DOE/ER-0153

Program Solicitation

Small Business Innovation Research Program

U.S. Department of Energy
Office of Energy Research
SBIR Program Manager

Closing Date: March 1, 1983

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DOE PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

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

Objectives of the solicitation include stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal research and development needs, increasing the commercial application of DOE-supported research results, 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 Innovation Development Act of 1982, Public Law 97-219. Under Phase I, DOE anticipates making approximately 100 awards during fiscal year 1983 to small businesses in amounts ranging up to $50,000 over a period generally not to exceed six (6) months. Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR program. The proposal should concentrate on that research which will significantly contribute to proving the scientific or technical feasibility of the approach or concept and which would be a prerequisite to further DOE support in Phase II.

Phase II awards are expected to be made during fiscal year 1984 to firms with approaches that appear sufficiently promising as a result of the first phase. Phase II awards are expected to be in the $200,000 to $500,000 range and to cover a period generally not to exceed 24 months. It is anticipated that one-third to one-half of Phase I awardees will receive Phase II awards, depending upon Phase I results and availability of funds. Phase II is the principal research or research and development effort; it will require a more comprehensive proposal, outlining the proposed effort in detail.

Under Phase III it is intended that non-Federal capital be used by the small business to pursue commercial applications of the research or research and development. Also, under Phase III, Federal agencies may award non-SBIR funded follow-on contracts for products or processes which meet the mission needs of those agencies.

Both Phase I and II contracts may include a profit or fee. This solicitation is for Phase I proposals only.

1.3 Follow-on Funding

In addition to supporting scientific and engineering research and development, another important goal of the solicitation is the conversion of DOE-supported research into technological innovation by private firms. Therefore, on an optional basis, the DOE program includes an incentive for proposers to obtain a contingent commitment for private follow-on funding prior to Phase II to continue the innovation process where it is felt that the research also has commercial potential. Federal funding pays for research meeting DOE objectives (Phases I and II); private capital provides for follow-on developmental funding to meet commercial objectives (Phase III).

Proposers who feel that their research has the potential to meet market needs, in addition to meeting the DOE objectives, are encouraged to obtain non-Federal follow-on funding to pursue the development phase. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent on the DOE-supported research meeting some specific technical objectives in Phase II which, if met, would justify non-Federal funding to pursue further development for commercial purposes in Phase III. Phase II proposals that provide such a commitment for follow-on funding will receive extra consideration during the evaluation process.

The recipient will be permitted to obtain commercial rights to any invention made in either Phase, subject to the patent policies as stated in this solicitation.

1.4 Eligibility and Limitations

A proposal must be limited to only one topic listed in this solicitation. When a proposal has relevance to more than one topic, the proposer must decide which topic is the most relevant and submit it under that topic only. However, a proposer may submit separate proposals on different topics or different proposals on the same topic under this solicitation. If a proposal substantially the same as the one submitted in response to this solicitation has been previously funded or is either funded, pending, or about to be submitted to another Federal agency, or to the DOE as a separate action, the proposer must so indicate and provide the information required by Section 4.4(12).

This solicitation does not obligate the DOE to make any awards under either Phase I or Phase II. The DOE is not responsible for any monies expended by the proposer before award of any contract.

Each proposer must qualify as a small business for research purposes as defined in Section 2.2. In addition, a minimum of two-thirds of each SBIR project must be carried out in the proposing firm.

Joint ventures are permitted, provided the entity created qualifies as a small business in accordance with the Small Business Act, 15 USC 631, and the definition included in this solicitation.

2.0 DEFINITIONS

The following definitions apply for purposes of this solicitation:

2.1 **Research or Research and Development**—Any activity which is (A) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (B) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (C) 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 **Small Business**—A business concern, including its affiliates, which is independently owned and operated, and at the time of award:

(1) Meets the size criteria for research and development of 500 employees or less and other regulatory requirements of 13 CFR, Part 121.3-8 of SBA Rules and Regulations, and FPR 1-1.701-1; and, for purposes of this solicitation,

(2) Is the primary source of employment of the principal investigator of the proposed effort at the time of award and during the conduct of the proposed research. Primary employment means that more than one-half, or at least 20 hours (average) per week, of the principal investigator's time is spent with the small business.

2.3 **Minority and Disadvantaged Business**—A concern that is:

(1) At least 51 percent owned by one or more minority and disadvantaged individuals; or, in the case of a publicly owned business, at least 51 percent of the stock of which is owned by one or more minority and disadvantaged individuals; and

(2) Whose management and daily business operations are controlled by one or more of such individuals.

A minority and disadvantaged individual is defined as a member of any of the following groups: Black Americans; Hispanic Americans; Native Americans; Asian-Pacific Americans; or Asian-Indian Americans.

3.0 TECHNICAL TOPICS

3.1 Topic List

Proposals will be considered in the following topic areas, listed in an arbitrary order: (1) Materials Sciences; (2) Chemical Separations and Analytical Instrumentation; (3) Biotechnology and Applied Microbiology, (4) Health and Environmental Effects Instrumentation; (5) Nuclear Medicine; (6) Advanced Power Generation; (7) Electric Power Transmission Technology; (8) Photovoltaic Research; (9) Transparent Solar Materials; (10) Sunlight Management in Buildings; (11) Improved Energy and Materials Usage in Industry; (12) Geotechnology; (13) Fossil Fuels Research; (14) Fossil Energy Engineering and Materials; (15) Fossil Energy Instrumentation; (16) Uranium Enrichment; (17) Nuclear Reactor Materials; (18) Nuclear Reactor Instrumentation and Technology; (21) Particle Accelerator Technology; (22) High Energy Physics Technology and Research; (23) Plasma Diagnostics and Instrumentation; (24) Plasma Heating Technology; and (25) Advanced Fusion Research. A detailed description of each topic is provided in Appendix E.

4.0 PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

4.1 Proposal Requirements

The purpose of a proposal to DOE under the SBIR program is to provide sufficient information to persuade DOE, and members of the research community who review the proposal, that the proposed work represents a sound approach to the investigation of an important scientific or engineering question and is worthy of support under the stated criteria.

A proposal should be self-contained and written with the care and throughness accorded papers for publication. Each proposal should be reviewed carefully by the applicant to ensure inclusion of data essential for evaluation.

The scientific or technical merit of the proposed research is the primary concern for all research supported by the DOE. A proposal may respond to any of the topics listed in Appendix E, or to specific subtopics areas within them, but must be limited to one topic or subtopic. The same proposal may not be submitted under more than one topic. However, an organization may submit separate proposals on different topics or different proposals on the same topic under this solicitation. Where similar research is discussed under more than one topic, the proposer should choose that topic whose description appears most relevant to the proposer's technical concept.

The quality of the scientific or technical content of the proposal will be the principal basis upon which proposals will be evaluated.

The proposed research or research and development must be responsive to the DOE program objectives, but can also serve as the base for technological innovation, new commercial products, processes, or services which benefit the public.

Proposals must be confined principally to advanced concepts in energy-related scientific or engineering research, or research and development, which may be carried out through construction and evaluation of a laboratory prototype, where necessary. Proposals principally for the development of proven concepts toward commercialization or for market research should not be submitted, since such efforts are considered the responsibility of the private sector. Commercialization is the objective of the follow-on funding option, which is to fund development efforts in Phase III using non-Federal capital, as a continuation of the research supported by DOE under Phases I and II.

4.2 Proprietary Information

If information is provided which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence to the extent permitted by law, provided it is clearly marked in accordance with Section 6.7.

4.3 General Content

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond should submit a research proposal of no more than 20 pages (no type smaller than elite on standard 8½″ x 11″ paper) not counting the budget. The proposal should be direct, concise, and informative. Promotional and non-project-related discussion is discouraged. To meet DOE requirements, all items are to be covered fully and in the order set forth below, but the space allocated to each will depend on the problem chosen and the principal investigator's approach. In the interest of equity to all proposers, all information, except for the budget, must be included in the 20 pages with no additional attachments.

It is not necessary to provide a lengthy discourse on the commercial applications in the Phase I proposal except to discuss them briefly under Section 4.4, items 3 and 4, as appropriate. The proposal must be principally directed at research or research and development on the specific topic or subtopic chosen.

4.4 Phase I Proposal Format

1. **Cover Sheet**—Photocopy and complete the form in Appendix A as page 1 of each copy of each proposal. All pages shall be consecutively numbered.

2. **Project Summary**—Photocopy and complete the form identified as Appendix B as page 2 of your proposal. The technical abstract should include a brief description of the problem or opportunity, project objectives, description of the effort and anticipated results. Potential applications of the proposed research should also be summarized in the space provided. The Project Summary of successful proposers may be published by the DOE and, therefore, should not contain proprietary information.

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

4. **Background, Technical Approach and Anticipated Benefits**

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

b. **State the anticipated results** of the approach if the project is successful and is carried over into Phases II and III. This should address: (1) the technical, economic, social and other benefits to the Nation and to users of the results such as the commercial sector, the Federal Government, or other researchers; (2) the estimated total cost of the approach relative to benefits, including an approximation of Phase II project costs; and, if appropriate, (3) any specific policy issues or decisions which might be affected by the results.

c. Discuss the significance of the Phase I effort in **providing a foundation** for Phase II research and development effort.

5. **Phase I Technical Objectives**—Enumerate the **specific** objectives of the Phase I research, including the questions it will try to answer to determine the feasibility of the proposed approach.

6. **Phase I Work Plan**—This section must provide an explicit, detailed description of the Phase I research approach. The plan should indicate not only what is planned **but how the work will be carried out.** Phase I effort should attempt to determine the technical feasibility of the proposed concept.

   The work plan should be linked with the objectives and the questions 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 proposal.**

7. **Phase I Statement of Work**—The Statement of Work must summarize items 5. and 6. above by very briefly stating the principal project objective(s), identifying the tasks to be performed and the performance schedule. It should also identify the deliverable which for Phase I will be just one item, the Final Report. A sample Statement of Work is included as Appendix C.

8. **Facilities/Equipment**—Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in the Optional Form 60, Appendix D) shall be justified under this Section.

9. **Consultants**—Involvement of university or other consultants in the planning and/or research stages of the project is acceptable. If such involvement is intended, it should be described in detail and included in the Optional Form 60 budget (if appropriate).

10. **Related Work**—Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, by the proposing firm, consultants, or others, how it interfaces with the proposed project, and any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic.

11. **Key Personnel**—Identify key senior personnel involved in Phase I effort including information on directly related education and experience. List relevant publications by key personnel. A resume of the principal investigator, including a list of publications (if any), must be included.

12. **Current and Pending Support**—If a proposal substantially the same as the one submitted in response to this solicitation 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 proposer must provide the following information:

    a. The name and address of the agency(s) to which a proposal was submitted, or will be submitted, or from which an award is expected or has been received.

    b. Date of proposal submission or date of award.

    c. Title of proposal.

    d. Name and title of principal investigator for each proposal submitted or award received.

    e. Title, number, and date of SBIR Program Solicitations under which the proposal was submitted or award received.

    f. Specify the applicable research topics for each SBIR proposal submitted or award received.

13. **Budget**—Photocopy and complete the budget form in Appendix D (Optional Form 60) for the Phase I effort only. Under the direct labor category, list all key personnel by name as well as by number of hours dedicated to the project. The budget portion of the proposal must be stapled together with the rest of the proposal, but may be in addition to the 20-page proposal limitation.

14. **External Review**—It is anticipated that, in addition to Government personnel, scientists and engineers from outside the Government may be used in the proposal review process. These may include personnel employed at universities, National Laboratories and in the private sector. The DOE will take into consideration, when making its decision to use outside evaluators, its obligations to avoid conflicts of interest and any competitive relationship between the proposer and the prospective outside evaluator. Proposers are requested to spe-

cifically authorize external review, for evaluation purposes only, on the cover page of their proposals. If the proposal does not expressly authorize external reviews, and evaluation outside the Government is nevertheless desired, the proposer should be aware that DOE may be unable to give the proposal full consideration.

