications will vary with each specific scenario, advances in lasers, optical filters, and sensor technology will promote their feasibility. **Grant applications are invited only in the following subtopics:**

a. Tunable Lasers—Grant applications are sought for solid state tunable lasers which operate in the ultraviolet range from 250 to 400 nm or in the infrared region from 1 to 5 μm and/or 8 to 12 μm . A high repetition rate (50 Hz or better) and high average power are required. These lasers must be capable of being used in the field to remotely detect effluents. As a result, they should be rugged, compact, portable, and efficient. Lasers which are limited to laboratory use will not be considered. Grant applications should compare the innovation to existing commercially available systems.

b. Laser Components—Grant applications are sought for laser components that will enhance the ability of tunable lasers to detect effluent species. Key components which have been identified are the development of non-linear crystals used in tunable lasers, electro-optic crystals used for modulating laser light, ultraviolet detector arrays, and diode pumped laser pumps. These components will receive primary consideration, but other innovations that improve the ability of a tunable laser to remotely detect effluents will also be considered. Components of the most interest will enhance tunable lasers in the 250 to

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400 nm, 1 to 5 μm , and 8 to 12 μm wavelength ranges. Crystal innovations must improve the conversion rate of photons for the tunable laser, create a higher damage threshold for the laser, and/or improve the transmission through the tunable laser. The ultraviolet detector arrays must improve the signal-to-noise ratio for multi-wavelength analysis of weak signals and provide greater speed for time/range gating over existing charge-coupled detectors. The diode pumped laser pumps must lower the cost and increase the power and efficiency over existing pumps. All components must be capable of being used in the field and should be rugged, compact, portable, and efficient. Grant applications should compare the innovation to existing commercially available systems.

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33. IMPROVED SENSOR TECHNOLOGY FOR NATIONAL SECURITY AND NONPROLIFERATION OF WEAPONS

Smaller, cost-effective, and more rugged sensors are required for numerous applications concerning national security and the nonproliferation of weapons of mass destruction. Data collected by these sensors must be compatible with commonly-available communication and data base standards to facilitate data retrieval for real-time analysis. **Grant applications are invited only in the following subtopics:**

a. Chemical Species Microsensors—Current sensor systems for nuclear effluent or chemical weapon

manufacture detection used by nonproliferation inspectors are bulky and cumbersome, and alternative systems must be developed to collect and store data. A microsensor on an integrated computer chip (IC) would be essential to the development of this type of detector. Grant applications are sought for the development of such microsensors which must be compatible with existing IC standards, controllable by an existing standard microprocessor, and show significant improvement over currently available commercial sensors.

b. Biometric Sensors for Security Applications—The existing method of photo badge presentation to a security guard for personnel identification is cumbersome and subject to erroneous identification. Grant applications are sought to develop unique biometric authentication sensors which utilize, for example, hand geometry, fingerprint identification, and/or voice recognition to enhance the efficiency of security at DOE facilities. Grant applications must clearly show cost effective innovations in biosensor technology to improve the current methods. Sensor performance characteristics of primary importance are invulnerability to tampering, non-intrusiveness, and high throughput rates.

c. Underground Structures Sensor Technology—National security agencies, federal and local law enforcement organizations, and arms control organizations are just a few examples of entities which have requirements for improved capability to detect and characterize underground targets. Of particular interest are sensors to detect buried spaces such as bunker or command-post structures, tunnels and cables, and rocket motors. Handheld or portable geophysical and remote sensing techniques developed over the past two decades have been promising but are limited in detection range, sensitivity, and user friendly operation. Grant applications are solicited for technology that will extend the existing detection capabilities of these sensors from meters to tens of meters or more when using airborne or handheld operations.

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* See Section 7.1

34. ENVIRONMENTAL TECHNOLOGY FOR NATURAL GAS, OIL, AND COAL

The design and development of fossil fuel processes must consider possible adverse effects on the environ-

ment. New environmental protection requirements are constantly under consideration by EPA, Congress, States, and others, as laws are reauthorized or amended.

Research and analysis can provide needed data and remediation methods for natural gas and oil recovery processes, and for gas field operations, to minimize the environmental impact and the cost of complying with regulations.

In addition, coal is a solid fuel containing components that are precursors of environmental pollutants or materials that are potentially damaging to downstream components. These deleterious materials include nitrogen and sulfur which form undesirable oxides during combustion. Further, coal contains mineral matter that is converted into ash that can lead to suspended particulates in air, erosion of or deposition in downstream components, and problems in solid waste disposal. Recently, there has also been concern about the effect of carbon dioxide from coal combustion on the global climate.

Grant applications are invited only in the following subtopics:

a. **Reduced Emissions from Coal Flue Gases—** Grant applications are sought to develop technologies to characterize and reduce emissions of toxic air pollutants in flue gases resulting from coal combustion. The pollutants of interest are: (1) toxic trace elements, especially mercury, Cl_2 , and HCl ; (2) respirable particulate matter (less than 10 microns in diameter); and (3) sulfur dioxide (SO_2), nitrogen oxides (NO , NO_2 , and N_2O), and carbon dioxide (CO_2) from atmospheric coal-fired combustors. Capture of at least 90% volatile species, such as mercury, is desired. Devices must be able to perform in the hot, dirty environment produced by the combustor. Regarding (2) above, particulate control devices should achieve collection efficiencies of 99.99% in this size range and be capable of handling gas streams with fluctuating characteristics produced by cyclic combustor operations. Regarding (3) above, technologies must treat flue gas downstream of the air preheater, be applicable to coal-fired systems in the electric utility and industrial sector, achieve a high degree of operational reliability (greater than 99%), and have low operating and capital costs. Parasitic energy requirements (encompassing the use of pumps, fans, reducing gases, steam, and fuel) for SO_2 and NO_2 control systems should not constitute more than 1% of

