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BUILDINGS SECTOR FIELD PROGRAM PLANNING WORKSHOP

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WORKSHOP PROCEEDINGS

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EXECUTIVE SUMMARY

On January 29-31, 1991, 20 buildings research managers representing 8 national laboratories met in Oak Ridge, Tennessee, for the "Buildings Sector Field Program Planning Workshop." The purpose of the Workshop was to provide the Office of Conservation and Renewable Energy (CE) with input from a coordinated field laboratory effort for the CE FY 1993 budget and planning process.

The workshop, one of five to cover each of the five sectors in CE, was requested by senior CE management. This report, along with those from the other Sector workshops, has been submitted to the Laboratory Senior Review Panel. The Panel has worked with CE senior staff to develop priorities and funding recommendations, based on this input, for the Assistant Secretary. The results of that effort are reported on separately.

Participants at the Buildings Sector Workshop reviewed the nine existing programs of the Office of Building Technology (OBT) at the key activity level and discussed a large number of initiatives that were new relative to the FY 1991 program. Participants did not suggest any changes in the number or names of OBT programs. However, modifications to incorporate new activities were suggested in all cases except for the Management Program. The most significant of these modifications are listed in Table E1.

Table E1. New key activities for FY 1991 OBT program.

NEW ACTIVITY	PRIMARY PROGRAM(S) FOR ACTIVITY	OTHER PROGRAMS AFFECTED
High Performance Building Envelopes and Perimeter Zone Systems	Materials and Structures Solar Technologies	------
Assured Building Energy Savings	Building Systems	------
Twenty-First Century Appliances	Lighting and Appliances	Heating and Cooling
FEMP Revolving Fund	FEMP	All Programs (Tech. Support)
Technology Support for DSM Utilities	Implementation and Deployment	All Programs and the Other Sectors
Thermal Distribution Systems	Heating and Cooling	Building Systems
Very High Efficiency Lighting	Lighting and Appliances	------
Efficient Moisture Control Strategies	Material and Structures	Building Systems Indoor Air Quality
Healthy Buildings Design and Ratings	Indoor Air Quality	Heating and Cooling
Community Systems (New)	Building Systems	Materials and Structures

STRATEGIC ISSUES

In addition to studying the technical content and appropriateness of programs and key activities, the workshop also discussed the operational strategy of OBT. Three types of strategic issues that could lead to more effective management emerged from the discussion. These deal with integrated planning, laboratory effectiveness, and goals/programs mismatches in OBT.

First it was suggested that OBT place increased emphasis on integrated planning. Integrated planning goes beyond "cross-cutting," which is perceived to be primarily a coordinating activity. Integrated planning includes strategic planning across programs and with other sectors, it involves an assessment of the role of Implementation and Deployment within all OBT programs, and it is an upgrading of the OBT Analysis and Assessment activity. This can have positive benefits for both the selection and the implementation of programs. Integrated planning improves selection by allowing a more rich variety of activities because it balances a perceived tendency in the present system to assign higher priority to activities that are confined within single program boundaries. Implementation is benefitted when programs with overlapping elements are all accelerated by sharing results and when new technologies that bridge gaps between activities are exploited.

Next are two suggestions that are meant to improve the effectiveness of laboratories that support OBT. The first is an Innovative and Exploratory Research Program to provide seed funding on a one-time basis for technical staff members to develop promising new concepts. This will allow for more thoughtful and thorough development of support information for new concepts and it will increase the incentive for researchers to more freely suggest serious new concepts. The second suggestion for improved laboratory effectiveness is assignment of a high priority to improvements in the equipment resources at laboratories through increases in capital equipment funding. State-of-the-art equipment is needed in order for the laboratories to perform world-class R&D and point the way for industry to develop new technologies. It is needed to maintain a leadership role in the standards development process. It is also needed to properly equip the Laboratory User Centers that are an increasingly important mechanism for technology transfer and industry involvement. Workshop participants suggest that capital equipment funding be increased to $3 to $5 million for FY 1993 and that a higher priority be given to obtaining capital equipment funds in out years.

The third set of strategic issues relate to perceived mismatches between OBT goals and program elements in two areas. First, the consensus of workshop participants was that existing funding levels for Retrofit Technology will not allow OBT to meet its long-term objective of leveling sector energy consumption. The group felt that the current effort must be greatly expanded to reach more markets in all climatic regions, such as the large middle-income housing sector and the broad range of commercial and industrial buildings. A more aggressive program is also required to develop and implement the advanced retrofit technologies necessary to obtain 40-50% energy savings to match targets for new buildings by the year 2010. This effort includes recommissioning to return systems to design status, operations, maintenance, and energy management.

A second perceived goal/program mismatch is in the Solar Technologies Program. The FY 1993 planning budget provided by DOE management did not adequately reflect research needs and energy saving opportunities in design-based (passive) solar heating- and cooling-load control technologies if the OBT objective to use only 75 percent as much nonrenewable energy by the year 2000 in the buildings sector is to be achieved. Because of the near-term strategic importance of this issue, workshop participants recommend revisions in program key elements to reflect the increased relative importance of passive solar technology over solar space conditioning equipment research and to generally strengthen funding for passive solar technologies.

PROGRAM RATINGS

One objective of the workshop was to evaluate OBT programs against one another according to a benefit/risk scheme consistent with goals in the National Energy Strategy report. In this scheme the evaluation criteria are energy security, economic competitiveness, environmental quality, market risk, and technical risk. Two procedures were used; at the workshop a simple voting procedure was devised in which each voting lab was asked to distribute an additional $12 million over the proposed FY 1993 budget among the nine revised programs. The total amount given to each program should reflect the relative importance of each program. Results of this vote are shown in Table E2 below. Subsequent to the workshop, participants used a scheme introduced by Sandia National Laboratory at the Industrial Sector Workshop. Here, a pairwise comparison was made for all nine revised OBT programs. A scale of 1 to 5 was used with 1 being "much less important" and 5 being "much more important." Each participating Lab compared programs against one another for two risk criteria—"technical risk" and "economic risk," and three benefit criteria—"energy security," "economic competitiveness," and "environmental quality." The risk criteria were given equal weight and were averaged as were the benefit criteria. The results are summarized in Fig. E1 as a plot of average benefit against average risk. The ellipses in Fig. E1 indicate the standard deviation in the measurements. From this exercise it is seen that OBT programs, when measured by these specific criteria, tend to be either high-risk, high-benefit or low-risk, low-benefit. This suggests that, for OBT, programs have been structured so that benefits are commensurate with risk.

Table E2. Summary of the vote to prioritize OBT programs.

Program	Laboratory Vote							
	Lab #1	Lab #2	Lab #3	Lab #4	Lab #5	Lab #6	Lab #7	Total
Solar Technologies		1		3	2	1	5	11
Materials and Structures	3	1	3	2	2		3	14
Lighting and Appliances	4		1.3		2		2	9.3
Heating and Cooling Equipment			3		1	5		9
Indoor Air Quality	1	0.5		3	0.5			5
Building Systems	1	7	4	4	3	2	2	23
FEMP		2.5			1			3.5
Implementation and Deployment	1		0.5		0.5	2		4
Management	2		0.2			2		4.2

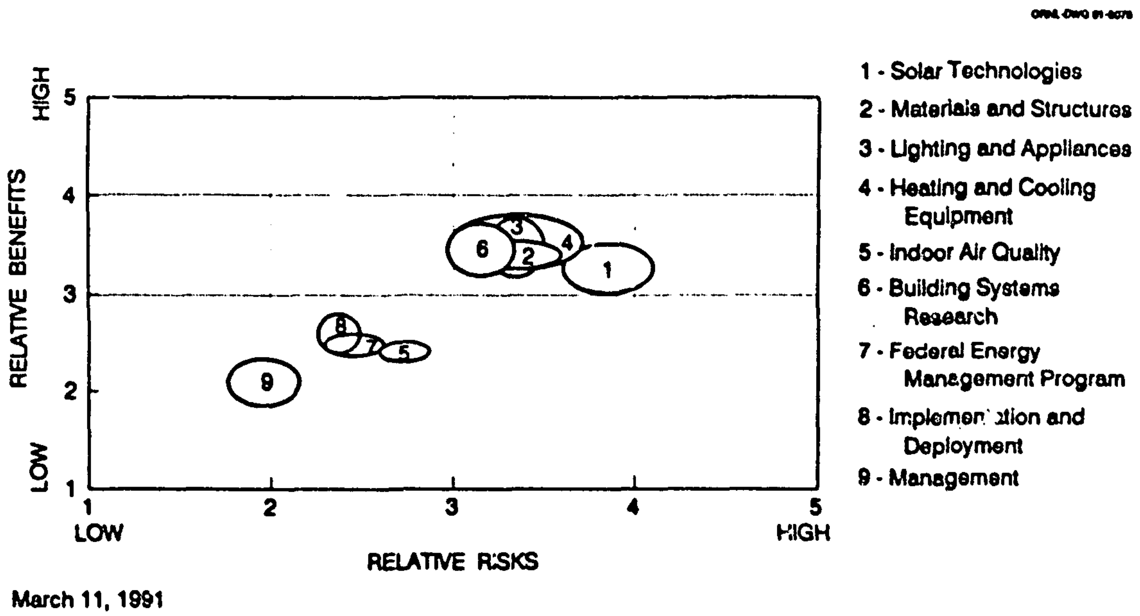

Fig. 1. Preliminary results for OBT program elements.

SUMMARY

This workshop is the first attempt to involve the DOE National Laboratories in the senior CE program exercise. The CE objectives were not all met, particularly those relating to suggesting priorities and program funding levels. Nevertheless, participants felt that they did make substantive contributions and that the involvement of the laboratories in this process is beneficial to CE and to the laboratories.

Attention at the workshop focused on program content and structure. It was concluded that existing programs have effectively addressed major areas of direct, high-potential energy savings and that new programs and initiatives will typically be more complex, crossing existing program and even sector lines and involving a range of researchers, practitioners, and users. It was also concluded that OBT programs and the potential energy savings resulting from efficiency improvements are strongly interrelated. This is mostly a peculiarity of the program structure in OBT. Program elements in OBT typically deal with functional aspects of buildings, not with whole building types, whereas energy savings are necessarily measured for whole buildings. Thus, it is difficult to rate programs in terms of energy savings because changes in one program area will affect the performance in others. Likewise, it is difficult to prioritize programs because all programs contribute collectively to building performance improvements.

1. INTRODUCTION

On January 29-31, 1991, 20 buildings research managers representing 8 national laboratories met in Oak Ridge, Tennessee, for the "Buildings Sector Field Program Planning Workshop." The purpose of the Workshop was to provide the Office of Conservation and Renewable Energy (CE) with input from a coordinated field laboratory effort for the CE FY 1993 budget and planning process.

The workshop, one of five to cover each of the five sectors in CE, was requested by senior CE management. The specific charge from CE requested that workshop participants:

- provide, at the program level, funding and relative priorities for key activities and new initiatives, descriptions of expected cost sharing and other benefits, and outyear funding for FY 1994-FY 1997;
- provide, at the sector level, a prioritization of all programs; and,
- identify opportunities to improve operational effectiveness and efficiency.

A draft agenda was submitted and accepted at a planning meeting held at SERI on January 10, 1991, and attended by senior managers from all laboratories and from CE. At that meeting it was agreed to restrict the attendance at each of the workshops to two representatives from each lab with each lab also having the option of assigning up to four additional representatives among the five workshops. The attendance roster, Appendix A, shows all attendees of the Buildings Sector Workshop.

Each participant was asked to bring to the meeting written material or proposed program enhancements and new initiatives. This request was particularly effective and reflected the enthusiasm of participants. Eighty-three (83) proposals were submitted for consideration. This data was made available to each participant on the first day of the workshop.

The introductory plenary session was a presentation of the workshop strategy and a short overview of goals, objectives, and issues taken from a document prepared by the Office of Building Technology (OBT). The workshop strategy will be described in subsequent sections of this report. It assumed that participants were familiar with and have, in fact, been active contributors to existing OBT programs. Therefore, the direction of the effort would not likely be a zero-base study of building energy conservation research, but rather a reaffirmation of its general structure with emphasis on first-order changes that ensure existing programs will meet revised challenges and new opportunities of the 1990s. The sector overview was provided to update participants on program elements they were less familiar with. In addition, participants were asked to reflect on these OBT goals, objectives, and issues throughout the workshop.

To facilitate the development of coordinated field laboratory input for CE planning, the Host, with input from DOE organizers, established a structured decision methodology. Each of the OBT Programs was assigned a facilitator having experience in the program area (see Appendix B). The facilitators were asked to work with the group assembled for the program discussion and to develop recommendations including restructuring of the program, enhancements, and new initiatives according to a prescription provided by the Host.

Prior to the workshop all participants were given information on the objectives and structure of the workshop, their role, and the information which they would be responsible for obtaining. They were sent a briefing package which contained the most recent statement of OBT mission, goals, and objectives and summary information on the nine program areas. The participants were also provided with the OBT FY 1992 Budget sans FY 1992 budget figures at the meeting. Participants were apprised of all group schedules and were allowed to take part in any group activity they chose.

Each program group was asked to conduct a benefit/risk evaluation of their area using a preconstructed format. Facilitators did not have enough time to do an adequate job; therefore, this report does not contain a clear benefit/risk analysis at the key activity level. Benefit/risk analysis is discussed further in Section 2.

2. SECTOR DISCUSSION

2.1 GENERAL COMMENTS

The workshop was divided into three segments: first, there was a plenary session to establish the methodology and go over background material; next, participants broke into three smaller groups to discuss particular OBT programs; and finally, everyone reassembled to review the program results and to discuss issues and new initiatives that cut across program areas. Procedures and comments relevant to specific programs are collected in the next section for each program. The purpose here is to review observations and suggestions that are appropriate to the whole of OBT.

In Section 3, where programs are discussed, the distinction between existing activities, revised activities, and new initiatives is occasionally blurred. For example, in the Materials and Structures Program, 20/20 Roofs and Super Windows are indicated as new initiatives even though they are already called out in the FY 1992 proposed budget, and Window Labels is listed separately but is, in fact, a revision of an existing program. In these and similar instances in the other program discussions, participants felt that there was insufficient time at the workshop to revise key activities so that they would accurately express the priority of important projects previously introduced but either not actually underway at this time or funded at reduced levels that significantly delay implementation. Thus, they adopted the more direct approach of discussing these projects separately. Also, some of the activities listed as new here have appeared on other conservation research lists. In this latter case the workshop provided an opportunity to reassemble a collection of research and implementation activities that represent a holistic assault on energy inefficiencies in the buildings sector.

Setting priorities based on technical merit at the key activity level in OBT is difficult because key activities, rather than being alternatives, are in fact complementary. That is, one does not decide to do A and not B, but only to do A before B. Standards and targets that reflect other criteria are needed. A benefit/risk procedure was provided by CE. Participants were not successful in using this procedure. This was partly because participants had difficulty interpreting the criteria, partly because of a lack of experience in using the criteria, partly because the detailed activity information required to make judgements was not available, and partly because the interrelated impact of activities on buildings energy use made it difficult not to "multi-count" savings. In one instance the entire group began rating the OBT programs. By the time the third program (out of nine) had been reached, the energy savings assigned to the rating numbers, because of multi-counting, added up to nearly as many quads as are used by the building sector. Thus, while participants strongly felt the need to use criteria other than technical merit, the benefit/risk method provided to the group could not be used effectively.