4.5 Other Information

- **Bindings**—Please do **not** use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.
- **Packaging**—All 10 copies of a proposal must be sent in the same package.

5.0 METHOD OF SELECTION AND EVALUATION CRITERIA

5.1 Introduction

Phase I proposals will be judged on a competitive basis in a two-stage process. All will be screened initially by DOE staff to ensure that they meet stated solicitation requirements. Proposals meeting these requirements will then be evaluated by scientists or engineers knowledgeable in the topic area. Proposals will be judged first on their relevance to the chosen topic. Those found to be relevant will then be evaluated using the criteria listed in Section 5.2. Final decisions will be made by the DOE based upon these criteria and consideration of other factors, including possible duplication of other research, and program balance. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by DOE to make any awards on any topic, to make a specific number of awards or to be responsible for any monies expended by the proposer before award of a contract.

Phase II proposals will be subject to a technical review process similar to Phase I. Proposals will be judged against Phase II criteria on a competitive basis. Final decisions will be made by DOE based upon the scientific and technical evaluations and other factors, including the commitment for follow-on funding, the possible duplication with other research, program balance, and budget limitations.

5.2 Evaluation Criteria—Phase I

The DOE plans to select for award those proposals offering the best value to the Government with approximately equal consideration given to each of the following criteria, except for number one which will receive twice the value of any other item:

1. **The scientific/technical quality of the Phase I research proposal** and its relevance to the proposal's stated objectives, with special emphasis on its innovation and originality.
2. **Qualifications** of the principal investigator, other key staff, and consultants, if any, and the adequacy of available or obtainable instrumentation and facilities.
3. **Anticipated benefits**, technical and/or economic, of the proposed research (Phase I and Phase II), if successful.
4. **Adequacy of the Phase I proposed effort** to show progress toward providing the feasibility of the concept.

Technical reviewers will base their conclusions only on information contained in the proposal. 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. Relevant journal articles should be identified in the proposal.

Where proposals are otherwise of approximately equal merit, proposals received from a small, minority and disadvantaged business will receive special consideration.

5.3 Evaluation Criteria—Phase II

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

A Phase II proposal can be submitted only by a Phase I awardee. It can be submitted at any time when progress attained under Phase I is deemed sufficient to justify the effort to be proposed under Phase II. It must contain enough information on progress accomplished under Phase I by the time of Phase II proposal submission to enable an evaluation of the project's promise if continued into Phase II. The Phase II proposal will be reviewed for overall merit based upon 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, with special emphasis on its innovation and originality.
2. The qualifications of the principal investigator and other key personnel to carry out the proposed work.
3. Anticipated benefits, technical and/or economic, of the proposed research.

4. Degree to which the Phase I objectives were met at the time of Phase II proposal submission.
5. The adequacy of the Phase II objectives to meet the problem or opportunity,.

Phase II proposal evaluations 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 to determine those proposals that offer the best value to the Government.

In the case of proposals of approximately equal merit, the provision of a follow-on funding commitment for continued development from non-Federal funding sources will be a special consideration. The follow-on funding commitment must provide that a specific amount of Phase III funds will be made available to or by the small business and indicate the dates the funds will be made available. It must also contain specific technical objectives which, if achieved in Phase II, will make the commitment exercisable by the small business. The terms cannot be contingent upon the obtaining of a patent due to the length of time this process requires. The commitment shall be submitted with the Phase II proposal.

6.0 CONSIDERATIONS

6.1 Awards

The DOE expects to make approximately 100 firm fixed-price Phase I awards ranging up to $50,000 to small businesses in fiscal year 1983. Awards are expected to be made no later than September 30, 1983. DOE will announce the names of those firms receiving awards, and successful proposers will then have generally six (6) months after award to carry out their proposed Phase I effort.

It is anticipated that one-third to one-half of the Phase I awardees will receive Phase II awards, depending upon the result of the Phase I efforts and the availability of funds. Phase II is to further develop ideas explored under Phase I. Specific instructions for the preparation of Phase II proposals will be sent to Phase I awardees by the DOE. Those Phase II proposers who wish to maintain project continuity must submit proposals no later than 30 days prior to the expiration of the Phase I contract. Successful Phase II proposers may then be issued a modification, which can be unilaterally exercised by the Government, 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 expected to be on a cost-reimbursable basis, not to exceed a proration of the Phase II effort as recommended by the SBIR Program Manager; it is intended to cover the start-up costs of the Phase II effort. Phase II proposers will be requested to provide an estimate of the amount of funding required to cover this interim period as part of their Phase II proposal. Should the two parties fail to agree on terms covering the Phase II effort, allowable costs experienced during the four-month interim period, but excluding any fee, will be reimbursed in accordance with Federal and DOE commercial cost principles. (See FPR 1-15.2 and DOE PR 9-15.2.)

The final date for receipt of Phase II proposals will be June 30, 1984. Proposers should be aware that proposals submitted later than 30 days prior to the expiration of the Phase I contract will be considered separately and will be subject to the availability of funds.

The period of performance under Phase II will depend upon the scope of the effort, but normally will not exceed 24 months. Phase II award decisions will be based upon evaluation of progress attained under Phase I and of the Phase II proposal. Phase II awards will generally range from $200,000 to $500,000, depending upon the scope of research or research and development.

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 cost-type contracts.

6.2 Reports

Six copies of a final report on the Phase I project must be submitted to DOE within thirty days after completion of the Phase I effort. The final report shall 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 or results, and potential applications of the research in a final paragraph. The summary may be published by the DOE and therefore should not contain proprietary information. The balance 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 used to report Phase I progress in a Phase II proposal, if submitted, may be used verbatim in the final report with changes only to accommodate results obtained after Phase II proposal submission, and modifications required to integrate the final report into a self-contained, comprehensive and logically structured document.

6.3 Payment Schedule

Payments will be made in accordance with a payment schedule agreed to by the Contracting Officer. In addition to customary progress payments, requests for advance payments based upon demonstrated need will be considered. The offeror shall include his cash flow requirements as part of the budget submission for Phase I.

6.4 Technical Data

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this solicitation shall remain with the contractor, except that the Government shall have the limited right to use such data for Government purposes and shall not release such data outside the Government without permission of the contractor for a period of two years from completion of the project from which the data was generated unless the data has already been released to the general public. However, effective at the conclusion of the two-year period, the Government shall retain a royalty-free license for Government use of any technical data delivered under an SBIR funding agreement whether patented or not.

6.5 Copyrights

With prior written permission of the contracting officer, the awardee normally may copyright (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.

6.6 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patentholder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a two-year period to allow the awardee a reasonable time to pursue a patent.

6.7 Markings and Treatment of Proposal Information

The proposal submitted in response to this solicitation may contain technical data and other data, including trade secrets and/or privileged or confidential commercial or financial information, which the proposer does not want disclosed to the public or used by the Government for any purpose other than proposal evaluation. To protect such data the proposer should type at the bottom of the cover page (page one) of his proposal the following notice.

> The data submitted on pages ________ of this proposal have been submitted in confidence and contain trade secrets and/or privileged or confidential commercial or financial information, and such data shall be used or disclosed only for evaluation purposes, provided that if a contract is awarded to this proposer as a result of or in connection with the submission of this proposal, the Government shall have the right to use or disclose the data herein to the extent provided in the contract. This restriction does not limit the Government's right to use or disclose data obtained without restriction from any source, including the proposer.

In addition, each page of the proposal containing proprietary data which the proposer wishes to restrict must be marked with the following legend:

> "Use or disclosure of the proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the cover page of this proposal."

Arbitrary and unwarranted use of this restriction is discouraged.

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event properly marked data contained in a proposal in response to this solicitation is requested pursuant to the Freedom of Information Act, 5 USC 552, the proposer will be advised of such request, in accordance with 10 CFR 709.9, and prior to such release of information he will be requested to expeditiously submit to DOE a detailed listing of all information in his proposal which he believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the proposer will ensure that any information released by DOE pursuant to the Act is properly determined.

6.8 Estimated Costs and Budgets

A Phase I price proposal must be submitted in detail in the format shown in Appendix D. Some items of this standard form may not apply to the proposed project. If such is the case, there is no need to fill out each and every line in the form. What matters is that enough information be provided to allow DOE to understand how the proposer plans to use the requested funds if the contract is awarded. Both Phase I and II contracts may include a profit or fee.

Equipment and Travel

Equipment budgets may be included under Phases I and II. The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed.

Equipment is defined as an article of non-expendable, tangible, personal property, having a useful life of more than one year and an acquisition cost of $500 or more per unit. Title to equipment will be vested with the DOE, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DOE.

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

Cost-Sharing

Cost-sharing is permitted for proposals under this solicitation; however, cost-sharing is not required nor will it be an evaluation factor in the consideration of a proposal.

6.9 Limitations

Restriction to Small Business

A small business must meet certain criteria to be eligible under this solicitation and certify to this on the Cover Sheet (Appendix A). See Section 2.2 for definition.

In addition, a minimum of two-thirds of each SBIR project must be carried out in the proposing firm.

6.10 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of numerous provisions in the Phase I contract. The outline that follows is illustrative of the types of provisions that will be included in the Phase I contract. This is not a complete list of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

1. **Standards of Work.** Work performed under the contract must conform to high professional standards.
2. **Inspection.** Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.
3. **Examination of Records.** The Comptroller General (or a duly authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.
4. **Default.** The Government may terminate the contract if the contractor fails to perform the work contracted.
5. **Termination for Convenience.** The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.
6. **Disputes.** Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.
7. **Contract Work Hours.** The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).
8. **Equal Opportunity.** The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
9. **Affirmative Action for Veterans.** The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran of the Vietnam era.
10. **Affirmative Action for Handicapped.** The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
11. **Officials Not to Benefit.** No member of or delegate to Congress shall benefit from the contract.
12. **Covenant Against Contingent Fees.** No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bonafide employees or commercial agencies maintained by the contractor for the purpose of securing business.
13. **Gratuities.** The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.
14. **Patent Infringement.** The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

7.0 SUBMISSION OF PROPOSALS

7.1 Address

Proposals (10 copies) must be addressed to:

SBIR Program Manager
U.S. Department of Energy
Washington, D.C. 20545

Handcarried proposals should be delivered to Room 1J-005, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. Secure packaging is mandatory. The Department cannot be responsible for the processing of proposals damaged in transit.

Do not send separate "information" copies or several packages containing parts of the single proposal.

One copy must be signed as an original by the principal investigator and an official empowered to commit the proposer. Other copies may be photocopied.

If a proposal acknowledgment card with the proposal number endorsed upon it is not received from DOE within three weeks following the closing date of this solicitation, the proposer should telephone the Acquisition Management Division promptly at 301-353-5450.

7.2 Deadline for Proposals

Deadline for receipt (10 copies) at the Department of Energy is 5:00 p.m. EST, March 1, 1983. Any proposal received at the office designated in the solicitation after the exact time specified for receipt will not be considered unless it is received before award is made, and: (1) it was sent by registered or certified mail not later than February 24, 1983; or (2) it was sent by mail and it is determined by the Government that the late receipt was due solely to mishandling by the Government after receipt at the Government installation; or (3) it is the only proposal received; or (4) it offers significant cost or technical advantages to the Government, and it is received before a determination of the competitive range has been made.

Any modification of a proposal is subject to the same conditions outlined above. The only acceptable evidence to establish: (1) the date of mailing of a late proposal or modification sent either by registered mail or certified mail is the U.S. Postal Service postmark on the wrapper or on the original receipt from the U.S. Postal Service. If neither postmark shows a legible date, the proposal or modification of proposal shall be deemed to have been mailed late. (The term "postmark" means a printed, stamped, or otherwise placed impression that is readily identifiable without further action as having been supplied and affixed on the date of mailing by employees of the U.S. Postal Service.); (2) the time of receipt at the Government installation is the time-date stamp of such installation on the proposal wrapper or other documentary evidence of receipt maintained by the installation. Notwithstanding the above, a late modification of an otherwise successful proposal which makes its terms more favorable to the Government will be considered at any time it is received and may be accepted. Proposals may be withdrawn by written or telegraphic notice received at any time prior to award. Proposals may be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal prior to award. (NOTE: The term "telegram" includes mailgrams.)