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the energy input to the combustor. Parasitic energy requirements for CO₂ control should be no more than 15% of the usable energy output. The system to control these pollutants individually, or in combination, must be simple to construct, operate, and maintain, and be capable of removal efficiencies of at least 80% for CO₂, 95% for NO_x, and 98% for SO₂.

b. Environmental Considerations in the Recovery and Processing of Natural Gas—Grant applications are sought to develop technologies or methodologies for: (1) the management of wastes (particularly produced water) generated during drilling, production, and processing (including waste minimization, characterization, treatment, and disposal); (2) the measurement, treatment, minimization, and disposal of naturally occurring radioactive materials (NORM) in natural gas drilling, production, and processing; (3) the evaluation and control of greenhouse gas emissions from production and distribution operations; (4) drilling and producing natural gas from wetlands, offshore, and other sensitive areas in an environmentally acceptable manner; and/or (5) characterization and remediation of polychlorinated biphenyl and mercury contamination of soils associated with natural gas production operations.

c. Environmental Considerations in the Recovery of Oil—Grant applications are invited on innovative methods and concepts that allow more efficient, effective, and economic reduction of environmental risk from the primary, secondary, and enhanced oil field extraction of petroleum. The areas of interest are: (1) technologies for the management of solid and liquid wastes generated during drilling and production, including waste minimization characterization, treatment, and disposal; (2) technologies related to the measurement, treatment, minimization, and disposal of naturally occurring radioactive materials (NORM) in drilling and production operations; (3) methodologies for drilling and producing oil from wetlands, offshore, and other environmentally sensitive areas in an environmentally acceptable manner; (4) environmentally safe and economically reversible plugging techniques; (5) improved methods for more cost-effective protection of drinking water aquifers, including logging techniques, well completion techniques, mechanical integrity testing methods, and plugging and abandonment methods; and/or (6) methodologies for characterization and remediation of soils, and surface and groundwater contamination from produced water, drilling wastes, hydrocarbons, and

other wastes associated with the oil drilling and production operations. Applications for research relating to open water oil spill cleanup technologies will not be considered.

d. Management of Coal Wastes—Methods of minimizing or utilizing coal-derived residues, especially wastes from advanced coal combustion or conversion technologies (such as fly ash, bed ash from Pressurized Fluidized Bed Combustion, bed material from Integrated Gasification Combined Cycles, and coal liquefaction by-products), are of interest. Grant applications are sought to develop technology: (1) to recycle the above wastes within the processes in which they are generated or to reduce the amount of waste generated through improved process modifications (e.g., in-bed sulfur sorbents with higher capacity); (2) to utilize residues produced in fluidized-bed combustion, limestone injection multistage burners, advanced flue gas cleaning, or gasification processes (these wastes typically have free lime or slaked lime mixed with coal ash and high pH which, if the waste is landfilled, may result in increased disposal costs); and/or (3) for advanced utilization techniques for waste from small-sized industrial boilers. Such facilities are spread over large geographical areas, might produce waste intermittently and in relatively limited quantities, rarely have dedicated disposal facilities, and, therefore, are likely to have high disposal costs.

For (2) and (3) above, grant applications should address uses for the whole waste and not just fractions that meet specific criteria. The complexity of the equipment and machinery needed to implement the proposed waste utilization techniques should also be addressed. In the past, high capital costs have been a deterrent to the implementation of new utilization methods.

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35. ADVANCED RECOVERY OF OIL

DOE seeks innovative methods and concepts that will contribute to more efficient, economic, and environmentally acceptable techniques for the recovery of domestic oil in declining fields. After primary (natural forces) and secondary (water flood and gas) pressurization recovery techniques have been used, approximately two-thirds of the original oil remains in place in the known producing fields - an estimated 327 billion barrels. About 100 billion barrels of this potential resource exists as pockets of mobile oil, bypassed because of heterogeneities in the reservoir. Much of this remaining oil can be produced by conventional methods once its location and the cause of its non-recovery are determined. Residual oil is also susceptible to recovery by enhanced oil recovery (EOR) techniques (i.e., the injection of heat, gases, or chemicals). Better reservoir understanding and engineering design of all of these operations (primary, secondary, and EOR) are needed to increase domestic oil production. Reservoir characterization is the most important means of understanding the reservoir. Its two main facets - defining the anatomy of the reservoir and determining how that anatomy governs fluid movement - are requisite to any improvements in an oil recovery strategy.

Grant applications are invited only in the following subtopics:

a. Sweep Improvement for Enhanced Oil Recovery (EOR) Processes—One of the major problems in EOR sweeping processes for light oil is the control of injected fluids. Grant applications are sought to develop methods to improve these processes. This may be achieved, for example, by directing the injected fluid into previously unswept zones while restricting the injected fluid flow into the high permeability zones (by deep plugging or by restricting flow). Both chemical and gas flooding processes are of interest. The process should not be based on profile modification or near-wellbore changes in permeability, electrical methods, in-situ microbes, chemicals produced in-situ by microbes, chemicals which are not reasonably characterized (whether or not they are produced by a chemical reaction or microbial methods), or a computer study. Novel sweep improvement agents proposed should neither be currently available from any major chemical supplier nor under patent rights to anyone other than the applicant.