The prioritization schemes actually used at the key activity level required participants to score each key activity on a scale of one to five with five meaning "must be done by DOE" and one meaning "must not be done by DOE." Scores were averaged and the key activities were prioritized according to their average score. This procedure was subjective, inconsistent across voting groups, and did not reflect judgment based on well-defined criteria. The results are displayed in each program discussion in Section 3.

At the Sector level, two different methods were used to prioritize the nine OBT programs. First, each voting lab was asked to distribute an additional $12 million over the proposed FY 1993 budget among the nine revised programs. The total amount given to each program should reflect the relative importance of each program. The results of this vote are shown in Table 1. This method required participating laboratories to distribute a total of $12 million over the suggested FY 1991 funding level among the nine modified OBT programs.

Table 1. Summary of the vote to prioritize OBT programs.

Program	Laboratory Vote							
	Lab #1	Lab #2	Lab #3	Lab #4	Lab #5	Lab #6	Lab #7	Total
Solar Technologies		1		3	2	1	5	11
Materials and Structures	3	1	3	2	2		3	14
Lighting and Appliances	4		1.3		2		2	9.3
Heating and Cooling Equipment			3		1	5		9
Indoor Air Quality	1	0.5		3	0.5			5
Building Systems	1	7	4	4	3	2	2	23
FEMP		2.5			1			3.5
Implementation and Deployment	1		0.5		0.5	2		4
Management	2		0.2			2		4.2

Subsequent to the workshop, participants were asked to use a different scheme for determining benefit/risk priorities that was introduced by Sandia at the Industrial Sector Workshop.

In this scheme a pairwise comparison was made for all nine revised OBT programs. A scale of 1 to 5 was used with 1 being "much less important" and 5 being "much more important." Each participating lab compared programs against one another for two risk criteria—"technical risk" and "economic risk," and three benefit criteria—"energy security," "economic competitiveness," and "environmental quality." The risk criteria were given equal weight and were averaged as were the benefit criteria. The results are summarized in Fig. 1 as a plot of average benefit against average risk. The ellipses in Fig. 1 indicate the standard deviation in the measurements. From this simple exercise it is seen that OBT programs, when measured by these specific criteria, tend to be either high-risk, high-benefit or low-risk, low-benefit. This Sandia method tends to be consistent with one's intuitive feeling, that is, that OBT programs have been structured so that benefits are commensurate with risks. It has been observed, however, that this method is a purely subjective assessment.

The main focus of the discussion during the plenary sessions was on suggestions, from a field laboratory perspective, to improve operational effectiveness of the buildings research programs and on the relative merits of specific new buildings research and implementation projects. Workshop

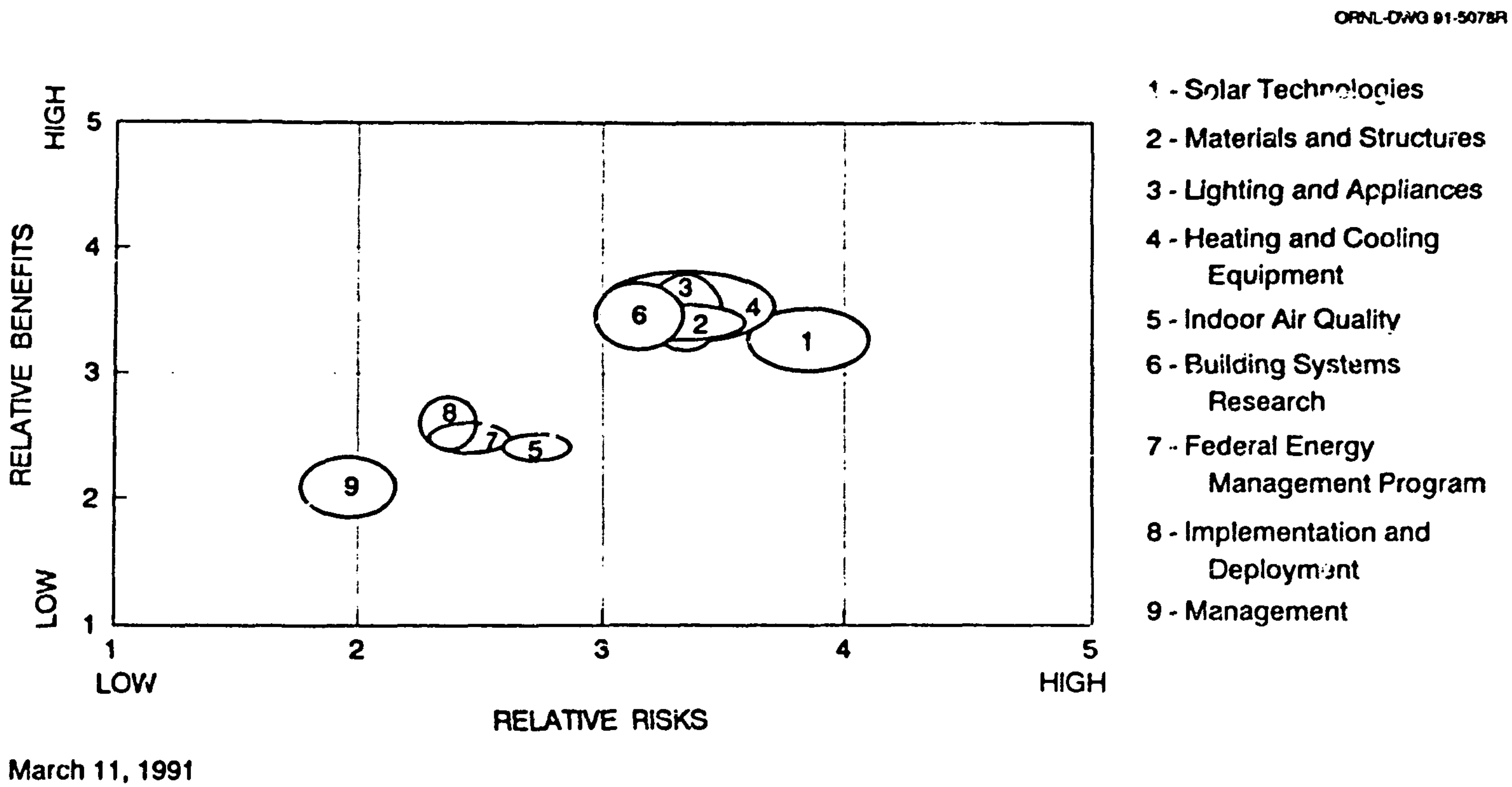

Fig. 1. Preliminary results for OBT program elements.

participants consider the following lists of "Strategic Issues" and "Representative New Activities" as a critical output of their efforts.

2.2 STRATEGIC ISSUES

Workshop participants generally felt that OBT's effectiveness comes from addressing national needs to achieve improvements in energy efficiency, and that major research programs already exist in areas with high potential for public benefit. In addition, OBT itself has also identified issues on policy matters. While participants felt qualified to discuss these policy matters, it was decided that the Workshop charge was to address planning, i.e., strategic, rather than policy matters. Consequently, participants focused their attention on suggestions offered as improvements to the implementation effectiveness and therefore to the quality and timeliness of products from OBT.

The group has observed changes in the structure of initiatives being submitted to OBT as compared with the past. Recent initiatives are more complex and tend to cut across existing program lines and even Sector lines. Initiatives that call for a new window, a new initiative, or a new heat pump are now being replaced by initiatives that ensure energy savings over the life of a building, that match a new collection of appliances to new building designs, and that integrate advanced insulations, windows, and solar perimeter strategies into new envelope systems. These new initiatives have perhaps even more potential to save energy, but they are more complex and not so easy to define and to implement. The following list of Strategic Issues contains several suggestions to OBT that, if followed, should help provide an improved basis for attacking new, integrated, and complex initiatives.

1. **OBT Integrated Planning.** It was the consensus of the workshop participants that more frequent planning activities that cut across the existing key activity and program lines, or "integrated planning," would strengthen OBT's overall program. Such integrated planning will allow OBT to more effectively assess new initiatives that combine concepts from several existing program areas. Integrated planning will counter a tendency to assign the highest priority to activities that are confined within single program boundaries. Symbiosis is also important. That is, programs with overlapping elements might all be accelerated if the overlap is understood and if the results are shared. New projects that bridge knowledge gaps between existing programs can be overlooked if closing gaps is not an objective. A program plan for buildings should be a holistic plan, yet it cannot be if the elements are separately planned and executed.

   Workshop participants acknowledged the need for integrated planning but at the same time recognized that the initially prepared material showed only occasional evidence of such planning and that there was not enough time at the session to rectify the problem. In some instances the cursory look by workshop participants at multiple programs was fruitful. If one looks only at a single component of a building envelope—a wall, a roof, a window—moisture is a problem but not necessarily a dominant problem. Yet, when these elements are looked at together as a building, moisture becomes the most common cause of degradation of thermal efficiency.

   What can be done? Integrated planning is needed, but it is not needed everywhere. These matters have been discussed in the past and there is probably no readily agreeable simple solution. The best recommendation is just to start, perhaps with a small group, or several groups working in parallel, toward the goal of identifying high-potential areas. Since new initiatives submitted to OBT also can cross sector boundaries, e.g., DSM projects (Utilities) and technology transfer (OFTA), these small group discussions might involve staff from other sectors in CE.

2. **Implementation and Deployment.** Implementation and Deployment (I&D) is a new program in OBT that incorporates but extends existing technology transfer activities. The consensus of the participants was that this is a critical aspect of the OBT program and should be expanded in scope. It should also, however, be more fully defined and planned to maximize its usefulness. Not only technology transfer, but related efforts in technical assistance, information dissemination, marketing, barrier removal, exhibits, and education should be integral parts of these activities. Development strategies should as nearly as possible be tied to the potential for energy saving impacts.

3. **Strengthening Evaluation and Planning.** The development of the National Energy Strategy has indicated the need for redirecting and strengthening the OBT Planning and Evaluation Program Element. In the past, OBT has been principally concerned with the planning and evaluation of R&D. The analysis of options for the National Energy Strategy (NES), however, has shown the need to develop a better understanding of the costs and benefits of policy options such as incentives, regulations, and information programs. The NES process also highlighted the need for improved analytical tools and technical data, especially in the area of renewable energy potential for buildings. The workshop group is recommending that OBT strengthen its role in central evaluation and planning to enable more thorough consideration of these topic areas.

4. **Innovative and Exploratory Research Programs.** Workshop participants suggest that a program be established that provides seed funding for research feasibility studies. This will strengthen the identification of new ideas with their source and will allow for more thoughtful development of support information. In turn, this should increase the incentive for researchers to more freely provide new concepts and will insure that the support information for items selected as new initiatives is adequate. Projects selected should be buildings-related but would generally not be elements of the OBT Spending Plan. They would be characterized by potentially significant but unconfirmed benefits in some combination of energy efficiency, energy security, cross-cutting of programs, and industrial participation. Projects typically would focus on improvement of the concept definition, identification of benefits and risks, and assessment of the likelihood of incorporation into existing programs or of start-up of a new OBT program. A two- or three-step selection process can be established for laboratory research personnel to participate in a program similar to SBIR. Grants would be on a one-time-only basis with no more than $50,000 allocated. Funding would be based on the relative technical and energy efficiency merits of the project and the likelihood that the project could result in a major new OBT initiative.

5. **Capital Equipment.** The workshop participants unanimously agreed that the OBT capital equipment budget is inadequate. The FY 1991 budget is $1.094 million, or 2.5% of the total OBT budget. The workshop participants recommendation is an increase to $3-5 million for FY 1993 and a higher priority for capital equipment needs in out years.

State-of-the-art equipment is needed in order for the laboratories to perform world-class R&D and point the way for industry to develop new technologies. It is needed to maintain a leadership role in the standards development process. It is also needed to properly equip the Laboratory User Centers that are an increasingly important mechanism for technology transfer and industry involvement. Without adequate equipment, the efficiency of the laboratories is reduced and their role tends to be shifted toward analytical studies.

It was noted at the workshop that several of the laboratories conduct research for CE using equipment from other DOE programs. While this kind of sharing is beneficial and should continue, it tends to limit the extent of testing that can be done, it can result in extensive delays due to scheduling and equipment modifications, and it can be more costly. Primary equipment needs for CE should be supplied through CE budgets.

6. **Retrofit Program Expansion.** The consensus of the group was that existing funding levels for Retrofit Technology will not allow OBT to meet its long-term objective of leveling sector energy consumption. With 90 million existing homes and 60 billion ft^2 of commercial floor space, the U.S. needs to address critical retrofit issues through an expanded and coordinated effort of research, demonstration, and incentive programs. The FY 1991 level of effort in the Existing Buildings Efficiency Research Program is limited to pilot efforts to promote energy efficiency in HUD rehabilitation programs, limited monitoring of retrofit performance, and support for a DOE solicitation. The group felt that the current effort must be greatly expanded to reach more markets in all climatic regions, such as the large middle-income housing sector and the broad range of commercial and industrial buildings. A more aggressive program is also required to develop and implement the advanced retrofit technologies necessary to obtain 40–50% energy savings to match targets for new buildings by the year 2010. This emphasis includes recommissioning to return systems to design status, operations, maintenance, and energy management. This latter effort has been combined in a proposed new initiative called "Assured Building Energy Savings," designed to assure the achievement and persistence of retrofit energy savings. A description of the initiative is found in the program summary for Building Systems Research, Section 3.6.

7. **Importance of Passive Solar Technologies.** During discussion of the Solar Technologies Program, it became apparent to workshop participants that the FY 1993 planning budget provided by DOE management did not adequately reflect research needs and energy saving opportunities in design-based (passive) solar heating- and cooling-load control technologies if the OBT objective to use only 75% as much nonrenewable energy by the year 2000 in the buildings sector is to be achieved. Previous successes of the passive solar program have demonstrated significant reductions in heating, cooling, and lighting loads in residential and commercial buildings with minimal additional costs. Because of the near-term strategic importance of this issue, workshop participants recommend revisions in program key elements to reflect the increased relative importance of passive solar technology over solar space-conditioning equipment research and to provide adequate funding for passive solar technologies.

8. **Addition of Community Systems Program.** The group observed that a range of buildings systems research projects do not fit into the current OBT program structure. These are projects that tend to deal with collections of buildings or with the building environment. Among these are issues such as building siting concerns, climate moderating envelopes, heat

island effects, and urban planning. Generally, these involve the interaction of a building, or buildings, with the environment. These are not a priori implementation issues. In most instances there is a recognized need for research. A community systems element of the OBT Program could address research aspects of these problems and provide technical support to regional and local agencies involved in energy efficient community planning.

2.3 REPRESENTATIVE NEW ACTIVITIES

Participants were asked to prepare written summaries of new activities for consideration at the Workshop. As mentioned earlier, 83 documents resulted from this request. Since there were no restrictions on submissions, there was some overlap between activities and there was a mixture of activities not yet submitted to OBT, activities in the OBT Budget but not yet funded, and activities in the OBT Spending Plan but with a low funding priority. In any event, there was a large number of initiatives, most of which were accepted and discussed by participants. Existing OBT activities were also discussed and rated. As seen in the Program Summaries in Section 3, ongoing activities were rated quite high and the consensus was that they should continue to receive a high priority for OBT support. The Program Summaries also contain extensive lists of longer-range activities that participants placed in line for significant FY 1993 OBT support. Because these lists are long, participants felt that it would be useful to outline a subset of activities considered to be representative of the best mid-range to long-range new activities discussed at the workshop.