8.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Wherever descriptions of topics (Appendix E) include references to publications not commercially available, information on where such publications will normally be available is included following the reference.

9.0 CONTACT WITH DOE

9.1 Oral Communications

Oral communications with DOE regarding this solicitation during Phase I proposal preparation period are restricted for reasons of competitive fairness.

9.2 Questions Pertaining to This Solicitation

Any and all questions pertaining to this solicitation should be addressed in writing to the address listed in Section 9.6. No telephone inquiries will be accepted.

9.3 Requests for Additional Copies of This Solicitation

Additional copies of this solicitation can be ordered by writing the DOE SBIR Program Manager at the address listed in Section 9.6. No telephone requests will be accepted.

9.4 Questions About the DOE SBIR Program

General questions about the DOE SBIR Program, but not pertaining to this solicitation or to requests for additional copies, can be submitted to Mr. Mark Kurzius, Program Spokesman, c/o SBIR Program Manager (see address in Section 9.6), phone 301-353-4396.

9.5 Information on Proposal Status

Evaluation of proposals and award of contracts will require approximately four to six months and no information on proposal status will be available until the final selection is made.

9.6 Correspondence Relating to Proposals

All correspondence relating to proposals should cite the specific proposal number and be addressed to:

SBIR Program Manager
U.S. Department of Energy
Washington, D.C. 20545

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH
SOLICITATION NO. DOE/SBIR 83-1

PROPOSAL COVER SHEET

Project Title: ______________________________

Topic No. ________ Subtopic ________ (if appropriate) Topic Title: ______________________________

Submitted By: Firm ______________________________

Mailing Address ______________________________

______________________________ State ____________ Zip ____________

Amount Requested (Phase I) $ ______________________ Proposed Duration: (in months, Phase I) ______________________

1. The above organization certifies that it is a small business and meets the definition stated in Section 2.2. Yes ______ No ______
2. The above organization certifies that it is classified as a minority or disadvantaged business according to the definition in Section 2.3. Yes ______ No ______
3. The above organization certifies that a minimum of two-thirds of any project awarded under this solicitation will be carried out within the firm. (See Seçtion 6.9). Yes ______ No ______
4. This proposal may be subject to external review (See Section 4.4). Yes ______ No ______
5. If the proposal does not result in an award, is the Government permitted to disclose the title only of your proposed project, and the name, address, and telephone number of the official of the proposing firm, to firms that may be interested in contacting the proposer for further information or possible investment? Yes ______ No ______

Principal Investigator	Corporate/Business Official
Name ______________________	Name ______________________
Title ______________________	Title ______________________
Signature ______________ Date ________	Signature ______________ Date ________
Telephone No. ______________________	Telephone No. ______________________

PROPRIETARY NOTICE (IF APPLICABLE, SEE SECTION 6.7)

U.S. DEPARTMENT OF ENERGY

SMALL BUSINESS INNOVATION RESEARCH PROGRAM
PHASE I—FY 1983
PROJECT SUMMARY

FOR DOE USE ONLY

Program Office	TTM	Proposal No.	Topic No.

TO BE COMPLETED BY PROPOSER

Name and Address of Proposer

Name and Title of Principal Investigator

Title of Project

Technical Abstract (Limit to two hundred words)

Anticipated Results/Potential Commercial Applications of the Research

Sample Statement of Work

1. Project Objective

The contractor 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. Scope of Work

The work to be performed consists of the following tasks:

2.1 Construction of tubular stabilized 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 yield 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.

Tasks 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. Deliverable

The contractor 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 this data.

CONTRA PRICING PROPOSAL (RESEARCH AND DEVELOPMENT)	Office of Management and Budget Approval No. 29-RO184	
This form is for use when *(i)* submission of cost or pricing data (see FPR 1-3.807-3) is required and *(ii)* substitution for the Optional Form 59 is authorized by the contracting officer.	PAGE NO.	NO. OF PAGES

NAME OF OFFEROR	SUPPLIES AND/OR SERVICES TO BE FURNISHED (Title of Proposed effort.)	
HOME OFFICE ADDRESS		
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED	TOTAL AMOUNT OF PROPOSAL $	GOV'T SOLICITATION NO. DOE/SBIR 83-1

DETAIL DESCRIPTION OF COST ELEMENTS

			EST COST ($)	TOTAL EST COST[1]	REFERENCE[2]
1. DIRECT MATERIAL *(Itemize on Exhibit A)*					
a. PURCHASED PARTS					
b. SUBCONTRACTED ITEMS					
c. OTHER—*(1)* RAW MATERIAL					
(2) YOUR STANDARD COMMERCIAL ITEMS					
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*					
TOTAL DIRECT MATERIAL					
2. MATERIAL OVERHEAD[3] *(Rate %X$ base=)*					
3. DIRECT LABOR *(Specify)*	ESTIMATED HOURS	RATE/HOUR	EST COST ($)		
Principal investigator					
TOTAL DIRECT LABOR					
4. LABOR OVERHEAD *(Specify Department or Cost Center)*[3]	O.H. RATE	X BASE =	EST COST ($)		
TOTAL LABOR OVERHEAD					
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST ($)		
TOTAL SPECIAL TESTING					
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST ($)		
a. TRANSPORTATION					
b. PER DIEM OR SUBSISTENCE					
TOTAL TRAVEL					
8. CONSULTANTS *(Identify—purpose—rate)*			EST COST ($)		
TOTAL CONSULTANTS					
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*					
10. *TOTAL DIRECT COST AND OVERHEAD*					
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate % of cost element Nos.)*[3]					
12. ROYALTIES					
13. *TOTAL ESTIMATED COST*					
14. FEE OR PROFIT					
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*					

1

OPTIONAL FORM 60
October 1971
General Services Administration
FPR 1-16.806
5060-101

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

and reflects our best estimates as of this date, in accordance with the Instructions to Offerors and the Footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE

NAME OF FIRM	DATE OF SUBMISSION

EXHIBIT A—SUPPORTING SCHEDULE *(Specify. If more space is needed, use reverse)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST *($)*

I. HAS ANY EXECUTIVE AGENCY OF THE UNITED STATES GOVERNMENT PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☐ NO *(If yes, identify below.)*

NAME AND ADDRESS OF REVIEWING OFFICE AND INDIVIDUAL	TELEPHONE NUMBER/EXTENSION

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify on reverse or separate page)*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*: ☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS OR ☐ GUARANTEED LOANS

IV. DO YOU NOW HOLD ANY CONTRACT *(Or, do you have any independently financed (IR&D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*:

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN AGENCY REGULATIONS?

☐ YES ☐ NO *(If no, explain on reverse or separate page)*

See Reverse for Instructions and Footnotes OPTIONAL FORM 60 (10-71)

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated costs *(and attached supporting information)* suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal the offeror shall, under the conditions stated in FPR 1-3.807-3 be required to submit a Certificate of Current Cost or Pricing Data (See FPR 1-3.807-3(h) and 1-3.807-4).

2. In addition to the specific information required by this form, the offeror is expected, in good faith, to incorporate in and submit with this form any additional data, supporting schedules, or substantiation which are reasonably required for the conduct of an appropriate review and analysis in the light of the specific facts of this procurement. For effective negotiations, it is essential that there be a clear understanding of:

a. The existing, verifiable data.
b. The judgmental factors applied in projecting from known data to the estimate, and
c. The contingencies used by the offeror in his proposed price.

In short, the offeror's estimating process itself needs to be disclosed.

3. When attachment of supporting cost or pricing data to this form is impracticable, the data will be described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request.

4. The formats for the "Cost Elements" and the "Proposed Contract Estimate" are not intended as rigid requirements. These may be presented in different format with the prior approval of the Contracting Officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal the offeror grants to the Contracting Officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1 Enter in this column those necessary and reasonable costs which in the judgment of the offeror will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferror or current market price.

2 When space in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the attachment in which the information supporting the specific cost element may be found. No standard format is prescribed; however, the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the Contracting Officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which depart significantly from experienced rates (reduced volume, a planned major re-arrangement, etc.); or justification for an increase in labor rates (anticipated wage and salary increases, etc.). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.

3 Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdown and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates.

4 If the total cost entered here is in excess of $250, provide on a separate page the following information on each separate item of royalty or license fee: name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description, including any part or model numbers of each contract item or component on which the royalty is payable; percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

5 Provide a list of principal items within each category indicating known or anticipated source, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.

CONTINUATION OF EXHIBIT A—SUPPORTING SCHEDULE AND REPLIES TO QUESTIONS II AND V.

APPENDIX E

TECHNICAL TOPICS

1. MATERIALS SCIENCES

This topic concerns research on fundamental aspects of mechanical, physical, and chemical behavior of materials and on techniques and phenomena of underlying importance to a broad range of materials applications in energy systems. New and improved materials can offer opportunities for achieving improved reliability, cost reductions, and higher efficiencies in existing energy systems, and may be critically important for establishing the practical feasibility of entirely new systems. Suitable substitute materials can provide protection against possible interruptions in the importation of strategically important materials. Innovative developments in instrumentation can lead to greatly enhanced capabilities in materials research and for energy-related applications of materials in industry. In general, research under this topic should have a science or an advanced technology orientation. Materials such as concrete, clay products, and wood are inappropriate for consideration under this topic. Also, proposals concerned with routine measurements or with minor improvements of materials properties will not be considered. Areas of interest for which proposals are solicited include (but are not necessarily limited to) the following subtopics:

a. New and Improved Materials—Research on structural ceramics aimed at establishing basic understanding needed for significant improvements in mechanical properties and long-term stability at high temperatures and in corrosive environments. Research on new alloys as substitutes for materials now requiring use of critical and strategically important elements. Science-focused research on new types of composite materials and on polymers.

b. Thin Films and Surfaces—Basic studies on the preparation and properties of rapidly solidified films (amorphous and fine-grain polycrystalline). Basic studies of solar photovoltaic materials. Surface research related to catalysis. Research at a basic level on corrosive, erosive, or environmental degradation of materials: effects under extreme environmental conditions, low-rate environmental effects (including accelerated test methodology), and protective surface treatments (both coatings and surface modification).

c. Processes—Research addressing fundamental aspects of materials processing and associated effects on the properties of materials and, ultimately, their usefulness in energy-related applications. Materials preparation (single crystals, polycrystalline, and amorphous). Relationship of structure, properties and behavior to preparation and history. Forming and joining (including welding). Crystal defects, intrinsic and extrinsic. Ion implantation and other processes for controlled modification of materials properties. Mineral processing and extractive metallurgy are excluded from this subtopic.

d. Instrumentation and Techniques—Structural and chemical micro-characterization of materials. Nondestructive evaluation of materials. New concepts in optical elements for the UV and soft X-ray regions and neutrons. New detectors for the UV and soft X-ray regions and neutrons with an emphasis on position sensitive detection and high data rates. New tunable lasers with broader wavelength ranges.