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b. Novel Surfactants—The inability of most known surfactants to tolerate high salinity, high hardness, and high temperature reservoir brines is a major problem in conducting EOR by surfactant flooding. Grant applications are sought to develop novel surfactants which operate under these harsh conditions. The novel surfactants should not be based on electrical methods, in-situ microbes, chemicals produced in-situ by microbes, chemicals which are not reasonably characterized (whether or not they are produced by a chemical reaction or microbial methods), or a computer study. Novel surfactants proposed should neither be currently available from any major chemical supplier nor under patent rights to anyone other than the applicant.

c. Steam Injection Recovery of Heavy Oil—A major problem area in steam injection processes is low reservoir sweep efficiency. Grant applications are sought on novel techniques for steam processes to: (1) improve the effective sweep of the reservoir during steam injection by reducing the effects of overriding gravity segregation, insufficient mobility control, and heterogeneities, or (2) recover the remaining oil left in the lower part of the reservoir after steam injection has been terminated. Grant applications on improvements in reservoir sweep efficiency should not include conventionally used foams in steam injection processes. Multiple injectants, either injected from the surface or created in situ, should be considered for mobility control and improved recovery.

d. Oil-Field Geoscience—A more complete understanding of the internal architecture of reservoirs, with an emphasis on the location and prediction of heterogeneities, is the key to determining how anatomy governs reservoir fluid movement. Grant applications are sought on novel methods: (1) to characterize and quantify reservoir parameters including porosity, permeability, pore structure, capillary pressure, fracture patterns, and facies geometry; (2) to interpret depositional, diagenetic, or structural features of reservoirs for prediction of the spatial distribution of heterogeneities and their influence on fluid flow within known oil reservoirs; (3) to characterize known hydrocarbon reservoirs such as wellbore logging, seismic tomography, electromagnetic tomography, and three-dimensional seismic profiling; and (4) for computer modeling of reservoir heterogeneities and reservoir/fluid interactions. Grant applications on new production equipment will be declined.

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* Available from Society of Petroleum Engineers, P.O. Box 838836, Richardson, TX 75083-3836 (Telephone 214-952-9393)

** Available from National Petroleum Council, 1625 K Street NW, Suite 600, Washington, D.C. 20006 (Telephone 202-393-6100)

*** See Section 7.1

**** Available from Alberta Oil Sands Technology and Research Authority, 500 Highland Place, 10010-106 Street, Edmonton, AB, CAN T5J3L8

36. NATURAL GAS SUPPLY

DOE seeks innovative methods and concepts that will allow more efficient, economical, and environmentally acceptable recovery of natural gas. Novel improvements in recovery techniques could lead to lower production costs and/or greater recovery efficiencies. DOE's interests in drilling, completion, and stimulation are to lower capital investment, improve recovery, and minimize formation damage. Collectively, these objectives are expected to reduce the unit cost of accessing and producing natural gas. The interest in low-permeability formations is to improve the detection, mapping and analysis, and gas production of naturally fractured gas reservoirs for economic recovery. The interest in gas delivery and storage is focused on assisting the storage industry to develop, test, and improve new or existing technology for improved storage system capacity and deliverability as well as to assist and provide the gas storage industry more accurate and timely information on the natural gas pipeline/storage system network. The interest in natural gas upgrading is in converting methane to liquids or chemicals in a simple one- or two-step process under moderate operating conditions of pressure and temperature, and advancing processing technologies for raising low-quality raw natural gas to pipeline quality.

Grant applications are invited only in the following subtopics:

a. Drilling, Completion, and Stimulation—Innovative approaches are desired to reduce the cost of drilling gas wells while improving or maintaining safety, and minimizing environmental disturbance. Grant applications are sought for technologies, systems, and methods which: (1) increase the rate-of-penetration, (2) provide timely, accurate geologic and

drilling information, (3) result in new tools for cutting medium-to-hard, abrasive formations, (4) enhance horizontal well, slimhole, and underbalanced drilling technology, (5) minimize stimulation fluid damage, (6) introduce and demonstrate novel stimulation concepts, and/or (7) develop new or improved completion hardware.

b. Low-Permeability Formations—Research has shown that gas production from low-permeability "tight" gas reservoirs is dependent on the presence of natural fracture systems for economic production. The use of horizontal or steeply inclined boreholes to increase production from these reservoirs is dependent upon the knowledge of fracture systems and their orientation for proper drilling design and stimulation. Grant applications are sought for innovative methods to identify, locate, and orient these fracture systems so that recovery of gas from low-permeability (<0.1 millidarcy) reservoirs can be improved. These innovative techniques/methodologies include: (1) high-resolution seismic techniques to locate naturally fractured reservoirs, and (2) improved geological and geophysical methodologies for mapping, prediction, and analysis of naturally fractured gas reservoirs.

c. Delivery and Storage—Grant applications are sought for innovative and cost effective methods to improve the deliverability and the capacity of the natural gas storage reservoirs. Topics of interest include: (1) cost-effective improved storage capacity for industrial/power generation users in areas of high demand, (2) new or improved methods to revitalize deliverability from existing storage wells, (3) methods to optimize new or infill storage field development, (4) cost effective methods to reduce gas migration in problem fields, and (5) cost effective methods to reduce gas trapping in aquifer storage.

d. Natural Gas Upgrading—Domestic supplies of natural gas are abundant. However, some natural gas resources are remote from gas transportation systems or contain large amounts of nonmethane gases which make them uneconomical to market as natural gas. The ability to convert these remote and potentially low-value gases to high-value liquids or to remove the nonmethane impurities could have significant favorable economic and energy efficiency impacts. Grant applications are sought for innovative technologies to convert natural gas to liquid fuels and to raise low-quality raw natural gas to pipeline quality. Regarding natural gas conversion to liquid fuels, interest is in

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simplified processes for producing specialty chemicals or higher value hydrocarbons directly and in new or improved separation techniques to remove desired products from unconverted feedstock. Regarding the raising of low-quality raw natural gas to pipeline quality, techniques using small scale facilities are sought and include: membranes, absorption/adsorption, and/or hybrid combinations of these technologies. With respect to the removal of hydrogen sulfide from natural gas, the techniques sought must also encompass its subsequent or direct conversion to elemental sulfur or other environmentally benign products.