1. **High Performance Building Envelopes and Perimeter Zone Systems.** This initiative includes several components: high thermal resistance "super insulations," advanced window concepts, perimeter zone control, and elements that integrate these new high energy efficiency concepts with each other and with buildings practice. The objective is to establish cooperative laboratory projects to develop and demonstrate economically feasible envelope and perimeter zone control systems for residential and commercial buildings that maximize direct use of renewable energy for heating, cooling, and lighting in perimeter zones. This initiative would expand and integrate existing programs on new insulation technology, thermal mass, superwindows, smart window technology, perimeter thermal control concepts, and zero energy dynamic curtain walls. The building envelope and perimeter zones account for 75% of energy used in the buildings sector. The initiative would include Cooperative Research and Development Agreements (CRADAs) and other technology transfer instruments to induce industry to buy into the development and implementation work. As viable systems are identified, appropriate teams of suppliers; component manufacturers, manufactured building firms, curtain wall suppliers, and users; and builders, designers, agencies, and utilities will be assembled to address issues of market penetration.

2. **Assured Building Energy Savings.** This initiative addresses the enhancement and persistence of energy savings that can be achieved through quality assurance during construction and retrofit, proper commissioning of newly installed energy systems and whole buildings, re-commissioning of existing systems to return them to operation as designed, efficient operating procedures, effective maintenance, development of automated systems to support energy-efficient building operation and maintenance, and development of tools to monitor and track energy use. It combines the Advanced Diagnostics/Audits and Construction/Commissioning Operation initiatives that are described in more detail in the Building Systems Program Summary in Section 3.6. The objective is to develop and test and support private sector

implementation of the scientific and technical base necessary to operate whole buildings as efficiently as is technically and economically feasible throughout building life. Current activities related to building commissioning and operation within Commercial Building Systems and those activities on operation, maintenance, and energy tracking within Retrofit Technology will be incorporated in this new activity. Close coordination with, and cost-sharing participation of, private sector organizations such as ASHRAE, ACEC, BOMA, and the equipment and controls industry will be involved to ensure utilization of products.

This activity is critical if improved energy efficiency in new and existing buildings is to provide a reliable and persistent substitute for additional energy resource supply. Limited research to date has shown that building energy use can be reduced by at least 20% (and often much more) with proper adjustment, repair, and minor modification of energy systems together with improved operations. An aggressive 1990 conservation scenario is projected to hold commercial building energy use to about the 14 Q level in the year 2030. However, inefficiencies due to poor commissioning, operations, and maintenance would prevent achievement of about 4.4 Q (31%) of the projected annual savings. If this new activity achieves only 50% of the technical potential, energy savings would reach 2.2 Q/y by 2030. Without this program, these savings may be lost entirely.

3. **Twenty-First Century Appliance Technology.** DOE research on appliances has passed through two phases. First was an extensive program in the late 1970s and early 1980s that led to a number of notable successes with major home and commercial appliances from refrigeration systems to oil burners to water heaters. Next was a more focused effort to hasten market penetration of more efficient major appliances through development of appliance standards and test procedures, which is ongoing. This new initiative addresses the need for another phase: a longer-term objective, in cooperation with industry through mechanisms such as CRADAs, to develop <u>new</u> appliance technologies and to demonstrate innovative design approaches for incorporating them into a <u>new</u> generation of energy efficient houses and commercial buildings.

   Because this is essentially a new effort, the initial focus will be to identify and assess the feasibility of the most promising opportunities. The major appliance energy end uses are for water heating, refrigeration and freezing, and cooking. Other important appliances and "plug loads" include dishwashers, clothes washers/dryers, communications systems, vending machines, and computers. Opportunities will be reevaluated for application of "integrated appliance" concepts such as waste heat recovery for water heating, advanced sensors and controls, self-diagnostics, advanced motor technologies, and high-performance thermal insulation. The goal of this effort is to develop new technologies that increase appliance efficiencies by 25-50% by the year 2000 in conjunction with ongoing efforts to make a transition to environmentally safe refrigerants. This should ensure that appliance technology is in step with other anticipated energy efficiency improvements in buildings.

4. **Federal Energy Management Program (FEMP) Revolving Fund.** The purpose of this initiative is to support the concept of a FEMP revolving fund for federal investments in energy efficiency improvements in federal facilities and to suggest that the total program funding be greater than the planned $300 million. A more realistic value is $600 million with perhaps 50% being obtained through utility cost sharing. This initiative also supports the addition of quality control measures, audit validation, and savings verification projects

initiated early in the effort. The revolving fund would complement other federal incentives for agencies to incorporate energy efficiency into buildings. These include legislative directives and executive orders encouraging efficiency investments, the Federal Shared Energy Savings Program that allows agencies to enter into shared savings programs with private industry firms, and encouragement for agencies to take part in utility demand-side management programs.

The fund is likely to have advantages over other incentive programs. The fund will provide up-front capital for implementing investments, which will allow agencies to decide on efficiency improvements outside other priorities for their own scarce capital funds. Although contracting with private energy service companies and many demand-side management programs also enables energy efficiency investments without front-end federal funds, such procedures have a number of disadvantages, including multi-year funding commitments, reduced savings to the federal treasury (because such firms usually require a high rate of return on such investments and are often willing to finance only the most reliable and cost-effective improvements), and more complicated contractual agreements (e.g., provisions assuring that the actions taken by the energy service company do not adversely affect building comfort levels or operations). Finally, a central fund for federal efficiency investments would enable interagency competition among candidate projects that could result in the selection and financing of more cost-effective investments.

Energy audits of federal facilities indicate that at least $1 billion could be invested in energy projects that would return the investment in 5 years or less. The first $300-500 million allocated by the fund would probably have payback periods of 2-4 years (20-50% return on investment), allowing the fund to support $100-150 million per year of investments while being continually replenished after the fourth year. In less than 10 years, the revolving fund would be able to return the original $300 million to the treasury, plus have a return at least equal to the federal borrowing rate. After the treasury is paid back, the continuing savings from the investments should be sufficient to maintain the revolving fund for the indefinite future. It is assumed that such a revolving fund would significantly increase the actual level of investment made by federal agencies in efficiency improvements and that as much as 50% of the net energy and cost savings resulting from these investments would not occur without the fund.

5. **Technology Support for Demand Side Management.** The purpose of this initiative is to develop an energy efficiency technology infrastructure to support the rapid growth in demand side management (DSM) programs. This infrastructure is needed to provide assurance that efficiency measures incorporated into DSM will perform in a predicted manner, to make available to DSM new efficiency measures as they become available, and to assist DSM technologists with interfacing increasingly sophisticated automatic, computer-based control systems with efficiency measures. It is apparent that this infrastructure is not high on the agenda for DSM operatives, who are absorbed in complex and important implementation issues.

Public utility commissions and electric and gas utilities are increasingly embracing the concept of integrated resource planning (IRP), in which energy-conserving and load-leveling customer-side programs are considered simultaneously with supply-side programs when making projections of future utility needs. While gas utilities and regulators are far behind their electric counterparts in implementing IRP programs, it will be necessary to achieve a certain amount of integration between electric and gas programs in order to use all available efficiency and load-leveling options most effectively. A potential shortcoming of current electric utility DSM programs is that they may use efficiency measures that can be made obsolete by new gas or electric technologies by the time they are put in place. Concurrently, those involved in development of new technologies are not typically aware of specific DSM programs unless high demand rates or similar disincentives are sufficient to create a market opportunity. The program established by this initiative would make information available on new measures and available options and would provide the interface between DSM operatives and developers of efficiency products.

6. **Thermal Distribution Systems.** Forced air and hydronic systems for distributing heating, air-conditioning, and ventilation air in buildings are only 50 to 60% efficient. Savings from a national program to improve thermal distribution systems are estimated to be in excess of 2 quads per year. Among the causes of lost efficiency are duct leakage, induced infiltration/exfiltration, and poor design sizing. Generally, these loss mechanisms are not well characterized, available design and maintenance guidance is uneven, and distribution system configurations are not consistent with advanced heating and cooling technology and tight building concepts. Many of the shortcomings of thermal distribution systems were outlined in a 1986 DOE Research Plan. Since then, research has reaffirmed these issues and has brought them to the attention of industry and utilities. The objectives of this activity are to assist the industry in developing the technical base for distribution systems that optimize the interface between advanced HVAC equipment and high efficiency envelopes and to promote actions that lead to early implementation of techniques to improve distribution system efficiency.

7. **Very High Efficiency Lighting.** Diode lasers or light emitting diodes (LEDs) used for illumination could have significant advantages over conventional incandescent or gas discharge lamps. Several technical approaches now appear quite viable because of the considerable efforts by various U.S. and Japanese electronic and laser firms. Advances in electrical conversion efficiency are impressive. Recently, wall electricity-to-light efficiencies of nearly 75% have been reported for lasers operating on the red edge of the visible spectrum (680 nm). This far exceeds the efficiencies of even the best fluorescent lamps (25%). However, visible lasers and LEDs in the blue-green wavelengths have not reached such high efficiencies.

   Research on diode laser illumination systems is high risk; therefore, early industry efforts are expectedly light. DOE involvement would greatly accelerate development work. Because the payoff is so high for an alternate illumination concept when feasibility is shown, strong industry participation can be anticipated.

   Elements in the research work include (1) resolution of technical issues such as some study of gallium nitride as a high-power blue-green emitter, selection of best wavelengths for a narrow-band emitter white-light source, material stability over time, response to voltage fluctuations, examination of psychophysical responses, and study of color rendition to these very narrow band emitters; (2) building up power and size to achieve lumen outputs necessary for general lighting, changing spatial geometries of elements for reducing heating, study of internal feedbacks as number of elements grows and of possible harmonic generation; and (3) prototype development and trials in working environments.

8. **Efficient Moisture Control Strategies.** Moisture is the cause of 90% of premature building degradation and is the leading factor for loss of thermal performance in existing buildings. In some instances efficiency improvements are even the cause of moisture problems; for example, tightening buildings to reduce air infiltration makes them more susceptible to moisture damage because internally generated moisture has less opportunity to escape. Several OBT Program Managers have activities underway that look at parts of this issue. The general pervasiveness of the problem and its complexity, however, require that a much more substantive, coordinated effort be set in motion if the problem is to receive the attention it merits. The purpose of this initiative is to provide this substantive, coordinated effort.

Significant cooperative support will come from the user sector since moisture is a recognized problem. This support can be strong when the extent of a problem is identified. For example, the Hotel and Motel Association took their moisture problem to Congress, resulting in a request in the budget bill that moisture in hotel wall systems be studied. Also, the Air Force Maintenance Command has given in situ roof drying a high priority for support when military attention is refocused on domestic facility issues.

A successful program will require cooperation among several OBT program areas: building structures, materials, windows, air quality, heating and cooling systems, existing buildings, and modeling. Objectives include development of advanced dehumidification equipment, development of moisture measuring tools and procedures to allow quantitative data to be gathered, providing data for design and construction of conventional buildings with effective moisture control, development of drying programs for buildings with moisture in the envelope system, and development of a predictive capability to help practitioners avoid moisture problems in new building concepts. Envelope system moisture control strategies and wetting and drying rates for in situ insulation need to be determined under well-characterized conditions and then field demonstrated.

9. **Healthy Buildings Design and Ratings.** The objective of this new key activity is to identify and quantify building-system, environmental, and psychosocial variables that ensure that energy-efficient new and retrofitted office buildings are healthy, comfortable, and productive environments; to develop guidelines for redesign and retrofit of existing offices with respect to ventilation and indoor air quality; and to develop design tools for healthy office buildings.

A 25% reduction in the energy used to condition ventilation air in U.S. office buildings would save about 1 quad per year, or about $1 billion per year. This could be achieved through increased ventilation system performance and increased ventilation efficiency by funding an aggressive research program to evaluate the relationships between building factors, ventilation, indoor air quality, and worker health and comfort in office buildings. Productivity gains in office workers due to improved air quality are likely to result in even more substantial gains than those achieved through direct energy savings. A very modest 1% increase in U.S. office workers' productivity due to improved indoor air quality would have a value of $20 billion per year. Even a 0.1% gain in productivity yields a savings of $2 billion annually, in addition to energy savings. Such a study is also likely to generate public interest and provide intangible gains for DOE. The linkage of improved indoor air quality and energy efficient office buildings could help overcome public perceptions that "tight" or energy efficient buildings are linked to "sick building syndrome." This initiative will produce both the information and the practical tools needed to reduce office building energy use while maintaining or even improving indoor air quality to eliminate concern about health problems due to air quality.

This program will involve multidisciplinary, hypothesis-driven field and laboratory studies to determine relationships among occupant health, comfort, and productivity; and building, ventilation, environmental, and psychosocial variables for a cross-section of new and retrofitted office buildings. It will require the development of diagnostic tools for large-scale measurement of air quality. It will also require the development of guidelines for design of new buildings and the redesign and retrofit of existing office buildings to provide good indoor air quality.

3. PROGRAM SUMMARIES

As previously stated, each of the nine OBT Programs were reviewed by a subset of the larger working group. Each session lasted approximately 1.75 hours. In each case, a facilitator opened the session with an overview of the program area. The group then discussed whether new key activities should be added to the existing list. This was followed by a discussion of the new initiatives recommended by each group participant. Finally, the small working group was asked to rank the existing and new key activities according to the following Likert scale: 1) must not be done by DOE, 2) should not be done by DOE, 3) could be done by DOE, 4) should be done by DOE, and 5) must be done by DOE. The group was also asked to recommend budget levels for FY 1993 for each key activity at "Full Cost" and at a "Restricted Cost". The "Restricted Costs" were figures recommended by CE management.

Each Program Summary contains roughly the same information: the names of the working group participants, a brief overview of the Program area, a table that identifies the Likert rankings and the apportioned budgets, a review of the working group discussion, and finally a brief synopsis of the recommended key activities or new initiatives.

3.1 SOLAR TECHNOLOGIES PROGRAM

GROUP PARTICIPANTS

Facilitator: Ren Anderson

John Finger	
John Andrews	Don Neeper
Joan Daisey	John Rivera
Phil Fairchild	Mike Wahlig

OVERVIEW

Dr. Anderson presented an overview of the Solar Technologies program to the group. Since this program area is new to OBT, there was a discussion of the main program emphases and their relation to other OBT programs. Solar technologies provide direct or indirect conversion of renewable energy sources to partially or fully meet building heating, cooling, lighting, and domestic hot water loads. Solar technologies include both design-based (passive) and component-based (active) strategies that control solar energy gains, transport, and storage within buildings. The magnitude of these energy gains is a strong function of season, climate, and building orientation. The solar resource for space heating is several times larger than is needed to meet the needs of residential and small commercial buildings, and the daylighting resource is an order of magnitude larger than is needed to meet instantaneous lighting loads.

DISCUSSION

Following the opening remarks, the first order of business was to review the depth and scope of the current key activities—Space Conditioning and Domestic Hot Water Heating Equipment and Daylighting. It was determined that the Space Conditioning and Water Heating key activity adequately covered the encompassed projects, but that the Daylighting key activity was not broad enough in scope to cover projects of interest to DOE. Therefore, it was recommended that a new key activity, Solar Building Systems, be designated to include some elements of Daylighting in addition to passive and hybrid solar heating and cooling technologies.

Table 2 is a summary of the group's recommendations for FY 1993 and a priority vote on each existing key activity and new or revised initiatives. The Solar Building Systems key activity was ranked higher because these options were believed to be more cost effective in the near term.