Bibliography

1. *Directions in Energy-Related Materials Research*, W. L. Clinton, et al, Mater. Sci. Eng. *35* (1) (1978)
2. *Basic Research Needs on High Temperature Ceramics for Energy Applications*, H. Kent Bowen, Mater. Sci. Eng. 44 (1980) 1-56
3. *High Temperature Corrosion in Energy Systems*, R. A. Rapp, et al, Mater. Sci. Eng. *50* (1) (1981) 1-18
4. *Aqueous Corrosion Problems in Energy Systems*, D. D. MacDonald, et al, Mater. Sci. Eng. *50* (1) (1981) 19-42
5. *Research Opportunities in New Energy-Related Materials*, J. L. Warren and T. H. Geballe, Mater. Sci. Eng. *50* (2) (1981) 149-198
6. *Proceedings of the Workshop on Basic Research Needs and Opportunities on Interfaces in Solar Materials*, Denver, Co., June 30-July 3, 1980, A. W. Czanderna and R. J. Gottschall, Eds., Mater. Sci. Eng. *53* (1) (1982) 1-167
7. *Nondestructive Evaluation and Energy Technology*, J. E. Gubernatis and J. A. Krumhansl, Mater. Sci. Eng. *52* (1982) 195-206

2. CHEMICAL SEPARATIONS AND ANALYTICAL INSTRUMENTATION

The DOE seeks research proposals in certain areas of chemical separations and analytical instrumentation. With respect to separations, current awareness of U.S. dependence on foreign sources for a large number of strategically essential metals has led to a demand for expanded domestic production of these elements. Since most domestic sources of such elements are low-grade ores or industrial byproducts, new separation processes of greater selectivity are needed to satisfy this demand. Regarding analytical instrumentation, new approaches for analysis of chemical species are sought which take advantage of state-of-the-art technology and recent scientific advances.

a. Chemical Separations of Strategic Materials—Separations processes should respond to the current thrust to replace energy-intensive metallurgical technologies of the past. Elements of interest for separation are those considered strategically essential, including but not limited to manganese, cobalt, chromium, nickel, and platinum. Innovative separations are especially attractive if they can be used for resource recovery from low-grade industrial wastes or spent nuclear fuel, since they simultaneously address the problem of the disposition of these byproducts. Innovative separation methods that will be considered include but are not limited to extraction, membranes, sorption, and filtration. The experimental approach would involve demonstration of the feasibility of the separations process for the appropriate applications on a laboratory scale, with consideration for future large-scale development.

b. Analytical Instrumentation—Innovative instrumentation approaches are sought for a wide variety of applications. These range, for example, from analyses of complex fuel mixtures to the determination of short-lived species on the surface of catalysts or in combustion chambers. Demand is high for new analytical instruments which are simple, fast, reliable, and inexpensive, which require a minimum of sample pretreatment, which can be used in the field or on-stream, and which exhibit superior characteristics of accuracy and reproducibility. In this subtopic, the DOE is especially interested in promoting development of instrumentation which capitalizes on recent advances in science and technology, such as tunable lasers and supercritical separations, among others. Emphasis is placed on the devising of new instrumentation for which the fundamental scientific groundwork has already been demonstrably laid. In addition to the general criteria cited above, special consideration will be given to instrumentation which can quantitatively determine for specific species one or more of the following: oxidation state, atomic composition, isomeric state, and site(s) of surface attachment. However, proposals in other novel areas of analytical instrumentation development will also be considered. The automation of existing analytical instrumentation or of data acquisition and handling is not of interest. Neither is the application of a new or existing analytical technique to the analysis of samples, other than limited experiments to show feasibility for a new technique developed under this program.

Bibliography

1. *Nation's Business*, October 1980, 33-38
2. *Industrial Research & Development*, November 1980, 95-104
3. *Chemical and Engineering News*, March 9, 1981, 5

3. BIOTECHNOLOGY AND APPLIED MICROBIOLOGY

The application of biotechnology for future energy production and conservation processes is currently being studied. While there are many unanswered fundamental questions about various fermentations and other bioconversions, there are also numerous gaps in knowledge at an intermediate level where innovative approaches are needed before pilot plants and later commercial development can be considered.

Two primary areas for biotechnology can be identified in support of DOE goals: (1) bioconversion of fuels or energy-intensive chemicals—especially those that can replace petroleum-based feedstocks; and (2) investigations supportive of environmental control technology related to energy production and conservation.

Energy-efficient processes are needed to convert a broad variety of organic substrates into high-value fuels or intermediate chemicals which are currently produced by energy-intensive non-biological means. Research areas of potential interest include: microorganism identification and improvement, coupled conversion/separation techniques, more efficient bioreactor systems, multiple product recovery, and substrate pretreatment techniques. Several specific research topics relating to these areas are listed below; however, other innovative ideas in applied microbiology and bioengineering relating to energy problems will be considered.

a. Lignocellulose Processing—Currently, the fractionation and isolation of the lignocellulosic primary constituents of biomass cannot be carried out economically, especially if a lignin byproduct is desired. Research is needed to effectively carry out the primary separation and to define suitable biochemical routes for the utilization of all constituents.

b. Advanced Bioreactor Concepts—Advanced bioreactor concepts could result in significant increases in productivity while decreasing energy requirements. Columnar systems utilizing retained cells or enzymes, such as fluidized-bed or fixed-bed reactors, appear to offer great promise, although these concepts are not currently well understood. Investigations of coupled bioconversion and separation processes and multiple column concepts may prove to be useful for a variety of processes.

c. Immobilized Biocatalysts—Biocatalysts such as enzymes or microorganisms can be most effectively used in advanced bioreactors when they are immobilized in or on a solid matrix. Research into immobilization concepts should focus on incorporating enzymes, organelles, or whole cells in or on particulate matrices that can be applied to the production of fuels or chemicals or to the energy-efficient removal of aqueous pollutants. Areas of study should include composition, stability, transport properties, and other characteristics of such systems.

d. Bioprocess Sensor Development—Advanced bioreactor systems can be efficiently operated only when effective process monitoring and control techniques are available. There is a significant deficiency in the availability of sensing devices that will allow the continuous monitoring of process parameters such as substrate and product concentration. Two general categories of sensors are contemplated. The first incorporates a biological system or component (that is, microorganism, organelle, enzyme, etc.) as an integral part of the sensor. The second category will employ novel analytical concepts for the measurement and monitoring of bioprocess parameters.

e. Biomass Productivity—The resource base for all fuel and chemical production using bioconversion is totally dependent on photosynthetically driven biomass production by plants. Clearly, there is much room for improvement in biomass production efficiency in terrestrial and aquatic systems. Research in this area utilizing innovative genetic techniques, plant cell and tissue culture, and other imaginative procedures could be pivotal in leading to improved production strategies. Investigations should focus on factors which limit productivity and how these may be overcome.

Bibliography

1. *Symposia on Biotechnology in Energy Production and Conservation*, No. 1, 1979; No. 2, 1980, No. 3, 1981, C. D. Scott, Ed., Published as supplements to *Biotechnology and Bioengineering*, Symposia No. 8, 10, and 11, respectively, Interscience Publication, John Wiley and Sons, New York.
2. *Energy from Biological Processes*, Vol. I and II, Office of Technology Assessment, Congress of the United States, Washington, D.C. 20510, 1980. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

4. HEALTH AND ENVIRONMENTAL EFFECTS INSTRUMENTATION

The DOE research program investigating health and environmental effects that may be associated with energy technology development requires continuing research and development to improve measurement, dosimetry, and instrumentation techniques. New, innovative measurement concepts or approaches as well as advanced system design and development are encouraged. Proposals should address areas where existing techniques limit the capability for detecting and quantifying potentially deleterious energy-related agents. Instrumentation improvements are also sought which will enhance techniques for defining material transport through environmental media. Proposals should involve new approaches in measurement science or offer promise of major enhancements over existing measurement technology. Proposals that suggest small improvements that are mainly product design and packaging, or that comprise product testing for commercialization, are not of interest. Subtopics include, but are not limited to, the following:

a. Health Research Requirements

- Radiation Instrumentation and Dosimetry—Advancements in mixed field beta/gamma and neutron/gamma dosimetry are needed for health protection purposes. Both personnel dosimetry techniques and portable field systems require improvements.
- Industrial Hygiene Technology—Portable instruments are needed for monitoring, in real time, high molecular weight, biologically active organic materials (aerosols and vapors) in the work place. Such instruments should have detection limits in the part per billion range.
- Analytical Instrumentation—Improved techniques are required to detect and measure biologically active materials in complex mixtures such as emissions and waste byproducts associated with energy technology development.
- Biomedical Instrumentation—Energy-related agents are known to induce cellular and subcellular modifications in biological systems. Advanced techniques for identifying and quantifying these induced alterations are of interest.

b. Environmental Research Requirements

- Precipitation Sampling—An automatic, self-contained sampler capable of sampling and preserving individual events for a one-week period is of interest. Critical requirements include: exclusion of contaminants during dry periods, integrity of each event sample, remote unattended operation, and on-line record of time of event and amount of precipitation. Also of interest is a similar precipitation sampling capability for sampling and preserving individual events for trace element analysis.
- Hydrogen Peroxide Monitor—There is a need for the development of analytical methodology and instrumentation for real time field use to determine hydrogen peroxide in cloud water and in precipitation at the parts per billion level. Hydrogen peroxide appears to be the most important oxidant for sulfur dioxide in the aqueous phase (cloud water and precipitation).
- Particulate Measurement—There is a continuing need for enhancing the current capability for characterizing particles. Examples of needed improvements include: better techniques for measuring size and concentration of unattached radon daughters that have clustered with other atmospheric constituents. Improved field methods for automatic real time counting and sizing of air-borne flyash cenospheres, and development of theory and practical aspects of low-pressure impactors for particles below 0.1 micrometer.
- Remote Sensing—Further advancements in remote sensing technology are desired for a variety of environmental applications. For example, there is need for improved definition of

organic vs. inorganic particles in surface and subsurface ocean layers, enhanced sensitivity for detection of ecosystem stress effects, and improved methods for estimating total biomass and biomass classification.

Bibliography

1. *Health and Environmental Effects of Synthetic Fuel Technologies: Research Priorities; A Report to the Federal Interagency Committee on Health and Environmental Effects of Energy Technologies,* Richard D. Brown, Project Coordinator, PB 81212474, 1981. Available from National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161
2. *Industrial Hygiene Monitoring Needs for the Coal Conversion and Oil Shale Industries,* Study Group Report, DOE/EV-0058, 1979 (NTIS)
3. *Proceedings of the Fifteenth International Symposium on Remote Sensing of Environment,* Environmental Research Institute of Michigan, Ann Arbor, Michigan (1981). Available from Environmental Research Institute of Michigan, P.O. Box 8618, Ann Arbor, MI 48107

5. NUCLEAR MEDICINE

The objective of this topic area is to enhance the beneficial applications of radiation, radioactive and stable isotopes and labeled compounds for the study, diagnosis, and treatment of human diseases or their underlying physiological processes. Research on new, practical, and innovative ways of exploiting their medical uses, of identifying and preparing new isotopes and labeled metabolically active compounds and of detecting and depicting their presence *in vivo* are of particular interest.

Proposals are solicited in (but need not be limited to) the following subtopics:

a. New Medical Applications for Radiation, Isotopes (Radioactive or Stable), and Labeled Compounds—Particularly for describing, evaluating, or treating cardiopulmonary and vascular diseases, cancer, brain disorders, metabolic processes, and physiological functions.

b. Improved Methods for Producing Readily Available and Biomedically Useful Radionuclides—These include short-lived gamma-emitters, and stable isotopes, labeled molecules, and other biological components (including elucidation of structure—activity relationships to better design efficacious radiopharmaceuticals); also needed are automated apparatus and techniques for preparing such radioactive moieties at the site of use.

c. Advanced Instrumentation for Non-Invasive Measurements and Imaging of Organ Function and Physiological Changes—This includes rapid, cost-effective techniques for measuring stable isotope enrichments; high spatial resolution imaging systems such as single-photon emission and positron emission tomography with improved accuracy, quantitative capability, versatility, and safety; and related developments in detector materials and devices as well as data handling and display systems.