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* See Section 7.1

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37. NATURAL GAS UTILIZATION

DOE is funding efforts to develop and demonstrate advanced technologies for the utilization of natural gas. Programs are underway to develop both advanced gas turbine systems and fuel cells for high efficiency production of electricity from natural gas. Successful commercialization of these advanced technologies will reduce national fuel use because of improved efficiency, while providing benefits to the U.S. environment and economy. DOE is interested in innovative research to support these developments. **Grant applications are invited only in the following subtopics:**

a. Advanced Turbines Components—Grant applications are sought for the development of novel components for advanced, ultra-high-efficiency gas turbine power systems and for the improvement of existing components. Component innovations must support the development of advanced power systems under the DOE Advanced Turbine Systems program (References 5 and 7). They should either contribute directly to the achievement of program goals or offer promise to provide improved performance in the time following initial commercialization. The innovations may address requirements for initial natural gas-fired systems or requirements for eventual adaptation of the systems to coal.

b. Thermodynamics of Advanced Turbines—Grant applications are sought to develop advanced thermodynamic cycles or cycle improvements to increase system efficiency in support of the Advanced Turbine Systems program (References 5 and 7). These efforts should either contribute directly to achieving program goals, offer promise to provide improved performance later, or contribute to system adaptation to coal-firing.

c. Molten Carbonate Fuel Cells—Molten carbonate fuel cell technology is important for stationary electric power generation. Grant applications are sought to develop novel designs and materials which can provide lower stack cost, longer operating life (lower decay rates), and improved performance (higher power density).

d. Solid Oxide Fuel Cells—Stationary power generation can also benefit from advancements in solid oxide fuel cell technology. Grant applications are sought to develop novel designs and improved

materials which can result in improved performance (lower internal resistance), longer operating life (lower decay rates), and lower stack cost.

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* See Section 7.1

38. ADVANCED COAL-BASED POWER SYSTEMS

The DOE is supporting the development of new, coal-fired power plants based on advanced pulverized coal technology with the potential for high efficiency, low emissions, and reduced cost relative to today's coal-fired generating plants. These systems include ad-

vanced pulverized coal combustion with both direct- and indirectly-fired cycles, integrated gasification combined cycle (IGCC), and pressurized fluidized bed combustion (PFBC).

In contrast to direct coal firing, in indirectly-fired cycles, heat released from coal combustion is transferred across heat transfer surfaces to the gas turbine working fluid (e.g., air) as it passes through the compressor section of the turbine, increasing its temperature to a level limited by system design characteristics and materials capabilities. Further heating of the working fluid, if needed, occurs through direct firing of a clean supplemental fuel in the gas turbine combustor in order to take advantage of modern gas turbine inlet temperatures. After expansion through the turbine, part or all of the turbine exhaust is used for the combustion of coal. Energy remaining in the coal flue gas (and in the gas turbine exhaust not recycled to the coal combustor) is extracted via a steam bottoming cycle. The success of the system depends in part on the ability to effectively and economically transfer heat to the working fluid while minimizing degradation of the high temperature heat transfer surfaces.

In an IGCC system, coal is converted into a gaseous fuel, which, when cleaned, is comparable to natural gas. The fuel gas, composed of hydrogen and carbon oxides, is generated in a gasifier when coal reacts with steam and air or oxygen. Over 99 percent of the coal's sulfur and particulate contaminants are removed before the fuel gas is burned in a high-efficiency combustion gas turbine/generator. The hot turbine exhaust gas produces steam to drive a steam turbine/generator. Today, six state-of-the-art IGCC technologies are in various stages of commercial demonstration with expected installation costs of \$1,500 to \$2,000 per kilowatt and with plant efficiencies around 40 percent. DOE seeks to achieve plant efficiencies of 45 percent and 52 percent, and capital costs of \$1,200 and \$1,050 per kilowatt, by the years 2000 and 2010, respectively. If these goals are achieved, IGCC investment could exceed \$150 billion by the year 2030.

PFBC systems have several inherent advantages over conventional pulverized-coal power systems. High system efficiency results from the combined-cycle configuration, which includes a conventional steam cycle and a gas turbine. Limestone or dolomite mixed with coal in the fluidized-bed removes the coal's sulfur, eliminating the need for post-combustion flue gas

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desulfurization. Lower combustion temperatures and air staging reduces the amount of nitrogen oxide emissions. Ceramic filters are used to clean the hot gases from the pressurized fluidized-bed combustor and partial gasifiers that are incorporated into higher-efficiency advanced PFBC systems. The ceramic filters ensure that turbine corrosion/erosion/deposition requirements and environmental emissions limits are met. Fluidized-bed combustion systems also produce a dry ash by-product that can be beneficially reused. PFBC technology is on the brink of commercialization, with five principal firms developing first-generation PFBC power systems capable of net system efficiencies approaching 42 percent with installation cost expectations ranging from \$1,300 to \$2,000 per kilowatt. DOE seeks to achieve PFBC system efficiencies of 45 and 52 percent, with capital costs of \$1,100 and \$1,000 per kilowatt by the years 2000 and 2010, respectively. If these goals are achieved, PFBC investment could exceed \$400 billion worldwide by the year 2030.

All of these coal-based power systems require materials and components capable of withstanding high temperatures and corrosive environments. Of particular interest are products that would improve system economics via enhancements to the capabilities/economics of materials used within these systems. Areas of interest include both alloy and ceramic materials used to contain working fluids such as high temperature air and supercritical steam.

Grant applications are invited only in the following subtopics:

a. Advanced Pulverized-Coal Power Systems—Coal-fired burners, integrated burner systems, and critical components have potential application to advanced pulverized-coal power systems including indirectly-fired cycles. Grant applications are sought to develop: (1) advanced combustion control diagnostics which provide continuous on-line measurement and control of the fuel and air flow rates for each burner, or at specific locations in the boiler or coal combustor; (2) low temperature heat recovery systems or systems integration schemes for using low-grade heat from the flue gas to economically increase power plant efficiency; (3) scientifically-based computational tools for design and performance analysis (applications may include improvement of existing codes or development of tools which address mitigation of coal-ash related problems, minimization of emissions, efficiency of fuel use, heat release patterns, and heat

transfer); and (4) critical components for use in advanced cycles (supercritical steam cycles and variable-composition working fluid cycles - humid air turbine cycle, and Kalina cycle), including pressurized high-temperature ceramic heat exchangers (including structural support designs and high pressure seals), novel high-pressure water injection systems, and direct evaporative coolers for advanced water-augmented indirectly-fired gas turbine systems.