Table 2. Recommended FY 1993 Funding Plan for the Solar Technologies Program.
($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Space Conditioning & Water Heating Equipment	R	3.5	3.9	2.6
Solar Building Systems	RI	4.5	4.4	3.4
TOTALS	--	8.0	-------	6.0

Key: N = Existing, R = Revised, I = Initiative

The group suggests that several new or revised initiatives receive funding in FY 1993. These initiatives were assigned to the revised key activities, as shown in Table 3.

Table 3. Revised key activities for the Solar Technologies Program

<u>Space Conditioning and Domestic Hot Water Heating Equipment</u>

Low-Cost Collectors
High-Temperature Collectors
Heating and Cooling Equipment

<u>Solar Building Systems</u>

Advanced Passive/Hybrid Heating and Cooling Systems
Cooling Load Control
Natural Ventilation
System Analysis
Building-Integrated Photovoltaics
Solar Guidelines/Diagnostics/Monitoring

Major barriers for this technology area include first costs, ease of implementation, durability, and performance. A new initiative for <u>Solar Control Materials</u> was proposed to overcome some of these barriers during the group meeting. Elements of this initiative included selective coating R&D, phase-change materials, dynamic coatings, movable insulation, and climate-optimized bandpass coatings (high-R/high-transmissivity materials, etc.). During the final day of the planning session, however, a more comprehensive new initiative, "Advanced Perimeter Thermal Control Systems," was developed with the objective of maximizing the direct contribution of renewable energy sources (including building-integrated photovoltaic power systems, solar gains, and direct ventilation) to heating, cooling, and lighting loads in the perimeter zones of residential and commercial buildings. The importance of this initiative is reflected in the fact that perimeter zones include 40% of the floor space in commercial buildings, and virtually 100% of the floor space in residential buildings, and account for 75% of the energy used by the building sector. Subsequently this new initiative was combined with advanced envelope material and component ideas from the Material and Structures Program to produce the proposed new initiative "High Performance Building Envelope and Perimeter Zone Systems," which is described in Section 2 of this report.

ACTIVITY DESCRIPTIONS

A brief description of both the revised key activities and surviving new initiatives for the proposed Solar Technologies Program for FY 1993 is provided next.

Space Conditioning and Domestic Hot Water Heating Equipment

Low-Cost Collectors. The objective of this project is to complete the development of existing thin-material solar collector research and integrate it into a low-cost solar domestic-hot-water system. Work will proceed in two main areas: collector development and balance-of-system development. The collector area will address basic improvements in the thin-material technology, with emphasis on bonding of the interfaces between thin-film polymers and metal foils, advanced plastics glazing materials, design of subcomponents that direct and control the flow of water through the collector, and collector fabrication. In the balance-of-system area, emphasis will be on the development of low-cost, easily installed storage and controls.

High-Temperature Collectors. Uncompleted research and development issues include component integrity and durability under high-temperature stagnation conditions, cost-optimized design and fabrication solutions, and materials selection and testing. Critical balance-of-system issues remain largely unexplored, such as possible use of heat pipe technology for reliability, durability, and cost advantages.

Heating and Cooling Equipment. Although great strides have been made in reducing the cost and improving the reliability of active solar energy systems, more research and technology transfer are needed to bring these systems to their full potential. Work in this area currently includes Certification and Reliability Research, Advanced Solar Heating Development, Advanced Solar Collector Development, Systems Analysis, and Technology Demonstrations.

Solar Building Systems

Advanced Passive/Hybrid Heating and Cooling Systems. Passive heating systems can experience problems in distributing solar heat from a building zone with solar exposure to other zones of the building. Furthermore, the majority of existing residences are not suited for retrofit with direct-gain, Trombe wall, or sunspace systems. In contrast, hybrid systems with active collection and passive storage and distribution of space heat can be adapted to almost any floor plan or building orientation, and they are modular, utilize very simple controls, and are suited to retrofit as well as new construction. These systems may utilize a collector on the roof, where the building's solar resource is largest, with thermal storage and distribution in interior architectural elements. The research will include performing simulations as needed to complete the sizing and design rules for hybrid heating systems. Experimental research will explore key prototype systems in outdoor test cells, with attention to scaling so that operation is similar to that in actual buildings.

Cooling Load Control. The objective of this work would be to develop a robust measurement-based quantification of the effectiveness of passive and low-energy cooling strategies such as natural and forced convection, radiative cooling, and solar gain control. These strategies can be very cost effective in many situations, but they have not been widely promoted because their energy effectiveness has not been accurately quantified.

System Analysis. This project will help set research performance priorities through analyses of the benefits to system performance and economics of solar heating and cooling technology options being developed or considered for development. Results of systems analyses will assist in making informed judgments on priorities for equipment development, and will help identify solar heating and cooling system configurations that are likely to prove successful (efficient and cost-competitive) in the long run. Elements of the analysis will aim to predict effects on component and system performance of improvements in material or subcomponent properties, thereby indicating which improvements are most worth pursuing experimentally. Systems analyses will similarly be used to calculate expected performance of specific heating and cooling system configurations and control strategies, providing guidance on which systems should proceed to experimental testing.

Moisture Transport. This project is to develop energy-efficient moisture management techniques for buildings in humid climates. It should be closely coordinated with the proposed Moisture Control Strategy project in the Materials and Structures Program. Activities could include 1) development of desiccant impregnated building materials to better manage interior humidity swings in buildings cooled by off-peak air conditioning strategies, 2) development of control system strategies and advanced equipment to increase building ventilation to improve indoor air quality without significantly increasing latent loads, and 3) development of an advanced software and material property database to conduct accurate systems analysis of the above concepts. Such software should be capable of conducting analysis of combined heat, moisture, and contaminant transport in multi-zone buildings. It should also be capable of performing control system and mechanical system interactions in short time intervals. The software would be modular, would run on a variety of hardware platforms, and would be easily upgraded.

Building-Integrated Photovoltaics. While photovoltaics is normally thought of as an electric supply side option for utilities, real growth opportunity for photovoltaics is in its integration into a building. Application of photovoltaics in buildings will be assessed on a collaborative basis with progressive electric utilities, building equipment manufacturers (such as the American Institute of Architects), and other governmental agencies (such as the Environmental Protection Agency and the state energy offices). Applications will be primarily for commercial or industrial buildings, either as retrofit options or for design of new construction.

Daylighting Systems. Daylighting systems include strategies for redirecting sunlight to reduce the need for conventional lighting in perimeter and core building zones. Natural daylight rivals the lighting efficiency of the most efficient conventional technologies, and, like other design-based solar technologies, can be extremely cost-effective. This project would support the development of integrated daylighting design tools and continue development of advanced performance monitoring tools for use in collaborative projects with manufacturers and material suppliers. This project would provide the technical support required to include daylighting strategies in the FEMP relighting initiatives as well as evaluate opportunities to incorporate daylighting as part of normal roof repair and maintenance activities in existing buildings. Research activities relating to development of advanced daylighting materials and components are discussed in the Materials and Structures Area.

Solar Guidelines/Diagnostics/Monitoring. This project provides direct support for near-term deployment of solar technologies by working directly with industry groups such as the National Association of Homebuilders to develop guidelines for design of passive and active solar systems, to provide technical support for development of performance rating and certification systems for solar equipment, to provide the analysis needed to incorporate solar technologies in building energy standards, and to develop advanced monitoring techniques which accurately measure the dynamic contributions of renewable energy sources to building energy loads. These development activities will be closely coordinated with related non-solar activities in the Building Systems area.

3.2 HEATING AND COOLING EQUIPMENT PROGRAM

GROUP PARTICIPANTS

Facilitator: Phil Fairchild

Don Neeper	John Rivera
John Andrews	Art Rosenfeld
John Finger	William Schertz
Roger McDonald	

OVERVIEW

Mr. Fairchild presented an overview of the existing Heating and Cooling program to the group. The goals of this program are to reduce heating and cooling energy consumption by 50% or more, to achieve additional reductions of 25-50% in electric peak load, to eliminate CFCs, and to significantly reduce carbon dioxide releases compared with the best available conventional equipment technology.

The Program currently consists of three Key Activities: Space Conditioning Equipment, Refrigeration Systems, and Distribution and Controls. The goal of the space conditioning equipment activity is to develop technology to utilize fossil fuels with a heating coefficient of performance of 2.0 compared with a maximum of 0.95 for the best presently available equipment, to eliminate CFC use in heating and air-conditioning, and to greatly reduce the impact of air conditioning on electric peak loads. The goal of the refrigeration systems activity is developing highly efficient alternative technologies to support an accelerated movement toward complete phaseout of CFCs. The goal of the distribution and controls activity is to develop basic technology and applications for reducing losses from thermal energy distribution systems.

DISCUSSION

Table 4 has a summary of the group's recommendations for FY 1993 and a priority vote on each existing key activity and new or revised initiatives. In the Space Conditioning activity it was recommended that the base program be expanded to accelerate the commercialization of the thermal absorption heat pump technology, and one new project was added. The Advanced Refrigeration Systems activity was expanded with the addition of five initiatives. Three suggested projects were added to the new Distribution and Controls activity. Finally, two new key activities were proposed: Technology Development for Demand-Side Management Programs, and Alternative Dehumidification and Cooling.

The new initiatives were assigned to a revised key activity, as shown in Table 5.

Table 4. Recommended FY 1993 Funding Plan for the Heating and Cooling Equipment Program.
($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Space Conditioning (base activities)	N	13.0	3.7	8.5
■ Commercial Building Oil Heating (added project)	I	1.1	2.3	0.5
Advanced Refrigeration Systems	R	8.5	4.3	5.3
Distribution and Controls	N/I	3.3	3.6	1.5
Technology for Demand-Side Management	I	2.8	4.1	1.4
Alternative Dehumidification/Cooling	I	3.1	3.7	1.25
TOTALS	--	32.0	-------	18.5

Key: N = Existing, R = Revised, I = Initiative

Table 5. Revised Key Activities for the Heating and Cooling Equipment Program.

Space Conditioning
Commercial-Building Oil Heating
Advanced Refrigeration Systems
Advanced Heat Exchangers
Electric-Powered Space-Conditioning Technologies for Cold Climates
HCFC-22 and HCFC-123 Alternatives
Advanced Materials Development for HVAC&R Systems
Near-Ideal, Long-Term Alternative Refrigerants
Distribution and Controls
Thermal Distribution Systems in Small Buildings
Advanced Diffuser, Control, and Distribution Systems Development and Testing
Project Residential Act, Inc.
Technology for Demand Side Management (DSM)
Utility-Customer Communication, Computation, and Control (UC-3C)
Heating and Cooling Technology Adoption
Alternative Dehumidification/Cooling
Integrated Desiccant Cooling and Dehumidification Systems
Desiccant Heat Pump Technology

A single vote was taken to determine the priority of the existing and new key activities. Advanced Refrigeration Systems and Technology for Demand-Side Management were deemed very important; the Space Conditioning work was also deemed important but there were some questions regarding the relative priority of the Stirling and I.C. Engine research. The new Alternative Dehumidification/Cooling key activity was also deemed an important expenditure area. The group felt that the area was very important in hot, humid climates that are experiencing increasing electricity demand and peak loads due to conventional air conditioning.

The vote was followed by a discussion on the proper distribution of dollars for FY 1993. The group felt that the successful completion of the heat pump research was greatly enhanced by increased annual funding. It also felt that there should be a significant increase in the Advanced Refrigeration Systems budget, including funding for the new project initiatives.

A brief description of the new project initiatives for the Heating and Cooling Program for FY 1993 is provided next.

Space Conditioning

Commercial-Building Oil Heating. Fuel oil consumption for space heating of commercial buildings presents a significant fraction of distillate fuel use in the U.S. Many opportunities exist for increasing the efficiency of oil heating systems in commercial buildings—both for retrofits and for new construction. A 15% increase in efficiency in heating commercial buildings fueled with oil would reflect an annual savings of 0.28 quads of energy or approximately $2 billion per year. Recent studies of commercial oil heating systems have found that many problems that limited residential oil heat efficiency still exist in commercial buildings. Many commercial boilers are older and were designed before energy efficiency was an important consideration. Boilers are frequently oversized, and the part-load efficiencies of these systems are low.

Advanced Refrigeration Systems

Advanced Heat Exchangers. The group proposes that three areas of heat exchanger enhancement be considered. The first is the enhancement of heat exchangers used to replace conventional CFC systems with ammonia systems for space conditioning and refrigeration systems. This effort deals with heat exchanger improvements to existing vapor-compression systems using ammonia as the refrigerant in retrofit situations. The second is the development of advanced heat exchangers to replace conventional CFC systems with nonazeotropic systems for space conditioning and refrigeration systems. This effort deals with compact heat exchangers used in conventional vapor-compression systems with nonazeotropic refrigerant mixtures. Finally, the project would develop advanced heat exchangers to replace conventional CFC systems with advanced ammonia/water absorption systems.

Comprehensive Assessment of Electric-Powered Space Conditioning Technologies for Cold Climates. This project would identify promising avenues to energy conservation and utility peak load reduction in cold climates. Much work has been done to date on various space conditioning technologies. Recent emphasis has been on warm climates, since that is where the greatest population growth is occurring. Nevertheless, there is a need to reexamine the options for cold climates to establish priorities for both research and implementation. In the electric-powered sector, winter peak loads are an issue in cold climates, even for utilities that are nominally summer peaking, since scheduled plant outages during the winter months often lead to overload during this time.

HCFC-22 and HCFC-123 Alternatives. Production of CFC-11, the most common refrigerant in current centrifugal chillers, will be phased out by the year 2000 under the terms of the Montreal Protocol. HCFC-123 is being introduced as an alternative, but HCFCs are scheduled to be phased out by 2030 by the Clean Air Act Amendments passed in 1990. A long-term alternative to HCFC-123 is therefore needed. HCFC-22 is the most widely used refrigerant in unitary air conditioning and heat pump equipment; therefore, an efficient substitute is key to recycling energy use in residential and smaller commercial buildings. This project would identify and characterize a substitute or substitutes for HCFC-22 for refrigeration, air-conditioning, and heat pump applications and for HCFC-123 for use in centrifugal chillers. The substitute(s) would have an ozone depletion potential (ODP) of zero and minimal global warming. The substitute(s) also would offer capacity and efficiency comparable or superior to that of HCFC-22 and HCFC-123, preferably without major equipment redesign, and would be compatible with both the metallic and nonmetallic materials used in conventional equipment.

Advanced Materials Development for HVAC&R Systems. Development of advanced materials for HVAC&R systems offers significant advantages including improved reliability, reduced system cost, and improved energy efficiency. For example, development of new materials to enable application of oil-free refrigerant compressors to refrigeration systems would 1) facilitate transition from CFCs to chlorine-free alternatives like R134a; 2) reduce system cost and complexity by eliminating the need for an oil management system; 3) increase energy efficiency by about 10% through better heat transfer in the heat exchangers, higher refrigerant mass flow, and reduced system pressure drops; 4) improve reliability by eliminating the potential for oil foaming, oil loss and sludge, varnish, and wax or acid formation; and 5) eliminate the hazardous-waste oil disposal problem.

Near-Ideal, Long-Term Alternative Refrigerants. This project would concentrate on identifying and characterizing a refrigerant or family of refrigerants to replace those now in use. The new fluid(s) must be safe to users, the environment, and equipment and must also be highly efficient. When introduced, CFC refrigerants were judged to be nearly ideal, based on their comparative safety, efficiency, and costs relative to the refrigerants they displaced. Ironically, their very stability, and therefore long-atmospheric lifetimes, is now recognized as a key factor in their negative ozone-depletion and greenhouse-gas effects. Near-term, transitional solutions are likely to be compromises while more ideal solutions are sought.