Bibliography

1. *Nuclear Medicine Instrumentation Development,* DOE Program, Study Group Report, DOE/EV 0034, February 1979. Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161

6. ADVANCED POWER GENERATION

Forecasts show that the fraction of energy which is used as electricity is expected to continue to increase because of the high degree of convenience and control and the ability to perform activities with potential for pollution under controlled conditions at remote sites. The major amount of power generation is by combustion of fossil fuels. In order to improve the economics of production of this form of energy, conserve natural resources, and maintain a clean environment, improved technologies for power generation are of value in carrying out the mission of the DOE. Subtopics include the following:

a. Gas Turbines—Higher efficiency and more durable gas turbines capable of operation on lower cost and lower grade fuels which will be available in the future can enable the utilities to be more cost-effective in their operation. Innovative research in the use of coal-based liquid, gaseous, and solid fuels for firing gas turbines while ensuring durability commensurate with utility and industrial requirements would be of value. Turbine vane and blade protection technologies which would enable gas turbines to operate on less expensive fuels, while still performing reliably, efficiently, and cleanly, would be of substantial interest.

b. Fuel Cells—Fuel cells convert chemical energy from fossil or other fuels directly to electrical energy, thereby avoiding the inconvenience of utilizing the energy in the intermediate form of heat. The relatively small size, modular nature, and essentially pollution-free operation of fuel cells enable users to add generation in small, efficient modules. Innovative advances in fuel cell electrodes, components, and designs would accelerate the time at which this technology can reach the commercial marketplace.

c. Novel Concepts of Power Generation—Many power generation concepts which utilize fossil fuels have been examined previously at levels of detail sufficient to select for development only those with the then-perceived greatest likelihood for successful development and commercial operation. However, such prior screening is not to be viewed as excluding new concepts not yet evaluated. Innovative ideas on power generation utilizing fossil fuels with promise of practical development are encouraged to be submitted in this subtopic.

7. ELECTRIC POWER TRANSMISSION TECHNOLOGY

This topic covers a wide range of efforts to advance the state-of-the-art of electric power transmission. The goal is to assure an adequate, efficient, economical, and reliable supply of electric power. Efforts are presently underway to extend power transmission technology into the ultra-high voltage (UHV) range. Power transmission systems are very capital intensive. An aggressive research and development program offers, therefore, a potential for significant savings over the years, improvements of the electrical performance, and reduced environmental impact at the power transmission facilities. Subtopics of interest are:

a. Fiber Optic Systems—Present approaches to high voltage and high current measurements suffer from limitations in accuracy and speed of response. As the cost of devices continues to increase with higher voltage levels, electro-optic and magneto-optic technologies become more promising as an alternate approach. Guided wave interrogation of electro and magneto sensitive crystals is likely to provide the basis for a measurement system that will meet or exceed present specifications for meters, relays, and fault location devices while overcoming such technical obstacles as current transformer saturation and oscillations.

b. Transmission Line Design—Increasing costs of power transmission lines have instigated attempts to refine the techniques used in analyzing mechanical stress on transmission lines and structures. Computer model approaches contribute to component and system development, which will reduce costs and increase the reliability of transmission line systems. Computer-aided systems to design and optimize transmission lines in order to achieve cost savings will be given increased emphasis.

c. Right-of-Way Maintenance—New techniques and equipment for clearing and maintaining transmission line right-of-way will be required to meet new environmental impact guidelines. Improved herbicides and tree growth retardants need to be investigated, as well as new techniques to reduce the danger-tree cutting, such as laser beam or high pressure water jet methods.

8. PHOTOVOLTAIC RESEARCH

This topic covers a wide range of DOE interests in the photovoltaic conversion of solar energy. The key areas of interest are conversion efficiency, cost reduction, and stability. These can be achieved by the use of new materials, new device technologies, and/or new system technologies. There are many areas of improvement that would be relevant, so only a few examples are cited as illustration. Proposals are solicited in, but not limited to, the following subtopics:

a. Innovative Deposition Techniques—Research to explore new ideas in the deposition of thin film photovoltaic materials and devices. This area includes the use of existing, potentially low-cost, deposition techniques with materials to which these techniques have not been applied.

b. Monolithic Multijunction Photovoltaic Cells—Research to solve the problems inherent in monolithic multijunction photovoltaic cells, such as current matching in two-terminal devices.

c. Photovoltaic Diagnostic Technique Development—Research on new techniques for diagnosing efficiency-limiting aspects of photovoltaic cells and/or the understanding of basic photovoltaic mechanisms.

d. Novel Concentrator Optics—Research on new optical techniques for solar flux concentration and beam-splitting at high optical efficiency.

e. Power Conditioning and Control—Research on new techniques for converting the variable direct current output of photovoltaic modules into constant, utility-compatible alternating current at high efficiency.

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9. TRANSPARENT SOLAR MATERIALS

This topic aims at the development of transparent materials for solar energy applications. Two areas of special interest are described below:

a. Thin Film Polymer Laminates—The objective here is to develop a thin film polymer laminate with a solar transmittance greater than 0.92, a lifetime of 10-15 years, and a potential of costing less than $\$5/m^2$ when mass produced. Current polymer materials which are stable in outdoor environments typically consists of fluorocarbons that are expensive. However, by utilizing a combination of polymers in a layered system, an inexpensive stable film may be achieved. Such a system would use a stable polymer as the outer layer with an inexpensive, but less stable, polymer as the bottom layer(s). This material would find application in flat plate collectors, passively heated buildings, heliostat plastic domes, and as a photovoltaic encapsulant. The primary advantages of such a film in solar energy systems compared to glass are lower weight, higher impact strength, and greater design flexibility (shaping).

In performing the research, attention should be given to degradation from environmental factors such as sunlight, moisture, and dust; correlation between microstructural changes and macroscopic property degradation, polymer-polymer bonding techniques, and stabilized co-polymers. A methodology for service life prediction should also be developed.

b. High Temperature Windows for Solar Receivers— This research is to aim at the development of transparent, high-temperature materials with low reflectance to separate radiantly driven thermal or chemical processes from the outside environment. This development can significantly improve the efficiency of both cavity and linear solar receivers.

The availability of high temperature windows would facilitate development of new processes such as direct radiant heating for chemical processing, synthetic fuel production, or thermochemical hydrogen production. Initial efforts should be at the laboratory and small solar test scale. Materials and processes exist that might provide high-efficiency windows for concentrated sunlight, but have not been analyzed and developed for this application. A program to develop and test these materials so as to provide performance and design data would significantly increase the use of windows. The development of new, high-temperature materials would permit fuller use of the high thermodynamic potential of concentrated sunlight. These materials could set the stage for development of thermochemical water splitting cycles, biomass and coal conversion processes, or the production of high value chemical products from sunlight.

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10. SUNLIGHT MANAGEMENT IN BUILDINGS

This topic covers research and development aimed at a better utilization of sunlight incident upon buildings. Two specific areas of interest are:

a. Advanced Daylighting Systems for Multistory Buildings—Lighting accounts for about one quarter of the total primary energy use in existing American commercial buildings. For office buildings constructed, as in current practice, with thermal envelope integrity and HVAC system efficiency, this fraction is closer to one half. Using daylight to illuminate buildings may have the potential for displacing more than half of this lighting energy, while substantially reducing both cooling energy consumption and peak electric power demand on the utility. Some work has been done on single-story buildings having many small roof apertures to facilitate distribution of light through the building. In order to achieve comparable performance in multistory buildings, there is need for more sophisticated systems for distributing light. This solicitation is for advanced concepts for daylighting multistory commercial and industrial buildings. Proposals will be entertained in any of the following three broad areas: stationary reflector systems; single-axis tracking reflectors; and multi-axis tracking reflectors.

b. Advanced Materials for Passive Solar Applications—Passive solar technology is well known and widely accepted for increasing the contribution of a cost-effective energy alternative to fossil fuel use in buildings. Its current use is generally confined to sun spaces, apertures (windows) which permit direct and indirect space comfort, natural lighting, and masonry construction for energy storage. Further research is needed in the following areas:

- Natural Light Management and Heat Load Control—Materials research should be directed toward the development of (1) low thermal conductance, high optical transmission materials and (2) optical switching materials. The objective is to replace conventional glazings with inexpensive materials that will reduce artificial lighting needs in buildings, reduce conductive heat transfer, and provide spectral control of the radiant transfer through the aperture. Aperture materials which transmit the visible portion of the solar spectrum while absorbing or rejecting the non-visible radiation may be possible. Control mechanisms include (1) electrochromic systems, (2) photochromic systems, (3) thermochromic systems, and (4) liquid crystal systems.
- Thermal Energy Storage Materials—Materials research should be directed toward development of: (1) storage materials with heat capacities per unit volume which are a factor of 10 larger than common building materials and (2) concepts that allow these materials to be integrated effectively within conventional building materials. Advanced phase change materials need to be developed, with particular emphasis on durability and stability.

11. IMPROVED ENERGY AND MATERIALS USAGE IN INDUSTRY

The DOE seeks innovative approaches and new concepts which will lead to substantially increased energy and material productivity in U.S. industry. The goal is to make U.S. manufactured goods more competitive in world markets, reduce national purchases of imported energy and create new U.S. energy conservation equipment for the industrial sector.

Proposals must be for innovative concepts or significant improvements in present practices, not for evolutionary incremental improvements in existing technology. Research projects are sought which will result in major savings for U.S. industry compared to the cost of implementing the innovation.

Subtopics of interest include, but are not limited to, the following:

a. New Techniques to Replace Those Presently Used in Processes Such as Extraction, Comminution, Beneficiation, Reduction, Cutting, Melting, etc.—A major process improvement in comminution is needed; this energy intensive process, used in many industries, could be made more energy efficient by materials improvements, analysis of the zones of maximum fragmentation and wear (fragmentation physics and media mechanics), and systems integration. Other examples are: a new manufacturing method to cut amorphous metal strip for electric motors or transformers, and a new scrap preheating system for steel furnaces.

b. Industrial Waste Energy Recovery—More efficient utilization of waste heat can be accomplished through the development of methods of reducing stream inputs by major improvements in current industrial process and facility operations and by devising new concepts which extract the remaining portions of the waste heat and return this energy to the operation in a useful manner. The former approach involves, for example, combustion improvements resulting from advancements in science, while the latter deals with developments which transport, transform, and/or upgrade the quality of the waste energy.

Examples are: New working fluids to operate above 500°F, new materials with high temperature tolerance and other characteristics which would be required, for example, by recuperators; and new concepts for monitoring combustion effectiveness and flame characterization to better control combustion processes and reduce fuel consumption.

c. Utilization of Industrial Wastes as Fuels, Chemicals, or Substitute Materials—In order to make significant use of the large unutilized wastes, new processes, techniques, and uses will have to be developed.

Interest areas and examples include:

Recovery of materials from inorganic sludges, ash, dusts, and semi-solid wastes, which typically contain metallics as oxides, or other inorganics having intrinsic value; waste carbon monoxide utilization—principally from ore reduction and carbon black production; innovative materials or products developed directly from waste as a principal constituent to be substitutes for conventional raw materials; innovative recovery of products and/or energy from agricultural wastes; innovative biological/enzymatic processes to utilize industrial wastes; and industrial waste water utilization.

d. Advanced Industrial Separation and Concentration Processes—The need for more efficient separation processes is widespread. Required functions include separations involving all combinations of solids, liquids, and gases.

Examples of important processes which could benefit from innovative improvements include: membrane methods, adsorption, advanced freeze crystallization, distillation, electrolysis, spray drying, evaporation, and condensing.

e. Improved Materials and Concepts to Reduce Friction Losses and Wear—New materials and concepts to reduce parasitic friction losses and wear and to allow operation of advanced heat engines at increased temperatures, including high temperature bearing materials, air/gas bearings, and low friction coating developments.

f. Novel Applications of Dielectric Heating

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12. GEOTECHNOLOGY

The DOE supports research in the geosciences in order to meet the long-term national energy needs of the United States. Programs in waste isolation, continental scientific drilling, and energy resource recognition and evaluation require the application of remote sensing techniques and drilling and logging technology in unusual and hostile environments. The DOE is interested in supporting the advancement of geophysical and geochemical remote sensing techniques, downhole logging, and sample acquisition in corrosive environments of high temperatures and pressures. Subtopics are:

a. Remote Surface and Subsurface Sensing Techniques—Innovative improvements and/or development of entirely new approaches in remote sensing. These include instrumentation, electronic packaging, data storage, and data transmission for downhole applications of seismic, gravity, electromagnetic, magnetotelluric, acoustic, and other methods.

b. Downhole Technology—Advances in drilling technology, fluid and solid sample acquisition maintaining in situ conditions, and downhole logging to temperatures between 300 and 1000 degrees Celsius and to drilling depths of 10 km.

c. Development of Low-to-Moderate-Cost Rapid Scanning Analytical Facilities—For field and laboratory use on geological samples.