The combustion systems may operate in either a slagging or non-slagging mode and must exhibit enhanced overall system performance (lower capital, operating, and maintenance costs) relative to conventional low-NO_x burners, with substantially reduced NO_x emissions and a high level of carbon utilization.

b. Integrated Gasification Combined Cycle Systems—Grant applications are sought to develop: (1) novel, effective, economic, and efficient processes and/or devices for removal of physical and chemical contaminants independently or in combination from coal gasification streams to levels that meet gas turbine and/or environmental emission requirements, (2) novel systems to decompose ammonia in IGCC fuel gas streams and/or to cleanly combust fuel gas with minimal NO_x production, (3) innovative low cost and reliable systems for sulfur removal from the pressurized IGCC fuel gas at high temperatures (i.e., above the dew point of the gas), (4) novel low cost technologies to produce sulfur byproducts in conjunction with high temperature sulfur removal, (5) systems for monitoring, characterization, and control of air toxics in IGCC gas streams, (6) novel low cost, long life barrier filter systems for high pressure, high temperature particulate removal in IGCC gas streams, and (7) improved instrumentation and components suitable for IGCC high pressure, high temperature gas streams.

c. Pressurized Fluidized-Bed Combustion Systems—Grant applications are sought to develop: (1) critical components such as more effective piping systems for high-temperature, high-pressure gas streams with high-solids contents, valves used to control the transfer of hot bed material, and coal/water paste feed pumps; (2) novel gas turbine compatible fuel gas combustion systems that can boost gas temperatures entering the gas turbine into the 2,600° F range with minimal NO_x production; (3) systems for monitoring, characterization, and control of air toxics in PFBC gas streams; (4) novel low-cost, long-life barrier filter systems for high-pressure, high-temperature

particulate removal in PFBC gas streams; (5) devices for simultaneously removing particulates and chemical contaminants independently or in combination to levels that meet gas turbine and/or environmental emission requirements; and (6) novel concepts and equipment configurations that allow the fuel-flexible nature of fluidized-bed combustion systems to reduce operating costs through the introduction of opportunity fuels (such as high sulfur coal, petroleum coke, and municipal waste sludges) and/or sorbents.

d. Materials and Components for Coal-Based Power Systems—Grant applications are sought for: (1) new structural ceramics and alloys including ceramic composite materials, nanocluster ceramics, advanced austenitic alloys, iron aluminides, and ultra-high temperature intermetallic alloys; (2) novel manufacturing/production techniques that would significantly reduce the cost of a material used in a coal-based power system (of particular importance is the incorporation of these advanced materials into near-net shape components which solve a critical problem in coal-based power systems, as opposed to the general assessment of a new material combination using coupon testing); (3) new coatings or other material formulations with improved high-temperature strength/corrosion resistance/economics relative to materials currently available or in development (applications in this area must focus on specific solutions to known corrosion mechanisms which lead to material degradation in the highly corrosive environments of coal-based power systems); (4) novel design tools/methodologies for the mechanical design of high-temperature heat transfer surfaces; and (5) improved techniques for joining ceramics to ceramics and ceramics to metals.

Grant applications are also sought to develop: (1) solid-state electrolytes for energy conversion, gas separation systems, and electrochemical reaction systems; and (2) functional materials for inorganic porous/non-porous systems that would be used in gas separations including ceramic filters for hot gas clean-up.

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39. ADVANCED FOSSIL FUELS RESEARCH

Though coal is our most abundant and inexpensive fossil fuel, the release of clean energy from coal requires the solution of many problems in processing, transport, and conversion. The results of novel approaches and innovative research could contribute to greater utilization of our fossil resources. **Grant applications are invited only in the following subtopics:**

a. Coal Preparation—Coal preparation processes are used to pretreat or modify coal to provide a fuel appropriate to various applications. These processes include removal of ash-producing minerals such as pyrite, trace elements, sulfur, and nitrogen through physical, chemical, biological, or combined methods. New process concepts, or improvements in existing processes, can enhance beneficiation technologies and/or the handling and marketability of coal through physical, physicochemical, chemical, or biological means. Grant applications are sought for advances in the following processes: (1) comminution, surface- or density-based cleaning, dewatering/drying for either low or high rank coals, reconstitution, and enhanced energy recovery through applications of high-technology instrumentation; (2) optimization programs for coal preparation, including hardware (i.e., advanced sensors, controllers) and software (i.e., advanced diagnostics, algorithms) that support artificial intelligence and neural networks in the whole plant or in unit operations within the plant; and (3) chemical or physicochemical coal treatment and/or biological methods for dechlorination, desulfurization, and denitrification.

b. Recovery and Processing of Coal Fines—It is estimated that millions of tons of coal fines (minus 28 mesh) are being impounded annually in the United States as waste material from coal preparation plants. Approximately 40 million tons of raw fine coal are produced just in the eastern U.S. Environmental and economic benefits that may be obtained from utilizing

these coal fines include limiting the amount of coal waste sent to storage ponds and providing a potentially low cost fuel. Grant applications are sought to develop technologies for the recovery, processing, and combustion of coal fines that are now being generated as waste products from coal preparation plants. Grant applications should identify novel approaches to converting specific coal fines waste stream(s) into a fuel form that can be utilized alone, or in combination with other fuels (e.g., industrial wastes and/or biomass).