Distribution and Controls

Thermal Distribution Systems in Residential and Small Commercial Buildings. Thermal distribution systems—the duct work or piping used to carry heat or cooling from the space-conditioning equipment (furnace, boiler, air conditioner, or heat pump) to the building spaces—are subject to significant energy losses. These losses can be direct—by thermal conduction through duct or pipe walls or via air leakage from ducts—or indirect—through increased air infiltration into the house caused by operation of a forced-air distribution system. Thermal distribution systems can have positive or negative effects on indoor air quality, such as providing controlled, even ventilation rates or inducing radon into a building.

Improvements in the efficiency of existing thermal distribution systems are possible by insulating and sealing duct work and by conducting system-oriented retrofits such as insulating basements in which ducts are located or undercutting doorways to reduce pressure imbalances in houses with a single common return. Improved design of systems for new construction is another major avenue to energy savings. Overall, it is estimated that more than two quads can be saved through improved thermal distribution.

Advanced Diffuser, Control, and Distribution Systems Development and Testing. Recent changes in the ASHRAE ventilation standard (ASHRAE 62-89) have tripled the minimum recommended amount of outdoor air delivered to occupants. Minimizing energy costs while maintaining high local indoor environmental comfort levels requires careful consideration of the air system components. Air distribution systems often do not effectively deliver air to all parts of the occupied zone, resulting in local areas of unacceptable comfort and air quality. Efficient and effective distribution and control systems eliminate these unacceptable areas.

Typical systems today are inefficient; more air than necessary is conditioned in an attempt to "oversupply" as a means of overcoming ineffective room air distribution. Improved air distribution will eliminate these excess capital and operating costs. Therefore, a need exists for better diffusers, controls, and distribution of air within a room. By combining advances in fluid flow, particularly in the areas of jet excitation and stability, with advances in ventilation technology in the areas of indoor environmental quality, significant improvements can be made in the design of diffusers. These diffusers will deliver air more efficiently, resulting in lower energy costs. This project will involve working closely with industry to design and test advanced diffuser concepts, such as "smart" diffusers with occupancy sensors, "tunable" diffusers that account for the buoyancy of the air, and "active" diffusers that target the occupied zone and ignore the unoccupied areas.

Project Residential Act, Inc. (Advanced Concepts and Technology for Implementation in the Next Century). Substantial expenditures of R&D are being made on advanced building thermal envelope, materials, and equipment and on measurement of indoor air quality. Not much is being done to integrate these new technologies into advanced housing concepts. Some areas of R&D that could lead to improved housing are not being pursued. (Examples: New means of providing comfortable indoor thermal environments and development of equipment for removal of gaseous air contaminants.) Implementation of "high-tech" measures to reduce energy consumption in the buildings sector is needed. Transportation has gone high-tech, buildings have not.

The basic approach will be to bring together and evaluate a wide range of both existing and new ideas and technologies to develop some preferred advanced housing concepts. Initially, a scoping study would be conducted to develop some concepts that will give credibility to the idea that this kind of project could produce some exciting and beneficial results. Energy-use analyses will be conducted to show that there could be a substantial energy saving. A research program will be defined that could generate interest and support. This program will be comprised of engineering and architectural studies to implement advanced housing concepts to provide a clean, safe, and comfortable indoor environment with low energy use at reduced cost.

Technology for Demand-side Management

Public utility commissions (PUCs) and electric and gas utilities are increasingly embracing the Integrated Resource Planning (IRP) planning ethic in which energy-conserving and load-leveling customer-side programs are considered side-by-side with supply-side programs. Gas utilities and regulators are far behind their electric counterparts in implementing IRP, and an integration of gas and electric IRP at the regulatory level is required to assure a level playing field for all beneficial technologies. A potential shortcoming of many of the current electric utility demand-side management (DSM) programs is that they are based largely on deployment of existing end-use products and equipment, which may, in some cases, be obsoleted by new (e.g., dramatically more efficient) gas or electric end-use technologies by the time (or shortly after) the planned end-use option is actually installed and operational. Concurrently, those involved in research and development of new end-use technology are usually not cognizant of utility-side load management issues, unless high demand rates or similar utility "disincentives" are sufficient to create a market opportunity (e.g., commercial cool storage). The technological revolution in computers and communications networks could also transform the gas and electric utility industries and enable them to automate control end-use equipment and appliances, in addition to transmission and distribution or pipelines, with net efficiency benefits. This revolution is likely to be paced by a complex interaction of PUC attitudes, utility acceptance/benefits, customer acceptance/benefits, and equipment manufacturer perception of market risk. The proposed work features collaborative pilot test and demonstrations with utilities and prospective industrial partners to demonstrate selected interface and equipment technologies, to quantify potential utility and customer benefits, and to reduce risks.

Measures for DSM programs are not limited to heating and cooling systems. OBT should consider DSM as one more means to get all its products into widescale commercial use. Nevertheless, DSM is particularly effective because utilities have the means of quickly creating widescale introduction of a technology. Although the topic has been introduced in the Heating and Cooling Program discussion, it would most effectively be implemented under Implementation and Deployment. Proactive DOE/utility program coordination will improve technology development and utility program planning and cause the necessary market opportunities, new products, and/or new implementation industries to emerge on an accelerated schedule.

Alternative Dehumidification/Cooling

Integrated Cooling and Desiccant Dehumidification Systems. Buildings in the U.S. use about 3.7 quads of primary energy per year for air conditioning and ventilation. This amount is increasing and at the same time creating several challenges: increased equipment energy efficiencies, improved indoor air quality, growing concern for improved comfort and environmental control, increased ventilation requirements, reduction of CFCs, and rising peak-demand charges. New approaches to space conditioning will be required to resolve these economic, environmental, and regulatory issues. Desiccant cooling and dehumidification, a technology known for some time, may provide important advantages in solving air conditioning problems. The objective of this project is to develop and evaluate integrated or hybrid desiccant cooling and dehumidification systems with electrically driven or thermally driven vapor-compression equipment. Integrated desiccant cooling and dehumidification systems with conventional HVAC systems and thermally driven systems, using the waste heat for desiccant regeneration, can reduce the total energy consumption for air conditioning by 0.2 to 0.5 quads per year. This work will be closely coordinated with solar-regenerated desiccant research in the Solar Technology area.

3.3 LIGHTING AND APPLIANCES PROGRAM

GROUP PARTICIPANTS

Facilitator: Mark Levine

Phil Fairchild	Roger McDonald
John Finger	John Rivera

OVERVIEW

Mr. Levine presented an overview of the existing Lighting and Appliances program to the group. The DOE Lighting and Appliances Program has four objectives: 1) improvement of appliance efficiency through a comprehensive research and development program; 2) mitigation of global environmental impacts; 3) improvement of lighting efficiency through the development of advanced light sources, lighting equipment, and lighting design methods; and 4) improvement of appliance and lighting efficiency through implementation of the most effective standards and test procedures.

DISCUSSION

Table 6 shows the results of the group prioritization. The five key activities, including two new key activities, are shown. The budget recommendations for the two FY 1993 levels showed that the three existing/revised and the two new initiatives have grown substantially. The largest percentage increase was for CFC replacements, with all three existing activities receiving roughly comparable dollar increases. Of the two new initiatives, the economic analysis of "Golden Carrot" fared somewhat better than the Advanced Appliances. The averages in the table mask the fact that two of the panel members favored CFC replacements and "Golden Carrot" initiatives; the other two favored Appliance Standards and Advanced Appliance research. All four participants showed good support for Lighting Research.

Table 6. Recommended FY 1993 Funding Plan for the Lighting and Appliances Program.
($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Appliance and Lighting Standards	R	4.6	5.0	3.4
Lighting	R	5.3	4.0	4.0
Appliances	I	1.1	3.0	0.7
"Golden Carrot" Economic Analysis	I	1.6	4.0	1.0
CFC Replacements for Refrigerators	RI	2.9	4.0	2.2
TOTALS	--	15.5	-------	11.3

Key: N = Existing, R = Revised, I = Initiative

The increases in the Appliance and Lighting Standards Program were for two purposes: 1) to increase the number of appliances for which test procedures and standards can be developed in the near-term, and 2) to establish a lamp and luminaire standards program. Increases in Lighting include the establishment of a new initiative, the use of diode lasers or light emitting diodes for general illumination, the development of a microelectronic package to make the surface-wave lamp technology a viable, cost-effective option, and the expansion of research on lighting applications and impacts (health effects). Funding was also suggested for the advancements of energy efficiency in appliances, including personal computers, copy machines, and other office equipment that plays a role in increasing commercial building electricity demand. The group also recommended that research on non-CFC refrigerants be transferred to the Lighting and Appliances Program and combined with the Appliances research program into a new key activity called "Advanced Technology and CFC Alternatives R&D for Appliances. This new key activity is described below. The group also recommended that the work still be closely coordinated with the Heating and Cooling Equipment Program.

The key activity structure is shown in Table 7.

Table 7. Revised Key Activities for the Lighting and Appliances Program.

Appliance and Lighting Standards
Lighting
Diode Lasers for General Illumination
Appliances
"Golden Carrot" Economic Analysis
CFC Replacements for Refrigerants

Three new initiatives were proposed in addition to proposals to expand the three existing research activities: 1) a new activity to evaluate the economics of utility incentives for appliances to "beat" the appliance standards—the so-called "golden carrot" program, 2) research on advanced concepts for improving efficiency of appliances and office equipment, and 3) energy labels for office equipment. The group merged the second and third initiatives.

Three proposals were made to revise existing activities: 1) a much greater effort on standards and test procedures, because of inadequate resources to meet the requirements of NAECA; 2) expansion of the lighting research with a new initiative to explore diodes as an advanced lighting source; and 3) expansion of the non-CFC refrigerant research combined with other DOE research to increase refrigerator efficiency.

A brief description of both of the new initiatives for the Lighting and Appliances Program for FY 1993 is provided next.

Very High Efficiency Lighting

Diode Lasers or Light Emitting Diodes for General Illumination. Diode lasers or light emitting diodes (LEDs) used for illumination could have tremendous advantages over conventional incandescent or gas discharge lamps. Several technical approaches now appear quite viable because of the considerable efforts by various U.S. and Japanese electronic and laser firms. Advances in electrical conversion efficiency are impressive. Recently, wall electricity-to-light efficiencies of nearly 75% have been reported for lasers operating on the red edge of the visible spectrum (680 nm). This far exceeds the efficiencies of even the best fluorescent lamps (25%). However, visible lasers and LEDs in the blue-green wavelengths have not reached such high efficiencies.

Besides their great potential for energy efficiency, they have several other significant attributes: 1) they are small and lightweight; 2) they provide a very high degree of linear polarization, thus reducing reflective glare; 3) they have a total absence of any toxic chemicals (mercury, a vital material for all gas discharge lamps, is toxic); 4) they operate at low voltage and currents, typically 10 volts dc 5 mA, which allows for very simple and safe wiring; 5) they are instant-start and can be expected to have very long lifetimes (>20,000 hours); 6) and there is almost no restriction on shape since the array elements are very small (1 mm^2). In addition, the power supply (10 Vdc) is an already well-established and extremely energy efficient technology with no health or safety concerns. The laser diode lamp (LDL) is the candidate for the ultimate light source. A savings of 50% of lighting energy amounts to 200 X 10^9 kilowatt hours annually, worth $17 billion.

Advanced Technology and CFC Alternatives R&D for Appliances (Appliances for the Twenty-First Century)

DOE's appliance efficiency activities have produced a number of notable achievements. An advanced supermarket refrigeration system that uses 14% less energy than standard systems was developed and is now in common use. A refrigerator-freezer (RF) was developed that used 60% less energy than models typical of the late 1970s, but the technology has not advanced since 1980. Other developments include electric heat-pump water heaters that use 50% less energy than resistance heaters, compressors for RFs and vending machines that are 25% more efficient than typical 1980 models, a bi-radiant oven that is 50% more efficient than conventional ovens, and a pulse-combustion commercial water heater. In addition, work on advanced evacuated panel insulations is being developed that could increase the R-value of appliance insulation by a factor of 2-5.

Appliance research should be expanded to cover other appliances and technology. Because this is a renewed effort, the initial activities should involve identifying the most promising opportunities to develop appliances with energy efficiencies consistent with the high performance expected from the next generation of building design. The major residential/commercial appliance energy end-uses are water heating, refrigeration and freezing, and cooking. Other important residential appliances include dishwashers, clothes washers/dryers, and television sets. For the commercial sector, energy use for many "plug loads" or other appliance uses such as vending machines, escalators/elevators, commercial laundry equipment, copying machines, personal computers, and other business appliances needs to be quantified and potential technological advances identified. Opportunities will be evaluated for application of waste heat recovery for water heating; advanced sensors, performance diagnostics, and controls; microwave, power electronics, and advanced motor technologies; high-performance appliance insulation; and integrated-function appliances. The goal of this research is to develop technology to enable an increase of appliance efficiency by 25-50% compared with current levels by the year 2000, together with a transition to environmentally safe fluids or alternative technology for residential and commercial refrigeration appliances. These goals should keep appliance efficiency in line with expectations for heating and cooling equipment and for building design. The potential market for these technologies includes all residential and commercial appliance applications. Total annual U.S. primary energy use for appliances is about 7 quads. At full penetration, the energy savings benefit from achieving key activity goals would exceed 2 quads.

With respect to CFC alternatives, refrigeration appliances account for about 10% of the total annual U.S. commercial and residential sector energy use. In addition, this appliance end-use showed the greatest potential adverse energy impact of any CFC end-use application associated with a CFC phaseout. This is the primary reason that this project is the current main focus of the OBT appliance key activity. Research addresses elimination of CFC use while also improving efficiency. Research is being conducted in collaboration with industry in two areas: 1) development of advanced vapor-compression systems that use non-CFC refrigerants for commercial and household refrigeration, and 2) development of non-vapor-compression refrigeration cycles such as Stirling for these applications.

"Golden Carrot" Economic Analysis

The purpose of this project is to perform the economic analysis necessary to expand to a nationwide "Golden Carrot" program. Led by Pacific Gas and Electric (PG&E), several utilities are forming a national consortium to offer significant rebates, e.g., $300.00, for the first 100,000 refrigerators sold that exceed the 1993 NAECA standards by 20-30%. The strategy is to provide industry with a strong incentive, in the range of $30-50 million, to manufacture a radically new refrigerator. This strategy has such a large potential that other appliances should be studied and priorities set for an expanded "Golden Carrot" program. Appliances in the residential and commercial sector use about 1000 BkWh/year, or the output of about 200 baseload, 1000 MW power plants. Therefore, a 20% improvement is 200 BkWh, which is worth $15 billion per year.

3.4 MATERIALS AND STRUCTURES PROGRAM

GROUP PARTICIPANTS

Facilitator: Jeff Christian

Michael Brambley	Don Neeper
Mark Levine	Steve Selkowitz
Roger McDonald	Walter Short

OVERVIEW

A brief presentation was given by Jeff Christian describing the Building Materials Key Activity and the Walls, Roofs, and Foundations Key Activity. Steve Selkowitz presented a description of the Windows and Daylighting Key Activities. The goal of the Materials and Structures Program is to provide the technology for zero net-heating/minimal-cooling energy building-design options to be demonstrated by the year 2000 through development of a strong fundamental research base along with support of key, highly leveraged, industry cost-shared program thrusts. The Program focuses on three key activities: Materials; Advanced Walls, Roofs, and Foundations; and Windows and Glazings.