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13. FOSSIL FUELS RESEARCH

Coal is both abundant and inexpensive compared to oil and gas. Greater use of coal is impaired by the inconvenience of using a solid fuel form, and of cleaning up the products of combustion which contain ash and gaseous pollutants. Innovative research could benefit coal utilization by enabling users to handle coal with a level of convenience and reliability approaching liquid and gaseous fuels, and by developing methods to remove sulfur and ash to levels comparable to oil in an economic manner. Technology is also being developed to utilize the reserves of coal and oil shale for the production of synthetic fuels to lessen dependence on imported petroleum. The DOE is interested in supporting research in synfuels conversion technologies with primary emphasis on utilization of coal and oil shale as feedstocks. Before commercialization of these synfuels can be achieved, much research needs to be conducted to obtain a scientific understanding of processes that are technically feasible, economically viable, and environmentally acceptable. Areas of special interest include:

a. Coal Cleaning and Clean Combustion—In the 1950's, engineering developments eliminated soot and particulates from coal combustion products, and recent developments have concentrated on reducing emissions of sulfur and nitrogen oxides and unburned hydrocarbons. Innovative research can contribute to further reductions in emissions of particulates and gaseous emissions, and to the innovative application of recent developments to industrial, commercial, and residential systems which have not yet benefited from recent engineering advances. Removal of ash and sulfur to levels comparable to fuel oil are desirable by physical processes, processes involving surface chemistry, and chemical processes for de-ashing and desulfurizing coal. Excluded is gasification, hydrogenation, pyrolysis, and organic chemical dissolution of coal.

b. Innovative Liquid Suspension Technology—Cleaned coal may be transported, stored, and burned in liquid suspension. Various techniques may be used to obtain stable suspensions of controllable viscosity suitable for pumping and atomization. Water, alcohols, or other suitable media may be used as the carrier fluid.

Innovative research on systems which combine subtopics (a) and (b) is encouraged, and the end product which is sought is a stable, clean fluid which has the potential for being substituted for oil in boilers, heaters, and furnaces.

c. Fundamental Coal Structure and Reaction Mechanisms—The objective in this area is to derive new fundamental information and concepts about coal structure and the chemical and physical mechanisms whereby these structures undergo devolatilization and gasification. The emphasis here is on new data from which either innovative process concepts can be derived or with which existing processes can be improved.

d. Innovative Gasification Methods—The objective in this area is to initiate or advance the development of novel approaches to the derivation of fuel gas or syn-

·thesis gas from American coals. The emphasis is on innovative process chemistry or reaction concepts, rather than new mechanical approaches to conventional gasification systems.

e. Gasification Mathematical Models—The objective in this area is to obtain mathematical models of gasification system phenomena which can be used to predict behavior under new circumstances not yet directly observed by experience, such as scale-up to larger size units. All unit processes in the complete gasification system, including gasification, gas cleanup, gas separation, and waste water treatment, are involved. The emphasis here is on parallel development of new experimental data and mathematical models whereby the data enables improvement and validation of the models.

f. Gas Cleanup, Gas Separation, and Waste Water Treatment Methods—The objective in this area is to develop innovative, effective, and economic processes for cleaning and separating gasification process streams and effluents. This would include the removal of particulates, tars, sulfur, alkali metals, acid gases, and other undesirable components from process streams, separation of gasification product gas components, and the removal of organic and inorganic constituents of waste water to meet requirements for water reuse in a plant or discharge under environmentally acceptable conditions. The emphasis here is on development of new approaches to solve problems in cost, efficiency, and ability to meet product quality and effluent requirements.

g. Direct Coal Liquefaction—Innovative process concepts or improved understanding of the chemistry of direct coal liquefaction is desired. The respective roles of process solvent and catalyst in the reaction sequence are important.

h. Indirect Coal Liquefaction—Research is solicited on the conversion of synthesis gas (from coal gasification) to liquid products by new concepts with improved selectivity for desired products.

i. Synfuels Characterization—Research is desired on the characterization of liquids produced from coal and/or oil shale.

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14. FOSSIL ENERGY ENGINEERING AND MATERIALS

This area covers a wide range of possibilities for research from complex systems functions to innovative modification of individual components. Since many of the component problems associated with coal and oil shale technology result from the corrosive and abrasive aspects of coal, oil shale, and intermediate products generated during processing, materials research and development is an important part of this topic. Although components have been adapted from the petro-chemical and electric utility industry, this has not always been successful and opportunities exist for new developments which will provide improved reliability, durability, and efficiency at reasonable costs. Excluded from the component area are process reactors and specific processing steps.

The materials research is directed toward improving the reliability, efficiency, and longevity of fossil systems through improvement in the behavior of materials. Modes of deterioration, which limit efficiency and lifetime, for which improved materials are required include: oxidation, sulfidation, hydrogen attack, brittleness, slag attack, environmental effects on mechanical properties, erosion, and abrasion. Research on coal or other mineral matter and concrete is excluded.

Specific areas of interest are:

a. Heat Exchangers—Heat exchangers are presently limited by materials deterioration and fouling. Use of innovative materials, cleaning devices, and novel heat exchanger concepts provide new possibilities to develop durable, reliable, cost-effective heat exchangers that survive or circumvent the fouling and corrosion/erosion problems at temperatures up to 3000°F.

b. Pumping Systems—Novel concepts are needed to develop durable systems for pumping high density solid/liquid slurries. New design approaches, such as liquid leg pumps, should circumvent or significantly minimize the erosive wear which presently limits the durability of state-of-the-art pumps.

c. Seal Systems—New approaches are needed for seal systems, both dynamic and static, for a wide range of applications such as pumps, valves, dry coal feeding equipment, and engines. Seal conditions include solid fines, corrosive gases and liquids, as well as high temperatures. Non-contact, flushing film concepts may be a promising approach.

d. Pressure Relief—Pressure relief systems are needed that will safely limit overpressure and reseal vessels processing hot gas streams containing solids and flashing liquids. Present state-of-the-art relief valves can incur erosive wear and are unable to reseal pressure vessels after a single operation.

e. Oxygen Separation—Development of a low-cost, variable-sized, maintenance-free device for separating and pumping oxygen could have many applications in fossil fuel conversion and utilization areas.

f. Rapid Shut-Off Valves—Concepts for fast acting, hot gas shut-off valves in sizes over 24″ diameter are needed for combined-cycle pressurized fluidized bed systems.

g. Rapid Ignition Systems—Concepts for rapid ignition systems for fluidized beds, gasifiers, and coal slurry combustors.

h. Hot Gas Clean-up—Concepts for particulate capture of 99.9% with particulates in the 1-100 micron range and operating with particulate-laden gas streams at 1800°F.

i. Heating Devices—In situ radio frequency energy delivery systems for heating oil shale underground.

j. Fabrication Techniques

- Welding—New methods are needed to improve the speed of welding thick section pressure vessel steels and the quality of the weld. This should reduce the cost and improve the reliability of coal conversion reactors operating at elevated temperature with high hydrogen partial pressures.
- Casting—Means of reducing the cost and improving the wear resistance and strength of components such as pumps and valves by techniques such as electroslag casting and plasma arc transfer processes.

k. Structural Ceramics—Structural ceramics such as silicon carbide offer the potential for improved efficiency and corrosion resistance in heat engines. Increasing the understanding of methods of improving toughness is desirable, as well as innovative manufacturing research. Thermal barrier coatings are included in this category.

l. Refractories—Refractories utilized as liners of slagging boilers and gasifiers are subject to deterioration. Research to optimize refractory structure and composition is warranted.

m. Corrosion and Erosion Resistance—A wide range of components including boilers, turbines, heat exchangers, pumps, valves, and diesels exhibit corrosion and/or erosion as the primary mode(s) of deterioration. Research is needed to investigate solutions to this deterioration by means of:

- Surface modification by laser treatment and ion implantation.
- Coatings and claddings applied by techniques such as physical and chemical vapor deposition, thermal spraying, and plasma transfer processes.
- Compositional changes as a result of surface alloying.

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15. FOSSIL ENERGY INSTRUMENTATION

Future large-scale advanced fossil energy processes such as coal gasification, liquefaction, and fluidized-bed combustion, will have to be monitored and controlled for reasons of process control, safety, reliability, economy, and protection of the environment. Smaller plants require diagnostic instrumentation to gather the data necessary for reliable scale-up of the processes. The required instruments will measure important process variables and monitor the integrity of critical equipment within the processes.

In these processes, sensors are exposed to hostile conditions—high temperatures, high pressures, severe corrosive conditions, and particle erosion. The time response required for safe operation may be in the millisecond range. In addition, the multiple-phase nature of the process media makes measurements even more difficult. For example, solids and liquids may flow at different speeds within a pipe, and the particles in a gasifier-entrained bed may be at a different temperature from the gas.

DOE is interested in supporting advanced applied research that will explore new scientific concepts or approaches to instrumentation, particularly those which pursue applications which are an outgrowth of fundamental research. Support will be confined to high-risk, advanced, applied research. Potential for scale-up to the requirements of commercial scale processes will be a major consideration. Proposals should concentrate on:

- The possibility of measuring important variables not currently measurable.
- Areas where major improvements (not incremental) can be made in sensitivity, accuracy, or response time by using new scientific principles or techniques.

Proposals that are mainly for product development, that is such that the original research component is minimal and the problem is essentially one of design or packaging into a new format, or testing some product for commercialization will not be funded. Examples of possible areas to be supported are:

a. Instrumentation for Combustion Research—Innovative research in instrumentation and diagnostic techniques leading to greater understanding of combustion and the combustion of solid and coal-derived fuels in particular, would enable combustors to be designed with improved features such as greater compactness, lower cost, greater fuel flexibility, and reduced emissions.

b. Flow Instrumentation—Measurement of the mass flow rates of the separate phases, particularly the solids, in solid-gas, solid-liquid, or solid-liquid-gas flow streams is needed. Generally this will involve independent measurement of density and velocity for a computed value of mass flow.

c. Temperature Instrumentation—Measurement of temperatures and temperature profiles within reaction or combustion vessels, temperatures of walls, and slag temperature is needed for temperatures to 3000°F within 50°F.

d. On-Line Compositional Analysis of Solids—The real time measurement of the composition of solids in fossil process streams is required for control of reaction rates and monitoring of harmful species.

e. On-Line Analysis of Gas Streams—The real time measurement of the molecular composition of gas streams as well as monitoring of harmful species is required.

f. Characterization of Particulates in Gas Streams—On-line monitoring of particles entrained in gas streams, including their number, size, and size distribution, composition, and velocity is required for protection of equipment—especially turbines—and environmental control.

g. Level Measurement—Measurement of fluidized-bed levels, levels of crushed solids in hoppers, and levels of solid-gas interfaces in fluidized beds is needed. Techniques which integrate over the surface or interface are preferred.

h. Viscosity—Non-sampling measurement of viscosities of slurries and of molten slag is needed.

i. Non-Destructive Evaluation of Equipment—Techniques for monitoring the integrity of process piping and vessels, including refractory linings, as well as components such as pumps, valves, and turbines, are necessary. Emphasis should be on identification of problems in time for handling during scheduled maintenance.