c. Solids Transport—Large amounts of coal are transported and processed each year, and significant amounts of money and energy are spent for these operations. Coal and other solid materials such as ash, sorbents, and catalysts are handled in many plants producing or using coal-based fuels (including coal preparation plants, industrial and electric utility plants, and liquefaction or other processing plants) in the bulk granular phase, dense pneumatic phase, or slurry phase. Knowledge of these flows is less mature than that of single fluid flow, and this lack of knowledge limits the effectiveness in handling bulk solid materials. New developments in solid transport technologies, including measuring and monitoring devices, will help to elucidate the basic characteristics and dynamics of these flows, improve the existing methods of handling solid materials, and reduce transport and processing costs. Grant applications are invited to develop: (1) novel, industrial-style instruments and devices that can diagnose, monitor, or control these granular, dense pneumatic, or slurry flows (parameters of interest include, but are not limited to, mass flow rate, solid concentration and velocity, and agglomerations of solid particles); (2) advanced control software that can improve the stability and reliability of the solid transport processes; and (3) new concepts and improvements for lowering attrition in dense pneumatic systems or for moving bulk solids over long distances with low energy consumption and low cost. The proposed efforts should be applicable to the specific flows found in fossil energy transport processes.

d. Conversion of Coal and Oil Products—Liquefaction refers to the direct hydrogenation of coal to produce liquids and to the production of liquids from syngas produced by coal gasification. Heavy oil processing refers to the upgrading of difficult to process heavy petroleum residuums via coprocessing with coal or other hydrogen addition and carbon rejection processing techniques. Grant applications are sought

to develop: (1) innovative reaction concepts and catalyst systems (fixed-bed or disposable) to promote more efficient conversion reactions (the emphasis is on significant process cost reduction and may include novel approaches for gaining additional knowledge of reaction chemistry as well as novel biological approaches); (2) novel methods for improving mild gasification of coal resulting in more valuable upgraded liquid and solid fuel products, lower costs, and/or improvement in environmental performance; and (3) innovative processes for the production of synthesis gas and/or hydrogen from coal (these processes may involve reactor concepts, catalysts, biological processes, and the separation of sulfur, nitrogen, and/or trace contaminants from coal gas streams). Grant applications on incremental improvements of conventional technology and minor modifications of prior work will be declined.

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40. IMPROVED TECHNOLOGY FOR OBTAINING RECYCLABLE MATERIAL FROM MUNICIPAL SOLID WASTE

Although landfilling is the most common waste management option, most states and many communities have set goals for diverting municipal solid waste (MSW) from landfills. These objectives are generally expressed as material recycle goals. A major obstacle to achieving these goals is the cost of collecting and/or separating potential recyclables from the MSW and preparing them as marketable secondary materials. Also, current practice often uses manual labor to conduct the sorting. Generally, the cost of recovering the material exceeds the cost of similar virgin materials. Innovative technology is needed that will reduce these costs and/or minimize the manual labor for generating marketable secondary materials.

Recycling/waste control/processing is identified as one of the national critical technologies in the area of energy and environment. MSW is a source of clean energy, but, if not properly treated, will continue to be an environmental burden in the future. **Grant applications are invited only in the following subtopics:**

a. Collection—Studies have shown that collection of recyclable materials at the curbside is usually the most expensive step. Costs of \$90 and \$150 per ton collected have been published, and some large cities have reported curbside collection costs of over \$200 per ton. In spite of the economic burden, curbside collection is the approach used at the community level. Current costs greatly reinforce the need for new commercial alternatives that the community can readily adapt to its specific needs. Grant applications are sought for innovative collection technology that could significantly decrease costs without compromising the quality and quantity of recyclable materials. Grant applications must address one or more of the factors which affect cost: crew size, productivity, extent of material separation, and vehicle and equipment requirements.

b. Material Separation and Processing—Recyclable materials collected at the curbside are processed in a material recovery facility (MRF). MSW, or the materials left after curbside collection, is

processed in a mixed waste MRF. Either method, MRF or mixed waste MRF, adds significantly to the cost of preparing recyclable material for the secondary material markets. Average costs of \$50 per ton processed have been published. The quality of the secondary materials often limits markets. Also, manual labor is often required to reach a satisfactory level of secondary material quality. Grant applications are sought to develop innovative methods for material separation and processing which reduce the need for manual separation and reduce the total cost. Possible approaches could include mechanical separation, coding, sensors, or new uses for secondary materials that can readily be scaled to the commercial level.

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* See Section 7.1

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41. LIGHTWEIGHT COMPOSITE MATERIAL FOR AUTOMOTIVE STRUCTURES

One of the missions of the DOE is to develop new and emerging technologies that promote the conservation of petroleum products. This goal is often coupled with a need to reduce environmental pollution by waste minimization or recycling efforts. Petroleum products find their greatest use in the transportation industry where automobiles currently account for just under two-thirds of the Nation's gasoline consumption and about one-third of the total U.S. energy usage. Since 75% of a vehicle's fuel consumption is directly related to factors associated with its weight, reducing the weight of future automobiles and the components comprising vehicular structures is critical to reducing domestic oil consumption.

Because of their high strength to weight ratio, composite materials have the potential for reducing vehicle mass without sacrificing passenger safety or comfort. However, several technological hurdles must be overcome before composites will see wide scale use in the load bearing structures of automobiles. **Grant applications are invited only in the following subtopics:**

a. Processing and Production of Low Cost Glass Fiber Preforms—The manufacture of composite materials often requires the use of preforms made of inexpensive glass fibers. These preforms are used to make liquid molded [Structural Reinforced Injection Molding/Resin Transport Molding (SRIM/RTM)] composites. Grant applications are sought for new processing technologies which will allow for an increase in the production rate of large glass preforms, and provide significant cost reductions in the resultant glass fiber preforms. The Phase II project should culminate in a prototype demonstration and show a path to commercialization.