Major thrusts of the Building Materials activity are development of high thermal resistance (high R-value) insulations that do not use CFCs, development of special non-CFC insulation for retrofit applications, and development of building materials with dynamic thermal properties—variable R-values and switchable emittance coatings.

The Walls, Roofs, and Foundations activity addresses application of advanced materials (dynamic, high-R, durable, non-CFC), design tools, and new program thrusts (30/30 roofs—R30/30 year life) and support of the Advanced Dynamic Wall project that provides for the integration of conservation and solar advances, e.g., high-R electrochromic windows, elimination of thermal bridges, moisture forgiving joints, and advanced composite walls, into new commercial and residential building wall technology. Another major thrust in this program is development of energy efficient moisture control strategies.

The Windows and Glazings activity includes 1) developing advanced optical materials and systems including very high-R "Superwindows," electrochromic "smart windows," and optical materials to enhance daylighting performance; 2) developing methods to characterize the thermal and daylighting properties of window systems to support the National Fenestration Rating Council's development of an accurate and objective window rating and labeling system; and 3) developing tools and guides for architects and engineers to achieve the program goal of converting windows from net energy losers to net energy gainers.

DISCUSSION

Table 8 is a summary of the group's recommendations for FY 1993 and a priority vote on each existing key activity and new or revised initiatives. The group suggests that nine new or revised initiatives receive funding in FY 1993. These initiatives include

- high performance insulations,
- PCM thermal storage in building surfaces,
- efficient moisture control strategies,
- advanced roofs: 20/20, 30/30 (R-30/30 year life),
- window rating,
- super windows,
- smart windows,
- zero-energy advanced envelope technology, and
- total fuel cycle for building materials.

Table 8. Recommended FY 1993 Funding Plan for the Materials and Structures Program. ($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Building Materials (base activities)	R	2.8	4.5	1.2
▪ High Performance Insulations	RI	1.15	3.75	0.6
Advanced Walls, Roofs, and Foundations	R	3.725	4.3	1.9
▪ Advanced Roofs: 20/20 30/30	RI	0.5	4.5	0.5
▪ Efficient Moisture Control Strategies	I	0.8	4.5	0.8
Windows and Glazings	R	6.0	4.75	3.1
▪ Smart Windows	I	1.5	3.5	1.5
▪ Window Labels	RI	1.0	4.0	0.7
▪ Super Windows	RI	1.0	4.5	1.0
▪ Zero-Energy Advanced Envelopes	I	1.6	3.25	1.0
TOTALS	--	20.075	-------	12.3

These new initiatives were then assigned to a revised key activity, as shown in Table 9.

Table 9. Revised Key Activities for the Materials and Structures Program.

Materials
High-performance insulations
PCM thermal storage in building surfaces
Total fuel cycle for building materials
Walls, Roofs, and Foundations
Advanced roofs: 20/20, 30/30 (R-30/30 year life)
Efficient moisture control strategies
Windows and Glazings
Window rating
Super windows
Smart windows
Zero-energy advanced envelope technology

There were two votes taken using the 0-5 suggested rating scale. The first ranked the three revised key activities: Building Materials—4.5; Walls, Roofs, and Foundations—4.3; and Windows and Glazings—4.75. The second vote extended the ranking to include both revised key activities and new initiatives. This ranking is found in Table 8.

Based on this vote and on discussions among group members, a restricted FY 1993 recommended budget was derived. This program contained three existing key activities:

- Building Materials;
- Walls, Roofs, and Foundations; and
- Windows and Glazings.

It should be noted that the "Windows and Glazings" key activity has always included a variety of Daylighting projects, from solar control coatings to the development of Daylighting Design Guides for architects. The portions of this work that were previously conducted in the "Solar Buildings" program, e.g., electrochromics, holographics, and simulation studies, have been combined within the "Windows" key activity. The Facilitator for Solar Technologies agreed this work should be shifted to the Material and Structures Program. The existing window industry (manufacturers and the design community) is not separated into supply- and demand-side windows. In other words, they do not design windows twice—once for heat loss and once for heat gain. Cost sharing and working with private industry is crucial to the successful implementation and deployment of fenestration and technologies.

The new initiatives which ranked the highest were Efficient Moisture Control Strategies and Super Windows. The group did not reduce the full 1993 budgets for these initiatives in the restricted 1993 column because of the high ranking they were awarded by the group. The third highest-ranking initiative was Advanced Roofs: 20/20, 30/30 (R-30/30 years of life). This has the potential of improving the efficiency of low-sloped commercial roofs by extending the durability. Current levels are 8/8.

A brief description of both the revised key activities and surviving new initiatives for the proposed Materials and Structures Program for 1993 is provided below. It should be noted that a number of these initiatives have been combined into a single "High Performance Envelope" initiative, which is described in Section 2. These projects include smart windows, super windows, high-performance insulations, and zero-energy advanced envelope technology.

Building Materials

Because of the environmentally unacceptable ozone depletion and greenhouse warming effects of CFC and HCFCs, they must be replaced to keep available what has been the highest commercially available R/inch insulation. Finding replacements for HCFCs will save 0.12 quads/year. Strong cost sharing is anticipated in this area from EPA and private industry. This would be an expansion of the existing joint DOE/EPA/Society of Plastic Industry project, but should include composite foams.

"Ageless Foam" is another initiative in this revised key activity. Current foam insulation loses its initial high R-value with time. Aging can cause an R-value loss of 30% in 10 years for some HCFC foams. If this R-value loss could be eliminated, 0.29 quads could be saved in residential building envelopes, commercial building envelopes, and refrigerators. Some very limited research is focused on "super insulation," such as vacuum insulations, i.e., powder-filled evacuated panels (PEPs). These panels have 2.5 and 5.0 times the thermal R-value of CFC blown foam and fiberglass insulation, respectively. Development of PEPs could save 1.35 quads/year in buildings and appliances.

Walls, Roofs, and Foundations

Advanced Wall Systems. The goal of this project is to develop efficient moisture-control strategies for envelope design and to develop advanced wall systems—first with HCFC foams, then with composite envelope systems with high R/inch with no CFCs or HCFCs. Tighter buildings save energy, but moisture control strategies must be incorporated in the design. The research leads to envelope systems which will not mold, mildew, or rot. This project could save hotel and motel owners $600 million/year; therefore, cost sharing is likely from private industry such as the American Hotel and Motel Association. Advanced wall systems development could lead to near-term energy savings of 0.3 quads, and integration of advanced wall technology concepts with P.V. could lead to energy savings exceeding 1.0 quads/year.

Energy Efficient Foundations. A historically ignored component of most buildings, the average R-value today is less than R-5. Cost-effective systems averaging around R-10 to R-20 should be adopted. The energy savings potential is 0.5-0.8 quads/year. Shallow insulated foundation systems restricted by most building codes needs development and demonstration, which could save energy and be very favorable to attaining the national goal of affordable housing, since first cost would be $1400 less per unit, thus reducing the monthly mortgage costs.

Advanced Roof Systems. This project would develop longer-life roofs and ventless attic systems with integral moisture control, thus enhancing thermal performance and lowering costs. It would also develop, with industry collaboration, roofs that can be recovered when they get wet without producing excess construction waste. Removal and disposal of wet roofs is energy inefficient and an environmentally harmful process. Technology to reroof wet roofs needs to be further developed and demonstrated, and supportable guidelines need to be developed. This research could lead to 0.7 quads/year of energy savings.

High-Performance Insulation. Several concepts were presented at the workshop, which could lead to cost-effective high-R "super insulation," i.e., vacuum panels, gas-filled insulating panels, silica aerogel, and dynamic-R insulations. Development work is needed to extend life and reduce cost. New barrier materials and powders would be developed. One very attractive feature of all of these systems is that the insulation thickness could be dramatically reduced, saving costs of construction by reducing the need for extended window and door jambs.

Efficient Moisture-Control Strategies. Tighter buildings save energy and can also contribute to enhanced moisture-control strategies. Building envelopes can be developed which have inherent moisture control capabilities without increasing building ventilation energy needs. Ninety percent of premature deterioration in building envelopes is caused by excessive moisture accumulation. Moisture research is necessary to provide building practitioners with the tools to design and build energy efficient structures without concern for eventually damaging moisture accumulations. Less than one percent moisture content by volume in an envelope cavity can increase heat transfer by 100%. Envelope system moisture-control strategies and wetting and drying rates need to be validated in well controlled climate chambers. Every year many millions of tons of wet insulation and roofing material are torn off buildings, less insulation is installed than should be, and landfill space becomes even more scarce. Concepts employing the envelope to contribute to interior-space humidity control will also be developed. The American Hotel and Motel Association alone loses $600 million a year because of excessive moisture accumulation on and in building envelopes.

Windows and Glazings

Smart Windows. The group recommended accelerating development of electrochromic smart windows. These windows would have electrically controllable transmission properties from 80% in the clear state to 10% in the dimmed state. This could provide reduced cooling loads, improved visual comfort and thermal comfort, better utilization of solar gain, and year-round daylighting. A higher first cost will be offset by reductions in HVAC costs and conventional shading systems.

Window Labels. DOE is working with the National Fenestration Rating Council to develop a uniform, nationally based energy-rating and labeling system for windows. National energy efficiency is improved by optimal investment of consumer dollars in window energy efficiency. A rating system that is consistent across all states and helps differentiate product performance will provide an added incentive for manufacturers to develop more efficient products. The labeling system will make it easier for new codes and standards to specify better technology and will enhance the credibility of product performance claims.

Superwindows. Improve window performance to the point that north-facing windows in cold climates require less annual heating energy than a highly insulated wall. This will require a total window R-value of R6-10. An R8 glazing is now available, but the total window R-value is only 4-5 because of frame losses. This cooperative DOE/industry/utility program would develop the appropriate design solutions and demonstrate the benefits of superwindows throughout the northern states.

Zero-Energy Advanced Envelope Technology. This project would develop envelope systems that require no net energy for heating, cooling, and daylighting. Dynamic energy-control technologies would employ low-thermal-transmittance glazings and claddings, collect solar gain to minimize cooling loads, utilize daylighting to minimize interior lighting needs, and provide electric power from photovoltaic elements incorporated on opaque portions of the envelope or interior of externally mounted operable shutters. The building envelope currently influences over 5 quads of annual energy use (heating, cooling, and lighting) and is a primary contributor to peak energy demand in buildings.

3.5 INDOOR AIR QUALITY PROGRAM

GROUP PARTICIPANTS

Facilitator: Joan Daisey

Ren Anderson
Michael Brambley
Jeff Christian

OVERVIEW

The Indoor Air Quality (IAQ) Program, which includes Infiltration and Ventilation, provides the building science and energy conservation perspective to the nation's indoor air quality issue. Increased knowledge is needed concerning the relationships among reduced infiltration, adequate ventilation, and acceptable indoor air quality. Consistent with the goal to "maintain indoor air quality to ensure an environment conducive to health, safety, comfort, and productivity of occupants," the program seeks to provide the technology base that would allow for energy efficient buildings that are comfortable, productive, and have no adverse health effects.

DISCUSSION

Table 10 is a summary of the group's recommendations for FY 1993 and a priority vote on the existing key activity and two new activities. The group suggests that IAQ core funding be reduced in FY 1993 to accommodate the two new key activities. The Facilitator provided a minority recommendation that the FY 1993 IAQ budget not be decreased below $1.8 million. Under the minority opinion the new Healthy Office Buildings activity would receive $200K.

Table 10. Recommended FY 1993 Funding Plan for the Indoor Air Quality Program. ($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full Cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Indoor Air Quality	N	3.0	4.2	1.0
Healthy Office Buildings Design Guidelines and Tools	I	3.0	4.0	0.85
Energy Efficient Buildings Ventilation and IAQ Standards	I	0.5	4.0	0.15
TOTALS	--	6.5	-------	2.0

Key: N = Existing; R = Revised; I = Initiative.

Table 11. Revised Key Activities for the Indoor Air Quality Program.

Indoor Air Quality
Healthy Office Buildings Design Guidelines and Tools
Energy Efficient Buildings Ventilation and IAQ Standards

A brief description of the revised key activity and the two new key activities for the Indoor Air Quality Program for FY 1993 is provided next.

Indoor Air Quality

The objective of this key activity is to increase the understanding of relationships between building ventilation and indoor air quality to provide the technological base to advance buildings energy efficiency while maintaining healthy, comfortable and productive environments. Key elements of the activity include integrated research on building energy systems and ventilation/infiltration/ventilation efficiency; characterization of indoor pollutants, sources, and concentrations; exposure measurement and modeling; development of measurement technologies (for ventilation, emissions, and indoor air quality); indoor air quality control technologies; and integrated assessment of indoor air quality issues. The activity includes long-, mid-, and short-term research.

Cost-sharing for the activity comes from EPRI, the California Institute for Energy Efficiency, Southern California Edison, BPA, the California Air Resources Board, the Consumer Product Safety Commission, EPA, and the National Institutes of Health.

The energy efficiency potential of this activity is about 1 quad of annual savings ($5 billion) in reduced ventilation and increased ventilation efficiency. Potential economic savings are high ($66 billion/year) in increased health and productivity.

Healthy Office Buildings Design Guidelines and Tools

Key elements of this activity include 1) multidisciplinary, hypothesis-driven field and laboratory studies to determine the relationships among occupant health, comfort, and productivity; ventilation; and environmental and psychosocial variables for a cross-section of new and retrofitted office buildings; 2) development of diagnostic tools and guidelines for redesign and retrofit of existing office buildings to provide indoor air; and 3) development of user-oriented design tools for architects and builders for design of "healthy buildings."

This area also has the potential for saving about 1 quad of energy and potentially would have $5 billion in health benefits.

Energy Efficient Buildings Ventilation and IAG Standards

This key activity would establish building ventilation and indoor air quality standards that will protect human health and materials and provide a basis for IAQ sensors for energy-efficient ventilation.

3.6 BUILDING SYSTEMS PROGRAM

GROUP PARTICIPANTS

Facilitator: Michael Brambley

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John Andrews	Steve Selkowitz
Joan Daisey	Michael Wahlig
Bill Mixon	

OVERVIEW

The energy performance of a building depends not only on the performance of the individual envelope components, e.g., walls, windows, and roofs, HVAC components, and lighting fixtures, but on the combined performance of these when integrated during design and construction into a whole building. The energy performance of the building subsequently depends on how the building as an integrated system is operated and maintained.

The goal of the Building Systems Program is to develop and implement the scientific and technical basis to design, build, and operate whole buildings as efficiently as is technically and economically feasible so that the buildings sector serves as a reliable substitute for additional energy resources. The program can reduce energy consumption in buildings by 25% in the near term (before 2010), with much greater savings thereafter (5 to 10 quads per year by 2030). The program currently focuses on 1) developing and implementing building energy standards for new federal buildings and promoting their adoption by state and local governments; 2) in collaboration with industry, developing and implementing simulation techniques and advanced computer-aided design tools in which energy is a primary design consideration; 3) with industry, performing RD&D necessary to encourage energy-efficient building practices in the industrialized housing industry; and 4) developing and encouraging adoption of cost-effective retrofit strategies for all existing buildings.

DISCUSSION

Table 12 is a summary of the group recommendations for FY 1993 and a priority vote on each existing key activity and new or revised initiatives. The group proposed heavily revising the four current key activities and adding three new activities. These new initiatives include Construction/Commissioning/Operation Guidance and Tools for Commercial Buildings, including Monitoring and Diagnostics; Advanced Diagnostics/Audits for Residential and Commercial Retrofits; and Heat Islands Mitigation. Each of the new key activities have several projects, as noted in Table 13.