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16. URANIUM ENRICHMENT

The DOE is the only supplier of uranium enrichment services in the United States. At the present time, almost all of the enriched uranium is produced using the gaseous liquid diffusion process developed during World War II. Advanced technologies are being explored by the DOE to replace the power-intensive gaseous diffusion process. Two advanced processes are under consideration: (1) the Atomic Vapor Laser Isotope Separation (AVLIS) technique, which employs finely tuned, red-orange laser light to separate the uranium isotopes; and (2) Gas Centrifuge separation.

a. AVLIS Engineering—As AVLIS proceeds from the early stages of engineering development at present to process demonstration, subsystem development and engineering will receive much attention. In this regard, AVLIS laser technology can profit from innovative research and development on the pump laser. The Copper Vapor Laser (CVL) is the leading baseline technology candidate. For CVL technology to satisfy AVLIS plant requirements, long-lived devices (thousands of hours of operation) must be developed in the 100 W-1 kw range at nominal pulse repetition rates in the 5 kHz range.

b. Gas Centrifuge Engineering—The working material used in the gas centrifuge is gaseous uranium hexafluoride, a highly corrosive material. Development of corrosion-resistant materials suitable for marking fragile centrifuge parts is a major research need.

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17. NUCLEAR REACTOR MATERIALS

The Department of Energy seeks innovative approaches to technical problems encountered in applied research and development in the field of nuclear reactor materials and structures. Solutions to such technical problems often generate important improvements in the performance of nuclear reactor systems. A need exists for the development of new materials capable of withstanding the high-stress environments encountered in nuclear reactors. Interests include but are not limited to:

a. Improved Alloys for Service in HTGR's at Very High Temperatures (850°-1100°C)—Some alloys for this temperature regime exist but allowable stresses are low. Many alloys are also subject to embrittlement by the small carbon content in the helium coolant gas resulting from corrosion of reactor graphites. Some alloy series have been found to benefit from protective oxides coating which can be obtained and sustained by use of a small water vapor content in the helium coolant gas. However, this water vapor can cause damage to reactor graphites. Candidate alloys are so reactive in this temperature regime that the permitted amount of water reacts with the first surface exposed rather than generally over the whole surface. The potential of carbiding is present over a wide portion of the temperature range and a more generally effective protective mechanism may be required (or a less susceptible alloy). Desired improvements include: (1) higher alloy strengths; (2) alloys that are less subject to carbiding effects from the carbon normally present in the HTGR helium coolant system; and (3) improved methods of fabrication of complex structures using alloys suitable for these regimes of temperatures, pressures, and gas impurities.

b. Advanced Burnable Absorber—The DOE is supporting the development of the technology to extend the burnup of light water reactor fuel, which reduces the amount of spent fuel generated and thereby relieves the pressure on the back end of the fuel cycle. Due to the higher initial enrichment, extended burnup fuel cycles are expected to require improved burnable absorbers or other technology to control power peaking.

c. Improved LMFBR Techniques and Materials—Innovative methods and/or materials development for the high-temperature (1000°F) conditions existing in sodium-cooled steam generators in LMFBRs are solicited. Representative needs include: determination of cavitation damage potential in sodium pumps; techniques for de-magnetizing 2¼ Cr-1 Mo steel tubing to permit reliable welding; improved structural analysis techniques; high-temperature lubricant for bolted applications in sodium; improved damping for geometries typical of LMFBR components to evaluate the effect of seismic loadings; small (6″ or less) Class 1 valves for LMFBR service conditions.

18. NUCLEAR REACTOR INSTRUMENTATION

The DOE is interested in supporting projects that may lead to improved measuring devices, computerized data acquisition equipment, and new sensors for use in monitoring and control of nuclear reactors, including the LMFBR. Subtopics for research and development include but are not limited to the following:

a. Improved Instrumentation for Water Vapor Monitoring in Large Helium Loops in the HTGR—The HTGR uses helium gas as a coolant. Water from heat exchangers can seep into the system. It is necessary to limit this water vapor to a few parts per million because of several adverse effects water can have on graphite structures and fuel assemblies. The HTGR presently uses subcooled mirrors to condense the water and a light system to detect the presence of condensed moisture on the mirrors. Desired improvements include: (1) faster response, (2) less complicated instruments, and (3) better accuracy over a wide range of water vapor contents.

b. Instrumentation for Safeguarding Reprocessing Plant Operation—The DOE seeks innovative approaches to high resolution monitoring of selective isotope throughput in LWR reprocessing plant operations. Commercial size plant operations (1500 tonnes heavy metal/year) have plutonium throughputs large enough that existing mass measuring devices/procedures result in material unaccounted for exceeding safeguard significance. The DOE is particularly interested in supporting projects that may lead to the capability of monitoring plutonium throughput at selected material balance areas to an accuracy of better than 0.05 percent on a real time basis. Devices that are highly tamper-proof are especially desired.

c. Rapid Personnel Radio-Analysis—This involves the rapid detection of radioactive contaminants within the human body. The general specifications of such an apparatus should include: (1) a machine large enough to climb into or walk through to enable the detecting equipment to have a complete view of the body, (2) counting time on the order of 4 - 15 seconds per individual, (3) ability to distinguish between different radionuclides and the amount of each present, and (4) capability of storing counting results for thousands of people.

d. Strain Measuring Devices (Tensile and Creep-Rupture Testing)—A contact extensometer is needed with improved accuracy and stability and with the capabilities of high vacuum operation and multiple measurements. An optical extensometer is needed with improved resolution, accuracy, stability, and tracking capability.

e. Strain/Displacement Transducers for Application to Piping Systems and Components—There is a need for such transducers with increased accuracy, resolution, and resistance to degradation due to high-temperature and radiation environments.

f. Sensors for Nondestructive Testing Applications—This includes: (1) ultrasonic transducers with improved resolution, sensitivity, high-temperature capability, and radiation resistance, (2) eddy-current probes with high-temperature capability, radiation resistance, magnetic saturation capability, and improved sensitivity, and (3) optical probes for viewing through long lengths (70 feet) of tubing with small bores (0.4 in. ID). Application of these sensors in arrays for imaging is also of interest.

g. Computerized Data Acquisition Equipment—More economical and efficient interfaces between mechanical properties test equipment used in nuclear reactor applications and microcomputers are needed. Such hardware would also require new software to handle mechanical properties data storage, analysis, and display.

h. Radiation Hardening of Electronics—High radiation levels in reactors and fuel processing facilities can have deleterious effects on electronic instrumentation. DOE has an interest in methods for radiation hardening of electronic equipment used in such environments.

i. High Sensitivity Long Neutron Detectors (5-8 Feet)—There is a need to develop and demonstrate such detectors for use in subcritical reactivity measurement of reprocessing equipment using noise analysis methods.

j. Extended Burnup Instrumentation Development—The DOE is supporting development of the technology to extend the burnup of light water reactor fuel, which reduces the amount of spent fuel generated. This technology will require improved instrumentation in the following areas:

- Fuel Performance Monitoring—Improved measurement techniques are required to evaluate and monitor the performance of fuel during reactor operation, poolside examination, and hot cell examination. For example, failure detection, fission gas release, dimensional changes, etc., need to be measured.
- Reactivity, Burnup, and Decay Heat Determination—Techniques are required to quickly and accurately determine the reactivity, burnup, and/or decay heat emanating from high burnup fuel.

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*Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

19. COMMERCIAL NUCLEAR WASTE MANAGEMENT

The objective of this topic is innovative applications of science and engineering to assist DOE in: (1) the safe management of existing nuclear wastes, and (2) the development of technology and facilities for the long-term management of present and future wastes. Ths solicitation is concerned only with the management of commercial waste. Commercial nuclear waste is the waste from the commercial sector for which the DOE has been assigned responsibility. Proposals are solicited in the following subtopics:

a. Waste System Technology—Advancements in low level waste technology are required in waste treatment and processing, volume reduction, and waste disposal methods.

b. West Valley Demonstration Project—Only one commercial venture to reprocess reactor spent fuels has been licensed in the United States. That plant, located near West Valley in western New York, was operated from 1966 to 1972. High-level waste from reprocessing about 650 tonnes of spent fuel is stored in tanks located in underground reinforced concrete vaults. The plant licensee terminated operation in 1976 and, in 1980 (Public Law 96-368, West Valley Demonstration Project Act of 1980), responsibility was transferred to the DOE for the immobilization of the waste at West Valley. Research is required before this task can be performed. The waste, present as a sludge, must be placed in a suitable form and containers must be developed for storage in a solid, durable form for long-term isolation as part of the West Valley Demonstration Project Act.

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20. NUCLEAR PHYSICS INSTRUMENTATION AND TECHNOLOGY

The DOE seeks innovative approaches to technical problems encountered in basic research in nuclear physics. Measurements in this field are typically performed at the limit of technical feasibility. Hence, new capability will often generate important advances in scientific knowledge. The DOE is particularly interested in supporting projects that may lead to advances in detection systems for nuclear particles and data acquisition and analysis systems used in nuclear physics experiments. Opportunities exist for developing equipment beyond the present state of the art and outside of the usual scope of research and development activities at the national accelerator facilities. Suggested areas of interest for research and development include, but are not limited to, the following:

a. Particle Detectors—Devices and materials for detecting charged particles (such as electrons, protons, heavy nuclei, muons, and mesons), photons, neutrons, neutrinos, and single atoms with improved resolution, sensitivity, stability, low noise, dynamic range, gain-bandwidth product, damage resistance, and background suppression. Examples include, but are not limited to, solid state materials (for example, silicon strip detectors, silicon detectors with high position resolution and multi-hit capability, charged coupled devices); high efficiency photon detectors (for example, microchannel plates, photo diodes, photomultipliers); photosensitive materials (for example, scintillators, bismuth germinate crystals, scintillating optical fibers); gas sensitive devices (for example, proportional, drift, and Cerenkov chambers); liquid argon and xenon ionization chambers; lead glass detectors; and single-atom detectors utilizing laser techniques.

b. Electronics for Nuclear Detectors—Instrumentation for processing analog and digital signals from nuclear detectors with significantly improved speed, resolution, counting rate, and noise suppression (for example, low noise amplifiers with good resolution and high counting rate, stable low threshold discriminators, monolithic flash analog-to-digital converters, and fast stable light pulsers with less than 1 ns rise time).

c. Nuclear Data Acquisition and Analysis—Research and development of devices and systems for the acquisition and analysis of nuclear data. Significant improvements are sought in speed, flexibility, transportability, storage capacity, and ease of use (for example, novel front-end processors for CAMAC in the form of auxiliary crate controllers, microprocessor-based systems for the display of nuclear data, and other systems for interfacing experiments to computers).

d. Targets and Target Systems—New materials or devices for targets in nuclear physics experiments which provide a needed property (for example, a spin-polarized gas jet target, surface materials which inhibit depolarization, and innovative ways of preparing isotopically enriched targets for in-beam experiments).