b. Liquid Composite Molding Technology—Large structural components for future automobiles may be molded in one piece to reduce assembly costs and production line start-to-finish times. In order to form large structural automotive parts, liquid composite molding (SRIM/RTM) technologies are expected to be employed where a reactive liquid resin is injected into a closed mold containing a preform

which would most likely consist of glass fibers. Grant applications are sought to develop molding process technologies, including mold and part designs, which are both rapid and cost effective. Grant applications should consider opportunities and restrictions inherent in the use of glass fiber preforms and the liquid molding process, address both mold and part design, and should involve polymer based composite materials. The Phase II project should culminate in a prototype demonstration and show a path to commercialization.

c. Durability Characteristics of Light Weight Composite Structures—Steel has been well characterized in a wide variety of environments to which it is subjected over the life of an automobile. One of the major barriers to the use of composite materials in automotive structures is the uncertainty of their response over long periods of time in a variety of climates and conditions. Grant applications are sought to develop test methods to evaluate the durability of automotive composites over a vehicle's life span while subjected to the same stresses and environmental conditions as current automobiles. Materials to be evaluated must be light weight polymer-based composite structures made from high volume manufacturing processes. By the end of Phase II, the test methods must be proven using potential automotive composite materials.

d. Test Methods for Structural Adhesive Joints—A critical aspect of using composite materials is the manner in which they are joined. Adhesive bonding is potentially an economical and structurally sound means of joining reinforced polymers and other alternative automotive materials and may overcome a major obstacle to the incorporation of polymer composites into automobiles. The automotive industry does not currently have a complete set of processes and methods for evaluating candidate adhesives, adherents, and their interactions for use in bonding structural automotive composite components. Grant applications are sought to develop test methods to evaluate the ability of an adhesive joint to resist fracture, creep fracture, fatigue, fatigue fracture, impact loading, and environmental degradation. Grant applications must develop and validate the test methods with multiple composite/adhesive combinations.

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42. HYBRID ELECTRIC VEHICLE TECHNOLOGY

New technology needs have been identified in connection with electronic systems for future highway vehicles. These systems could improve the energy management and control of electric and hybrid electric light-duty vehicles. Electric drive highway vehicles will be controlled by solid state electronic devices, thereby increasing the number and complexity of interactions between system components. There will be a need for high efficiency electronic devices and for the development of an integrated approach to vehicle electronic development. This topic is in support of the Partnership for a New Generation of Vehicles (PNGV). **Grant applications are invited only in the following subtopics:**

a. High Power Switching Controls for Hybrid Electric Vehicle Transportation Systems—Advanced semiconductor power switching devices have potential application in electric and hybrid electric passenger vehicles. Grant applications are solicited to develop silicon carbide field effect devices with significantly increased power density over conventional silicon devices. The proposed devices must operate in

harsh environments (temperature extremes, moisture, vibration, electromagnetic interference) without requiring extreme protective measures such as climate conditioning. Grant applications should attempt to quantify: (1) the development risks inherent in scaling up the device current/power density (a scale-up factor of approximately 100 over conventional silicon devices); and (2) the cost of devices in production volumes of 20,000 to 100,000 per year.

b. Multiplexing Wiring Systems for the Control of Hybrid Electric Vehicle Powertrain and Auxiliary Power Systems—Multiplexing (interactive data communication) is forecast to be important in the car of the future. Multiplexing is a technology that allows for serial data communication instead of parallel communication. If successfully applied, the technology will provide many system performance benefits, particularly for vehicles which are highly dependent on electronic controls. Grant applications are sought to develop methods for utilizing multiplexing as a future data communication protocol for the hybrid vehicle electric driveline and auxiliary power (human factors power needs) control systems. Grant applications must include analyses to determine technology critical paths and cost effectiveness for multiplexing systems as potentially applied to hybrid vehicles.

c. Combustion Sensing for Hybrid Electric Vehicles Using Alternative Fuels—In hybrid electric powertrain systems, sensors will be required for combustion and engine output detection and control. Hybrid vehicle engines may be smaller in power output, will likely use alternative fuels, and may perform in significantly different operational regimes than the engines in conventional vehicles. The increasing demand for simultaneous reduction in exhaust emissions and fuel consumption will further drive the requirement for advances in electronics, and in particular, sensors and sensing systems. Grant applications are sought to develop sensors and sensor systems that can detect and control parameters of combustion and engine output and that can function in the operational environments of advanced hybrid vehicle engines (piston, gas turbine, diesel, or Stirling). For example, direct combustion monitoring sensors could optimize the air/fuel ratio for emissions and the energy efficiency change with the fuel's chemical composition.

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* See Section 7. 1

43. MODULAR AND PANELIZED PASSIVE SOLAR BUILDINGS

Modular and panelized buildings are manufactured at least in part in the factory, and then erected at the site. Passive solar buildings, using solar and environmental resources in combination with energy efficiency measures, can significantly reduce the heating, cooling, and lighting energy requirements of the buildings. Passive solar strategies in monitored residential buildings have provided 30 to 50 percent of the heating and cooling requirements of the buildings, and reduced the heating, cooling, and lighting requirements of non-residential buildings by 46 percent compared to conventional energy-conserving buildings of the same type. Generally, passive solar buildings cost little or no more to build than conventional ones.

Analyses have shown that advanced passive solar technologies can potentially provide 75 to 95 percent of the heating, a significant portion of the cooling, and 80 percent of the perimeter lighting needs of a well-designed building. To achieve this potential, buildings must be designed with the understanding of how solar technologies interact with one another and with other

building systems within the context of the whole building. This can be demonstrated most effectively in the design, construction, and performance monitoring of buildings. However, contributions can also be made through evaluating the potential of materials and concepts using design and analysis tools that properly account for the dynamics of passive solar buildings. **Grant applications are invited only in the following subtopics:**

a. Modular Townhouses for Infill Housing—Widespread use of row-house construction has occurred since the settlement of the U.S. These two- and three-story units strung together along varying lengths of roadways, and derived from European housing styles, have provided efficient, affordable housing at a very "human" scale. New housing developments have sought to emulate the charm and amenity of row-houses. Modular construction, which is utilized in approximately 5 percent of new housing, has frequently been utilized for town- and row-housing. Seldom are modular units used for town- and row-housing on urban infill sites, and seldom is passive solar design employed.