Table 12. Recommended FY 1993 Funding Plan for the Buildings Systems Program.
($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full Cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Commercial Buildings	R	5.0	4.0	3.5
Residential Buildings	R	6.0	3.8	3.5
Standards and Guidelines	R	5.0	4.7	3.5
Retrofit Technology	R	7.0	4.5	3.9
Construction/Commissioning/ Operation Guidance and Tools for Commercial Buildings, including Monitoring and Diagnostics	I	1.5	4.0	1.0
Advanced Diagnostics/Audits for Residential and Commercial Retrofits	I	2.2	4.3	1.0
Heat Islands Mitigation	I	0.5	3.3	0.1
TOTALS	--	27.2	-------	16.5

Key: N = Existing, R = Revised, I = Initiatives

Table 13. Revised Key Activities for the Buildings Systems Program.

<u>Commercial Buildings</u>

Design Tools (advanced CAD and sizing tools)
Systems Interactions/Innovative Systems
Advanced Performance Simulation (DOE-2, DOE-3, EKS, and ASEAM equivalent)
Air Systems (Test Laboratory and Innovative Concepts)

<u>Residential Buildings</u>

Industrialized Housing
Industrialized Housing Test Center
Advanced Housing Technologies
Joint Venture Residential Research
Hot Climates Research
NAHB National Program Plan
Outstanding Buildings Program
CLEVER House

<u>Standards and Guidelines</u>

Development
Demonstration
Implementation

<u>Retrofit Technology</u>

Retrofit Applications/Field Testing
DOE/HUD Initiative
Advanced Retrofit Technology (e.g., daylighting and EMCS assessment)
Improved Underlying Methods
Model Energy Management Programs

<u>Construction/Commissioning/Operation Guidance and Tools, including Monitoring and Diagnostics</u>

<u>Advanced Diagnostics/Audits for Residential and Commercial Retrofit</u>

<u>Heat Island Mitigation</u>

This area drew a great deal of attention because of its relative newness and lack of a comprehensive strategic plan. Each group member proposed several new activities, many of which overlapped in content. For the most part, the group consolidated these ideas as they appear in this report. Concentration was centered on the areas where most potential energy savings were perceived—building design, operation, and retrofit. The group felt strongly that if OBT is to meet its stated goal of level sector energy consumption over the next 40 years, these two areas would have to be emphasized, the program emphasis would have to be expanded, and a great deal of additional funding would have to added.

Recommendations were then made to expand current activities to better capture the opportunities they present to conserve energy, particularly Residential Buildings and Retrofit Technologies; establish collaborative efforts with industry to improve implementation, particularly in Residential Buildings and Standards and Guidelines; and to accelerate selected projects within the key activities, for example, in Commercial Buildings.

Collaboration and cost-sharing with industry and state/local governments are important ingredients of most additions to the existing key activities. Developing and implementing new technologies for energy-efficient building design involves close collaboration with industry to ensure commercialization of products. Several of the new elements in Residential Buildings involve collaboration with the home building and industrialized housing industries, and Retrofit Technologies includes interaction and cost-sharing with utilities, state/local governments, and other federal agencies for successful implementation.

Several ideas for new initiatives were submitted, including advancements in retrofit technology; summer heat island mitigation; an "outstanding" buildings program; the CLEVER House; energy design guidelines for large commercial buildings; an industrialized housing test center; a demonstration program for advanced and innovative housing designs; performance quality assurance in building construction, commissioning, and operation; development of an HVAC system design tool; commercial building diagnostics; several enhancements to the present building standards; and commercial and residential building systems programs. Many of these overlapped considerably. The attendees agreed that these could be absorbed as new activities within the existing key program elements or aggregated into two new key activities:

- Construction/Commissioning/Operation Guidance and Tools including Diagnostics and Monitoring, and

- Advanced Diagnostics/Audits for Residential and Commercial Retrofits.

These areas were recommended as new key activities because they represent gaps in the current program and address key issues that must be explored to take maximum advantage of energy conservation opportunities.

The final initiative is Heat Island Mitigation. Although most agreed this is an important topic, the workshop participants expressed concern over whether Building Systems was the appropriate program for this topic and discussed the possibility that it be located under Implementation and Deployment.

The priorities set by vote indicate the predominant, but not unanimous, view among attendees that the Retrofit Technologies key activity does not currently address all essential aspects of building retrofit and the program requires significant expansion. Proposed activities in this area are primarily focused on reducing the uncertainty in savings available from retrofit, improving estimates of the savings, developing improved tools to promote retrofit and improve performance, and promoting more widespread implementation.

Assured Energy Savings

As part of a continued discourse, Ren Anderson, John Andrews, Mike Brambley, Bill Mixon, and Mike Wahlig met informally to further discuss the importance of a strong retrofit and operations activity. They developed a new initiative called "Assured Building Energy Savings Program (Retrofit and New Buildings)" that combined elements of the Commissioning/Construction/Operation and Advanced Diagnostics/Audits and Retrofit initiatives. This was recommended at the full workshop meeting as a major new thrust to replace the two previous initiatives and to be included as a highlighted item in this workshop report.

The objective of this initiative—Construction, Commissioning, Operation, and Maintenance Technology for Persistent Savings—is to address major gaps in the existing Building Systems program having significant potential energy savings. Activities would focus on developing and implementing methods and technologies for ensuring proper commissioning and operation of existing and new buildings to maximize energy performance and to maintain that performance by proper operation and maintenance over the building's life. This would be a major new thrust for Building Systems research.

A brief description of both the revised key activities and surviving new initiatives for the proposed Building Systems Program for FY 1993 is provided next.

Commercial Buildings

Energy-efficiency improvements in the commercial buildings sector have not kept pace with improvements in the other sectors, including those in residential buildings, despite large potential. Studies performed in the 1980s showed that efficiency improvements of more than 50% are possible by considering energy early in building design; 15% of these savings could be achieved with no increase in first costs. Providing technologies and procedures that ensure proper operation and maintenance of building systems would result in even greater savings in both new and existing commercial buildings. Energy has traditionally been a low priority in building design and operation. Integrating energy efficiency considerations, knowledge, and capabilities into building design and operation is essential to improve the efficiency of the building stock. Federal involvement is vital to make this happen; without it, this large potential energy resource will remain untapped. Design procedures and tools that integrate energy standards with other design considerations are necessary to eliminate barriers to more stringent building energy standards; designers need these tools to use evolving energy standards and will reject the standards without such tools.

Design Tools and Advanced Performance Simulation. The objective of this project is to make energy performance a primary consideration in the design and operation of commercial buildings. This will be accomplished by continuing development of complementary programs in energy analysis (DOE-2, DOE-3, and ASEAM) and design technologies (AEDOT). The DOE-3 energy analysis program will build upon the widely used DOE-2 building energy analysis computer program to make it easier for users to perform analyses of innovative HVAC systems that are now prohibitively time-consuming. The additional capability will enable users to select from a library of preconfigured systems or to assemble systems from component models rather than develop the system and modify the computer code as is required by DOE-2. DOE should expand the program in simulation to include simplified energy analysis programs, such as enhanced versions of ASEAM, that run in reasonable times on widely available personal computers. Professionals in a number of fields, such as building retrofit and design, are requesting these simplified tools.

The AEDOT design technology utilizes advanced computer technologies, such as artificial intelligence, hypermedia, and sophisticated computer visualization techniques, to make readily available as part of advanced computer-aided design systems the expertise now available to only relatively few design professionals. These technologies will provide automated access to complex analysis tools, such as DOE-2 and DOE-3, and important cost and performance databases, as well as new design tools developed as part of the project. The AEDOT systems will be developed in a cooperative effort with the CAD industry to ensure that they are integrated into commercially available CAD systems of the future, enabling architects and designers to routinely include energy efficiency in design.

System Interactions/Innovative Systems. This project focuses on understanding the interactions between building systems, developing design guidance that takes advantage of these interactions, and developing new innovative systems that integrate traditionally separate systems to improve building energy performance. Previous efforts have focused on an exploratory study of integrating a commercial building HVAC system with thermal storage provided by the building structure and an ongoing experimental investigation (at NIST) into the interactions between HVAC and lighting systems. This project should be expanded to investigate other system interactions and to field-test concepts that utilize the interactions to increase building energy efficiency.

Air System Efficiency. The objective of this project is to minimize energy use and maximize indoor environmental quality provided by mechanical ventilation and air handling systems in residential, commercial, and industrial buildings. The tasks necessary to reach that objective are to 1) reduce air system capital and operating costs, 2) improve air system performance and reliability, and 3) provide advanced diagnostic tools and operational experience.

Residential Buildings

Residential energy efficiency has reached a plateau, and sector energy consumption, especially electricity from higher cooling demand, is increasing. Proper integration of components and subsystems can reduce consumption by over 25% from the most stringent present-day residential standards levels. The movement toward industrialization of the home building market provides significant opportunity for industry change. Significant energy efficiency improvements are possible through improved structuring of design, construction, and operation of new residential buildings. Building most new homes in a factory will allow for improvements in shell tolerances and for the use of newer technologies while costs are held down.

Industrialized Housing and Advanced Housing Technologies. The objective of this project is to improve the energy efficiency of housing while enhancing quality and reducing costs. The project will develop factory-based construction technologies—industrialized housing—that will move as much of the labor as possible from the building site to a centralized location, permitting closer tolerances that will improve building longevity and reduce thermal losses. Affordability is expected to be enhanced by reduced labor requirements.

A second activity, housing technology adoption, will seek to enhance the adoption of new technology within existing construction practices. This will be done by first analyzing the process of technology adoption in the homebuilding industry and then selecting existing technologies that can most improve product quality, energy efficiency, and cost effectiveness.

Each of the above activities will include a program of field evaluations and will be closely coordinated with the building industry by working with the National Association of Home Builders (NAHB).

Industrialized Housing Test Center. Currently, manufactured buildings use about 1.25 to 2 times the energy per square foot of site-built structures. However, the factory environment has the inherent potential for producing buildings of very high thermal quality. One major impediment to realizing this potential is the lack of hard data on the energy savings potential of various innovative energy conservation options. It is proposed that an Industrialized Housing Test Center be established that would allow rapid and accurate determination of the thermal characteristics of manufactured buildings. The center would include a large-scale high-bay environmental enclosure in which new and existing industrialized buildings of all types could be tested under controlled conditions of temperature, radiation, wind, and humidity. Such a facility would not only allow testing of the buildings, but would also allow rapid development and validation of field-testing techniques and simulation programs.

Joint Venture Residential Research. The goal of the industrialized housing joint venture program is to "establish regional projects to develop or demonstrate techniques to improve the energy performance of factory-made housing offered by United States firms." The selection of projects will consider regional differences in housing needs, housing design, construction techniques, marketing practices, and construction materials. Projects must demonstrate state-of-the-art product quality, energy efficiency, and adaptability to renewable forms of energy of factory-made housing offered for sale in the U.S. Projects must also 1) be structured to demonstrate improvements in housing design, fabrication, delivery systems, construction processes, and marketing; 2) develop a detailed characterization of the needs of the home building industry; 3) establish a close working relationship with all sectors of the home building industry; and 4) be coordinated to pool and conserve resources.

The establishment of the joint venture program will complement the research program by accelerating the use of research results in the industrialized housing market. Joint venture activities have the potential to reduce energy consumption by 25% compared with current energy standards, to reduce first and operating costs, and to increase the productivity of the housing industry. DOE has begun to survey industrialized housing producers, production builders, and material and components manufacturers, and their respective trade associations, to assess the need for and interest in such a program.

Depending on the level of funding available, possible joint venture activities include improving the manufacturing and building process; advancing material, component, and whole building design and engineering; developing tools to improve productivity; lessening institutional, economic, and regulatory impediments or barriers to adopting new energy efficiency technologies; and designing and testing model houses of the future.

Hot Climates Research. With the majority of new home construction taking place in the southern tier of the United States, a shift is necessary in the focus of the Department of Energy's residential energy conservation research program. Even though the conservation of heating energy has been widely explored, the understanding of cooling energy conservation is virtually nonexistent. The goal of new research would be to develop energy conservation strategies and technology innovations that would contribute to a 30% reduction in typical air-conditioning energy consumption in the south. These strategies can include high-technology building systems such as multizone air conditioning and air distribution systems that are capable of reducing utility peak loads, passive solar techniques utilizing natural cooling, and building thermal and moisture capacitances. This research should be coordinated with related research in the Solar Technology program.

NAHB National Program Plan. The objective of this project is to help NAHB develop and administer a national voluntary energy efficiency program, targeted at new and renovated housing, that can result in a very significant reduction in the annual use of electricity, natural gas, and oil-based fuels in the U.S. by the year 2001. A policy, research, development, and administrative plan will be implemented by NAHB. The goal of the project is to significantly improve the way home builders address energy conservation in new homes and renovations. It will provide educational material and guidelines on increased levels of insulation, window thermal values, air-tightness and ventilation, indoor air quality, solar utilization, mechanical systems, advanced digital smart controls, super-efficient appliances, advanced lighting, and other new-housing, renovation, and light-construction technology.

Outstanding Buildings Program. This project would identify outstanding buildings and publicize them, thereby "improving the breed" by promoting selection of better designs by builders, owners, and the financial community. One of the major impediments to the adoption of energy-conserving technologies in buildings is lack of credibility concerning what works and what doesn't. The home owner and the builder alike are bombarded with claims, some accurate, some specious. There is a need for an "honest broker" with no axe to grind who can sort out the good from the bad. It is proposed that the national laboratories are in a unique position to play this role.

The CLEVER House. This project would be used to design and evaluate, in the field, an integrated, low-energy housing concept called the CLEVER house (Controlled Living Environment through Ventilation Energy Recovery). Much has been learned about possible ways to combine desirable aspects in housing—energy efficiency, affordability, aesthetics, and comfort. From Scandinavian housing in particular we have learned how to produce an energy-efficient, well-ventilated house. The key elements here are a low natural infiltration rate, adequate thermal insulation, and a forced ventilation system that employs a heat pump to recover energy that would otherwise be lost. Work in this country has extended the concept to cover the cooling mode. This same type of system could provide not only energy efficiency but also very good dehumidification. On the electrical side, the use of direct current in the house would provide significant possibilities for energy conservation, load leveling, and integration with photovoltaics to provide a significant portion of the house's energy needs. Because of the vast potential for energy savings inherent in the above concepts, there is a need for field evaluation that, if successful, could be replicated on a regional basis as demonstrations.

Standards and Guidelines

The primary objective of this program is to provide economical design standards for new commercial and residential buildings to improve energy efficiency and promote the use of nondepletable resources to the maximum extent that is cost-effective. The standards are mandatory for the federal sector and voluntary for the nonfederal sector. Demonstration activities will assess the energy effects on and costs to building occupants, owners, and builders. Implementation activities will provide information and technical assistance to support state and local adoption of improved standards.

The activity will include training and implementation support to administering organizations and the major code organization; conducting field performance testing of buildings designed and constructed to the standards; determining energy saving performance and cost effectiveness of the standards, and demonstrating that indoor air quality meets acceptable standards.