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21. PARTICLE ACCELERATOR TECHNOLOGY

The DOE supports a broad research and development program in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced research and development is sought in support of this program, particularly with respect to new concepts of acceleration, advanced theoretical studies, and device development that will contribute to overall advances in accelerator technology. Suggested areas of interest include, but are not limited to, the following:

a. Theoretical Studies—Physical phenomena and principles underlying the design, operation, and performance of accelerators, storage rings, and beam transport systems. Areas of special interest are: effects of space charge, collective phenomena, beam-beam interaction in storage rings, polarization/depolarization mechanisms, non-linear beam dynamics, and phase space cooling.

b. Radio Frequency (rf) Acceleration—Very high gradient (>100 MeV/m) accelerating structures (superconducting or room temperature), particularly for wavelengths in the range 1 cm to 10 cm. High peak power klystrons (P > 150 MW) operating at L band or higher; high average power klystrons (P >1 MW, cw); free electron lasers, etc. There is particular interest in new concepts for multi-megawatt pulsed devices operating in the 3 to 30 gigahertz range.

c. Charged Particle Optics—Devices, concepts, and techniques utilizing electromagnetic, electrostatic, or plasma techniques to manipulate high momentum charged particle beams.

d. Phase Space Cooling—Theoretical studies, new concepts, and new or improved devices for stochastic or electron beam cooling of proton and/or antiproton beams. Areas of special interest are low dispersion, high beta waveguides (1 to 10 GHz); special high frequency, large band-width rf power amplifiers (>2 kW, >2 GHz band-width at center frequencies of 1 to 10 GHz); high voltage (1 to 5 MV), high current, low emittance electron beam sources; and high power beam collectors.

e. Advanced Accelerator Concepts—Particular interest exists in new acceleration concepts to provide very high gradient (>200 MeV/m) acceleration of intense beams of particles. Stageability, stability, manufacturability, and cost effectiveness are of concern.

f. Diagnostics—Novel concepts and devices are sought for rapid, computer-compatible measurement of beam intensity, position, profile (transverse and longitudinal), emittance, polarization, luminosity, momentum, energy, etc. Non-destructive techniques are preferred.

g. Ion Sources—Sources of particle beams for accelerators with improved intensity, emittance, and range of species, for example, high charge state sources for heavy ions, sources of negative light and heavy ions, and polarized sources for hydrogen ions, heavy ions, and electrons.

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22. HIGH ENERGY PHYSICS TECHNOLOGY AND RESEARCH

The DOE supports research and development in a wide range of technologies essential to the DOE's program in high energy physics. Principal areas of current interest include: advanced superconducting magnet and radio frequency technologies; very high speed electronics instrumentation; particle detectors; data acquisition and analysis systems; and special computer systems.

The DOE also supports research to explore the basic constituents of matter, the forces between these constituents, and the transformation of matter and energy at the most elemental levels. Although the dominant mode of experimental research is usually large, collaborative efforts at major national particle accelerator facilities, there are experimental and theoretical endeavors in collaborative or stand-alone efforts where small business can make creative and innovative contributions.

The areas in which proposals are solicited include, but are not limited to, the following subtopics:

a. Advanced Superconducting Materials and High Field Magnets

- Superconducting Materials—New or improved materials and related processing techniques for high critical current, high critical field superconductors including, but not limited to, niobium titanium, high tantalum content niobium titanium, niobium tin (NB_3Sn), tertiary alloys, etc., to produce low stabilizer (Cu,Al) to superconductor ratio multi-filamentary wire for use in very high field magnets ($B > 10$ T). Superconducting alloys for radio frequency application (L, S, and higher frequency bands) with particular emphasis on alloys with high critical temperature, low secondary emission coefficients, and correct stoichiometry.
- Superconducting Magnets—Design and fabrication of new or advanced concept dipole and quadrupole magnets for use in accelerators, storage rings, and high energy particle beam transport systems. Needed in this area are dipoles and quadrupoles with high magnetic fields (>10 T), low harmonic field coefficients, and low-cost when fabricated in quantity.

b. High Speed Electronics Instrumentation

- Electronics—Circuits and systems for rapidly processing pulse data from particle detectors such as proportional wire chambers, scintillation counters, Cerenkov counters, etc. Representative processing functions and circuits include, but are not limited to, very high speed counters (>200 MHz), time-to-amplitude converters, fast analog-to-digital converters, fast preamplifiers, etc. Systems of these devices compatible with the international CAMAC standard and/or the Fastbus instrumentation system are of particular interest.
- Systems—Advanced, high speed logic arrays and microprocessor systems for fast event identification, event trigger generation, data preprocessing, etc., with very high throughput capability. Such systems should be compatible with or implemented in the international CAMAC standard or Fastbus.

- Fastbus—A new instrumentation standard for interfacing modern computers to physics experiments is being developed by the U.S. NIM/CAMAC Committee at the request of the high energy physics community. Known as Fastbus, this is a flexible, multiprocessor-compatible modular data base system with wide application for data acquisition, data processing, and equipment control. Research and development is solicited for development of new Fastbus logic modules including, but not limited to, segment interconnects, segment extenders, fast buffer memories, counter modules (64 or more counters/module, f $>$200 MHz), segment display modules, microprocessor modules, and diagnostic modules.

c. Cryogenics and Cryogenic Systems—New and significantly improved cryogenic devices and systems for helium service in the temperature range 2 K to 20 K. Examples include, but are not limited to, new or significantly improved heat exchangers, rotating machinery (turbo-expanders, circulating pumps, compressors), transfer lines, cold seals (in pressure ranges from vacuum to 20 atmospheres), low heat-leak valves and computer compatible instrumentation (temperature, pressure, flow, etc.).

d. Special Computer Systems—A wide variety of innovative software and hardware for application in high energy physics experiments, data processing, and theoretical computations including, but not limited to, broadband intercomputer communication channels (5 MHz to multigigahertz); distributed microprocessor systems, pattern-recognition systems; emulators for very high speed computation; very large scale parallel processors (X100 to X1000 Cray-1 or IBM 3081) for large scale simulation; and cost-effective, multiple-access, very large, memory systems.

e. Theoretical and Experimental Physics Contributions—This subtopic includes, but is not limited to:

- Work exploring new or novel concepts for elementary particle physics and its relationship with other sciences (for example, applications of elementary particle physics to nuclear physics and astrophysics).
- Mathematical and computer algorithms giving new impetus to data handling and analysis.
- Novel experimental techniques which result in less costly and less complex apparatus (for example, need for small, less costly calorimeters, vertex detectors, etc.).

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23. PLASMA DIAGNOSTICS AND INSTRUMENTATION

The DOE is interested in plasma diagnostics and instrumentation to support a broad spectrum of fusion research activities. The goal of the SBIR solicitation is to develop and demonstrate novel techniques and instrumentation that provide reliable three-dimensional spatial and time resolution for all critical plasma parameters. A working definition of this topic includes those techniques and apparatus needed to detect, evaluate, suitably record, and display plasma and field parameters. Such measurements are crucial to the magnetic fusion energy program as the essential link between a plasma configuration attained in the laboratory and the theoretical formalism necessary for its evaluation, understanding, and suitable control as well as extrapolation to reactor conditions. Within the context of this solicitation, thought should be given to how advanced standardized data acquisition and display systems can be integrated into the diagnostic demonstration. Innovative proposals are sought in, but not restricted to, the following subtopics:

a. Measurement of Magnetic Field Configuration—The measurement of internal magnetic fields for conditions where plasma energy is such as to preclude the use of physical probe is a major need of the fusion program. Field measurements in tokamaks and elmo bumpy tori are needed to determine relatively small deviation from the vacuum field, such as poloidal fields from current distribution or spurious radial fields which are important for transport and stability considerations. Field measurements in high beta and mirror devices are needed to determine magnitude and direction of the primary field (for example, identification of field reversal points, verification of magnetohydrodynamic equilibrium configuration).

b. Ion Temperature—This measurement is necessary to determine the bulk plasma confinement time and ion-electron thermal transport. Although x-ray and ultraviolet Doppler techniques are currently in use, with the advent of higher temperature and density plasma, neutron counting, spectroscopy or other innovative techniques might significantly enhance the measurement capabilities.

c. Measurement of Equilibrium Electron Density and Temperature—Both the electron density and temperature need to be measured as a function of time and space in order to allow evaluation of the energy content of the confined plasma and the transport of energy and particles within it.

d. Fluctuations—The primary goals in this area are to obtain time-dependent measurements, localized in space, of the plasma potential, density, current density, temperature, and the fluctuating magnetic field.

e. Measurement of Impurities—Impurity radiation from hot, dense plasma represents a major energy transport or loss process to the walls. An evaluation of the attained confinement, at least of the gross integrated impurity-related loss, is essential. More detailed evaluation of the species distribution and charge state is also necessary to predict and understand this classical loss process. The objective of this subtopic is the development of instrumentation needed to quantitatively identify at least the line density and composition of impurities present, including neutral hydrogen, as a function of position and time.

f. Fusion Products—The role of the fusion product diagnostics gains in importance as the program approaches reactor-like plasma regimes. In current large-scale devices such as the Mirror Fusion Test Facility, the Tokamak Fusion Test Reactor, and also in the early operational period of follow-on experiments, sophisticated measurements of neutron spectra and charged fusion product particles will be necessary. New approaches in this subtopic are solicited.

In addition to the above, other areas of interest which require improved techniques or new instrumentation include: alpha particle velocity distribution for deuterium-tritium (D-T) plasma; density and velocity distribution of injected particles slowing down in a plasma or the high-energy tail velocity distribution resulting from rf heating; and charged-particle detectors that provide full energy spectra of multiple species at multiple times during plasma experiments. In particular, spatial resolution is important for analysis of edge plasma phenomena.

24. PLASMA HEATING TECHNOLOGY

This topic covers a wide range of technology related to heating plasma in a fusion research device. High power electromagnetic waves with frequency ranging from tens of megahertz to one hundred gigahertz and energetic neutral beams are used for heating ions and electrons of the plasma. DOE seeks innovative ideas and approaches in both sources and components related to generation and application of the electromagnetic waves and neutral beams. Two subtopics are as follows:

a. High Power Radio Frequency Sources and Components—In general, sources and components meeting the simultaneous power, duty cycle, pulse length, and frequency requirements are not presently available. Creative research will be necessary to develop unique and innovative ways to provide these components and sources. The relevant frequency ranges are 50-300, 1000-4000, and 30,000-140,000 MHz. Power levels in the several hundred kilowatt to several megawatt range are required. Although some research is done with pulsed devices, strong emphasis is given to continuous (CW) power systems. Components of particular interest are coaxial and waveguide transmission lines, D.C. and radio frequency isolators, circulators, vacuum feedthroughs, stub tuners, dummy loads, and instrumentation for power monitoring and arc detection. In essence, all components from power generation, through transmission, to delivery to a plasma load are candidates for innovative development.

b. Research and Development of Hydrogen and Deuterium Negative Ion Systems—Research leading to better understanding and mastery of the processes utilized to produce, accelerate, transport, and neutralize negative hydrogen and deuterium ions from cesiated surfaces is desired. Negative ion systems are to be used for continuous operation. Issues such as how the correct surface coverage of cesium is to be maintained are important. Ideas to improve performance and reliability are encouraged.

25. ADVANCED FUSION RESEARCH

The DOE is interested in developing alternative concepts and configurations for high density, high temperature plasma confinement that might eventually lead to attractive thermonuclear fusion power reactors for commercial electric power production. The strategy is to identify crucial confinement issues and submit them to test at relevant conditions of temperature density, collisionality, etc. In addition, the DOE is interested in innovative methods for modeling and significantly improving the predictive capability of existing fusion configurations. Subtopics include, but are not limited to, the following:

a. New Concepts—A number of alternative concepts have been studied for many years. Some are in various stages of development from conceptual definition to performance scaling tests. This subtopic invites proposals on new approaches to the generation of fusion power which are different from, and offer potential advantages over, concepts presently pursued.

b. Concept Improvement—Proposals are sought for innovative theoretical or experimental studies which could lead to significant improvements in tokamaks, mirrors, and other existing concepts. Important areas include beta optimization, size and power-density improvement, advanced fuel cycles, and steady-state operation. Recent examples of such ideas are thermal barriers in magnetic mirror systems and spheromaks.

c. Theoretical Modeling—Novel ideas are solicited to develop analytical and numerical models for significant improvements in predictive capability. Among the topics of current interest are:

- Radio Frequency Heating—Important problems include wave propagation through hot, dense plasmas, mode conversion, energy deposition, and wave-induced transport.
- Plasma-Wall Interaction—Important problems include wall erosion minimization, impurity control, refueling, and energy partition among radiation, conduction, and convection.
- Instability Studies—The most important problems tend to be associated with nonlinear effects and the onset of turbulent behavior.

Recipients of contracts will have access to the Magnetic Fusion Energy computer facilities, with specific allotments to be negotiated according to the details of the research.

Research which is clearly related to inertial confinement fusion is excluded from this solicitation.

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