Grant applications are sought for the design and development of innovative concepts for passive solar modular townhouses appropriate for urban locations where sites range from large open areas of ten acres or more to small lots accommodating two or three dwelling units. Concepts must integrate (1) passive solar heating, natural ventilation for cooling and indoor air quality, and daylighting, (2) non-toxic, recyclable materials/products, and (3) solar domestic hot water (if merited from an economic standpoint). In addition, concepts must emphasize the potential for manufacturing, be realistic and replicable in both community-scale housing projects and small sites, address anticipated energy savings associated with passive solar design and thermal comfort, accommodate the variable orientations and surroundings of urban sites, and provide integrated passive solar design and occupant needs for communications, security, lighting, and appliances. Extra-wide modules (ranging from 16 to 24 feet in width) which incorporate the entire width of the dwelling, resulting in fewer on-site connections, are of interest as are innovative steel framing concepts that showcase non-commercial construction suitable for urban fire districts. Grant applications should identify one or more existing modular producers, preferably those located in areas close to urban housing sites, and their involvement in Phases I or II of the project

should be described. **Grant applications involving improvements to existing products and designs will not be considered. Likewise, applications that do not integrate passive solar design will be declined.**

b. Panelized Buildings with Masonry Construction—Panelized building systems, including advancements like structural insulated panels (SIPs), are becoming more widespread in commercial and institutional building applications. Concrete masonry has been a staple in construction for centuries, with new systems constantly emerging. Optimal combinations of these two technologies, integrated to create passive solar non-residential buildings, present significant opportunities for comfortable, attractive, affordable buildings. Grant applications are solicited for the design and development of innovative concepts for passive solar commercial and institutional building construction systems that combine SIP systems and concrete masonry systems. These concepts should result in passive solar structures that effectively integrate: daylighting, passive solar space heating and ventilation preheat, natural ventilation for cooling and indoor air quality, and non-toxic, recyclable materials. Grant applications must address the following issues (for resolution in Phases I or II of the project): (1) anticipated solar contributions of the design to heating, cooling, and lighting needs, savings in energy consumption, and reduction in peak electric demand, (2) the simplicity of the system and its ability to integrate electric power distribution, auxiliary HVAC systems, communications, or electronic network, (3) ease of fabrication, and (4) the interfaces between panels and masonry to minimize air infiltration and conduction losses, and to reduce insect infestation and moisture penetration. Grant applications must also include indications of adherence to industry standards or practices.

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Please note: (1) The technical topics are to be interpreted literally; DOE personnel are not permitted to elaborate on the language in the technical topics. (2) The award selection process is extremely competitive. Last year, only 1 out of 11 grant applications was awarded. Only those applications with the highest scientific/technical quality will be competitive.

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* See Section 7.1

44. TECHNICAL IMPROVEMENTS FOR ADVANCING PHOTOVOLTAIC APPLICATIONS

The technical feasibility of photovoltaics (PV) has been accepted for some time, and niche markets exist for terrestrial applications. However, significant technical problems must be solved before photovoltaic costs come down and markets grow to multibillion dollar annual sizes. **Grant applications are invited only in the following subtopics:**

a. Environmentally Responsible Methods of Removing and Recycling Thin Film Photovoltaic Semiconductors—Thin film PV modules often contain materials that could be recycled in order to reduce their potential environmental impact and/or regain their value for future use. Grant applications are sought for new capabilities to remove thin film materials (for example, cadmium, selenium, gallium, indium, and tellurium in CuInSe₂ and CdTe devices) from glass or similar low-cost substrates in order to facilitate recycling. Criteria for success are: cost of the procedure, completeness of the removal, minimization of unwanted waste streams resulting from the procedure, and usability of removed material for recycling.

b. Low-Cost, Module-Ready Arrays/Systems for Large Markets—Grant applications are solicited for the development of low cost, highly integrated PV arrays that could meet competitive cost goals if they were produced and installed in volume. Design criteria must address: (1) the integration of modules into arrays and the deployment of the arrays in the field; (2) flexibility for integration with various pre-packaged module assemblies that could be shipped easily to the system site; (3) reduced materials and manufacturing

costs, ease of transport and installation (including module assembly), and general usefulness for large photovoltaic markets; and (4) balance-of-system cost reductions (excluding power conditioning) in order to make systems cost competitive. Proposers should be prepared to build and install prototype arrays in Phase II.

c. Large Area Nonpulsed Solar Simulators—The use of simulators to measure the efficiency of PV cells and modules is critical for determining performance, both for research and development purposes and in order to establish projections for outdoor energy production. Most of today's commercial simulators use light pulses to activate photovoltaic cells/modules. However, such pulsed simulators can cause unexpected measurement artifacts in some of today's advanced PV technologies (especially thin films and multifunctions). Grant applications are solicited for the design and prototype assembly of a new generation of non-pulsed PV simulators for large area modules (1 m² and larger) suitable for use with advanced photovoltaics. These simulators must retain the same quality as previous simulators (e.g., in terms of area uniformity, repeatability, and temperature control). Cost and ease of use of the proposed simulators should also be addressed.

d. Increased Photovoltaic Wafer Productivity by Cutting Thinner Wafers with Less Kerf Loss—Solar cells fabricated using wafers cut from ingots of crystalline silicon dominate the current market for PV modules. A significant way to reduce costs is to cut more wafers from each ingot. This can be accomplished by reducing the thickness of the wafers and by reducing kerf loss in the sawing operation. Until recently, conventional inner diameter blade saws have been used to cut these wafers, but wire saws are now recognized as a superior alternative. Grant applications are sought for improved wire-saw technology, or entirely new equipment and techniques, that will increase the yield of wafers less than 300 micrometers thick.

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* See Section 7.1

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