Retrofit Technology

The average life of current buildings is at least 50 years; many of the buildings that will exist in 2030 already exist today. The large difference in consumption between existing buildings and new construction indicates significant potential for energy savings (50% in residential buildings and at least 20% in commercial buildings). While a suite of retrofit technologies (and tools for analyzing their application) exists, their penetration into the building population is limited. Reasons for this include 1) uncertainty about whether savings will be achieved, 2) up-front costs of audits, 3) capital costs for installation of conservation measures, and 4) (in some cases) physical barriers. This key activity directly contributes to the sector goal of accommodating growth in square footage with no increase in energy consumption by addressing these impediments to more widespread application of retrofits. The program should implement the following strategies to promote increased application of retrofit technologies: 1) increase the reliability of energy savings and consumer confidence in them; 2) lower the costs of audits and installation of retrofit measures; 3) accelerate the rate of adoption of demonstrated improvements (now at the applied research and demonstration stage); and 4) develop and demonstrate new retrofit technologies that can reduce energy use by 40–50% (some that are now at the basic research stage), which for the residential sector will match industry goals for energy efficiency of new homes by 2010.

Federal, state, and utility programs and the industry need hard data on the actual performance of retrofit measures and effective delivery mechanisms, and have demonstrated interest in cost-sharing the needed research. Utilities can provide capital and spread risk, and so they have been and increasingly will be the focal point for retrofit activities. DOE can provide the technologies and technological expertise needed to ensure that maximum benefits are achieved and meet expectations.

Retrofit Applications/Field Testing. The objective of this project is to improve and accelerate the adoption of near-term technologies. This would be done through continuing research to improve retrofit technologies and diagnostics; developing and demonstrating quicker, simplified audit techniques and supporting their rapid deployment by the semiskilled labor usually involved in auditing; developing simplified techniques for identifying opportunities to increase energy efficiency by improving building operation and maintenance and testing them using existing empirical data; demonstrating improved retrofit potential in both residential and commercial buildings for all six regions of the country; developing regional guidance for technology transfer and assistance; providing technical assistance in the application of retrofit initiatives to HUD and FEMP; expanding field performance experience in joint efforts with utilities that validate project impacts and test advanced retrofit concepts; and gaining widespread acceptance of audit procedures through the consensus standardization process of ASTM.

DOE/HUD Initiative. The overall goals of the DOE-HUD initiative are to 1) apply existing technical information on energy efficiency to HUD-assisted housing construction and retrofit activity, 2) make housing more affordable through energy efficiency improvements in HUD programs, 3) reduce federal outlays for utility expenditures, and 4) make community development activities more competitive through improved energy efficiency in HUD programs. This effort should be continued through financial and technical assistance, information dissemination, prioritization of HUD programs, and revision of HUD regulation and program guidelines.

Advanced Retrofit Technology. The objective of this project is to develop advanced envelope, equipment, and operation and maintenance retrofit options, e.g., daylighting retrofit systems for single-story buildings, to demonstrate cost-effective energy savings of 50% by the year 2000. This will be done by determining the maximum savings that can be achieved with current and emerging materials and technologies in four regions of the country to prioritize these strategies; assessing the retrofit program potential using existing empirical data; developing advanced material, retrofit systems, and applications of manufactured housing technologies as necessary to meet the objective; demonstrating advanced retrofit packages for each building sector in six regions; developing advanced retrofit packages for each building sector in six regions; developing advanced audit and inspection protocols and guides; developing material for education programs; and providing assistance during transfer to practice.

Improved Underlying Methods. The objective of this project is to develop advanced diagnostic, energy monitoring, and auditing tools that decrease the costs of audits and retrofits and improve the reliability of energy savings. Efforts will focus on 1) developing the capability to calibrate simulation and audit tools to empirical data to improve the ability to estimate potential energy savings; 2) doing research to reduce the time, cost, and complexity of energy monitoring; and 3) developing energy-savings opportunity screening tools and advanced audit and diagnostic methods, particularly for commercial and multifamily residential buildings.

Model Energy Management Program. Effective implementation of energy conserving actions results from a process that involves not only an auditor but a decision maker. The audit identifies technological (and organizational) opportunities to reduce and manage energy use. These opportunities must be acted upon by the actual decisionmakers in the organization. Identification of opportunities from the audit is only the first step and by itself does not result in action to take advantage of the opportunities. An audit is only one essential part of an ongoing energy management program that is matched to the needs, capabilities, and opportunities of a particular facility. The objective of this project is to define, test, and disseminate model energy management programs for specific identifiable segments of the population of existing buildings.

Technical components of the energy management program should include audit tools, evaluation tools and procedures, diagnostic tools, and performance tracking and analysis tools and procedures. Organizational aspects of the energy management programs that should be modeled include the organizational policy, education and training, financial criteria, and sources of financing. Model energy management programs that account for all these factors should be defined, tested, and evaluated in a joint effort with utilities, large institutional facility operators, and state, local, and federal government entities. Development of effective model energy management programs should then be followed by deployment by utilities, state and local governments, and FEMP.

Construction/Commissioning/Operation Guidance and Tools, including Monitoring and Diagnostics

The objective of this initiative is to develop in a joint effort with industry the technology and procedures for ensuring quality construction and retrofit and effective operation and maintenance of buildings so that energy savings are captured over the entire life of a building. This will require a comprehensive program that includes developing and disseminating manual procedures to capture a portion of the potential savings in the near term and automated, computer-based technologies that capture and ensure even greater savings by assisting with efficient operation and maintenance over the entire life of a building in the longer term. Activities will focus on three areas:

- **Building Operation Technology:** Efforts will focus on joint efforts with industry to develop technology that will ensure energy-efficient operation of both new and existing buildings. Existing field databases will be analyzed to identify and characterize building operation problems (in terms of nature, prevalence, and impact). This will be followed by development of new technologies in collaboration with industry that focus on solving these problems by providing improved building operation and maintenance to achieve savings of more than 20% across all new and existing commercial buildings. Developments will include systems that automatically identify and diagnose building operation problems in real time and provide assistance to building operators in correcting them. This is essential to ensure that energy savings are maximized and that they persist over the building's life. This activity will address the myriad of undetected and uncorrected operating problems common throughout the commercial building stock today.

- **Building Construction:** The construction phase is almost always overlooked in efforts to improve the energy performance of buildings, yet construction is the phase during which quality control is most critical. This activity will provide tools for 1) ensuring that design expectations manifest in equipment and installation specifications are effectively communicated to the contractors responsible for construction, 2) tracking construction activities and providing information and advice on the energy impacts of decisions (e.g., deviations from design specifications) during construction, and 3) ensuring that a full description of the as-built building and systems is available for use during building start-up and operation. Products of this activity will be integrated with construction management practice.

- **Building/System Commissioning:** This is the phase of the building life cycle in which contractors make the building work well enough to be accepted by the owner. This project activity will involve defining, developing, and testing 1) commissioning protocols, diagnostic methods, and monitoring technology and protocols for initial start-up and recommissioning (after retrofit) of equipment, systems, and whole-buildings, 2) benchmarks and standardized tests that allow the contractor to efficiently communicate to the owner that the design has been implemented, and 3) systems that continuously self-diagnose, -tune, and -recommission building equipment and systems and become integrated as part of building operation systems.

Activities in all three areas will involve initial assessment of needs to focus later efforts for greatest impact, methods and technology development, field testing, and demonstration. All activities will be performed in collaboration with industry (such as builders, materials suppliers, and building controls manufacturers) and professional societies such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the American Society for Testing and Materials (ASTM). In addition to industry, partnerships will be developed with utilities and state and federal agencies to facilitate field testing and to promote the transfer of results into practice.

Advanced Diagnostics/Audits for Residential and Commercial Retrofit

The objective of this initiative is to develop, test, and demonstrate improved audits and advanced diagnostic methods to support them as a significant part of the effort to reduce the costs and uncertainty associated with building retrofits. Products of this effort will include diagnostic instrumentation, audit tools, analytic methods, and implementation guidelines. Efforts will focus in four areas:

- less expensive, quicker audits that focus investment on measures and support rapid technology deployment by semiskilled labor,
- analytic methods to support audits that link savings estimates to empirical data,
- simplified techniques and tools for identifying operation and maintenance opportunities and for diagnosing building component and equipment failures as part of auditing and retrofits, and
- improved performance tracking and analysis tools and procedures.

Needs in each of these areas will be assessed and development carried out in collaboration with utilities, professional societies (such as ASHRAE and AEE), state and local government agencies, other federal agencies, and private auditing and retrofit specialists. The results of research and development will be field tested and demonstrated in joint efforts with these organizations.

Heat Island Mitigation

Summer temperatures in cities are typically 5-10°F higher than those in surrounding areas. These "heat islands" are growing in size and intensity at the rate of about 1°F per decade in some cities.

Heat island mitigation primarily requires energy-efficient urban design measures. Simple as it may sound, preliminary analyses suggest that increases in tree coverage and increased surface reflection from buildings and pavements can reduce peak cooling loads in many American cities by as much as 30%. This translates into many billions of dollars of avoided investment in electric peak generating capacity, avoided bills for consumers, and avoided emission of CO_2.

Mitigation measures will "whiten and green cities"—whiten by increasing the albedo or reflectivity by lightening the color of roads, parking lots, and roofs, and green by planting trees to shade buildings and increase cooling by evaporation.

Research is needed to develop inexpensive, durable surfaces that are light colored and to develop procedures for selecting resilient native deciduous trees and other vegetation. Monitoring and analysis are needed to document the effect of these strategies on cooling demand. Technology transfer is needed to persuade utilities and local governments of the benefits of these activities for lowering peak power demand.

3.7 FEDERAL ENERGY MANAGEMENT PROGRAM

GROUP PARTICIPANTS

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OVERVIEW

The Federal Energy Management Program (FEMP) provides leadership and guidance to federal agencies to improve the efficiency and fuel flexibility of energy use in federal buildings, transportation and operations. Its mission is to transfer energy management experience among federal agencies and effect adoption of energy efficient technologies through leveraging with the private sector, utilities, and other federal entities. The program provides leadership in demonstrating energy efficient techniques and technologies, such as new lighting technologies, so that federal energy consumption will be reduced by 10% by 1995 and up to 20% by the year 2000. The aging infrastructure of the federal government offers a significant opportunity to save energy through energy efficient retrofits and aggressive pursuit of utility demand reduction strategies and, as a result, offers an important potential to reduce energy consumption and airborne pollutants.

The program focuses on near-term activities to develop engineering and management tools for federal energy managers to use in improving the energy efficiency of their facilities and in demonstrating how effective techniques and technologies are cost-shared by other Federal agencies and the private sector, with the DOE contribution limited to technical assistance.

DISCUSSION

The group recommended a base program of $12.0 million in FY 1993, an increase of $3 million over DOE's recommended budget of $9 million. The program funding spread and priority is found in Table 14. Please note that the group rated all of the key activities a "5"; everyone in the group thought that DOE has an important obligation to the matter of stimulating energy use reductions in the federal sector.

Table 14. Recommended FY 1993 Funding Plan for the Federal Energy Management Program.
($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Planning and Reporting	R	0.9	5.0	???
Policy Development and Evaluation	R	0.8	5.0	???
Tool Enhancement	I	2.6	5.0	???
Technical Guidance and Assistance	R	5.5	5.0	???
Technology Adoption	I	2.2	5.0	???
TOTALS	--	12.0	-------	9.0

Key: N = Existing, R = Revised, I = Initiative

The primary reason the group recommended the changes in this program is the level of activity that will occur in the near term in energy management within federal agencies and installations. The federal sector is simply not prepared to take full advantage of legislation regarding energy management, cost-sharing opportunities with utilities, and the implementation of rules. FEMP needs to 1) rapidly develop the tools, approaches, and protocols that can be easily used by federal energy managers, and 2) demonstrate these approaches in such a manner that they become an integral part of an agency or installation's energy management culture. Failure to do so will result in major costs to the nation's taxpayers. The group recommended this program regardless of the outcome of the proposed revolving fund.

In regard to the proposed revolving fund, the group noted that it is under-capitalized at $300 million, but would be workable with cost sharing in excess of 50%. The group also recommended allocating 12% of the revolving fund project investment for monitoring and verification.

The benefits from the recommended program are huge. Projections are for long-term impact: 1 quad of annual savings by 2020 with cost sharing in excess of 50%. The near-term economic potential is also significant through at least a 30% (~0.4 quad in 1987) reduction of annual federal energy use (excluding jet fuel), amounting to well over $100 billion in cost avoidance and at least 6 quad of energy savings through the year 2010. By the year 2020, the annual savings from this program will be over $10 billion (in 1990 dollars). The FEMP has already provided and will continue to provide other significant benefits to the federal sector, including streamlined federal rules for cost sharing and procurement and designing/demonstrating fuel-blind integrated resource planning at the installation/agency level.

A brief description of the revised and new key activities for FEMP for FY 1993 is provided next.

Planning and Reporting

FEMP is required to track and report to Congress information characterizing the federal government's energy use and energy bill. New and expected changes in federal energy management legislation and policy, e.g., Executive Orders, will impose increased tracking and reporting requirements on FEMP. The federal government's rapidly changing energy management climate is a reflection of the changes occurring within the electric and gas utilities, the traditional suppliers of energy to federal facilities. FEMP needs to devote additional resources for a strategy to stay ahead of these developments. The additional effort in strategic planning is warranted with over $100 billion in cost savings at stake.

Policy Development and Evaluation

The heightened interest in federal energy management by Congress, DOE, and the private sector will continue to result in increased emphasis on implementing legislation and policies which are effective. FEMP needs to evaluate the effectiveness of existing policies, document this, and develop analysis demonstrating the impact of proposed policies on federal energy management. Some policies are currently in place, and others are evolving, which will create incentives for federal managers to engage in suboptimal behavior. FEMP needs to be positioned to identify these early on. Many states have experimented with and implemented or rejected myriad polices related to energy management in public facilities. A specific activity targeted at formal exchanges of information with states will also ensure that policies being considered have the highest probability of achieving the intended result.

Tool Enhancement

FEMP is charged with providing expert guidance to federal energy managers on ways to improve energy efficiency and fuel flexibility. The typical large federal installation is akin to a city; it generates some of its own energy such as steam, purchases energy, and uses a mix of fuels. However, the federal installation is typically not metered and is "owned" by one entity. Legislation and orders exist that require the facility to pursue energy goals and to do so using specific procedures and cost-shared approaches. Energy managers have requested tools which can be directly applied to this situation with a minimum of effort. The purpose of the tool enhancement activity is to position the federal energy manager to take the most cost-effective actions.

Technical Guidance and Assistance

FEMP needs to demonstrate to federal agencies how tools and procedures being developed can actually be used to identify and implement the most cost-effective, cost-shared projects. FEMP designs and conducts workshops to transfer expertise and tools and also works directly with federal facility managers to demonstrate the application of fuel-blind IRP at installations and within agencies. The goal is to use the tools to put a process in place which ensures that agencies and installations will acquire the most cost-effective energy projects.

Technology Adoption

The federal sector is several years behind the private sector in adopting commercially available energy technology. There are many barriers to the federal sector's adopting new technology, and these are being identified and documented. One barrier which we have identified is the risk-averse nature of federal facility managers and the lack of information on how new technology will perform within the existing physical infrastructure. To date, FEMP has addressed this barrier by focusing on test beds for new technology. It is not yet clear if technology test beds will significantly shorten the lead time for new technology adoption although this is the working hypothesis. All barriers to the federal sector's rapid adoption of available technology need to be identified, the relative contribution of each barrier characterized, and strategies developed and implemented for overcoming them.

Project Financing

Energy efficiency can only occur with actions which will save energy and reduce cost. Any plan for achieving this at an agency or installation level must have as one component the insertion of new technology into the existing physical infrastructure. The most cost-effective way to do this is for the federal government to provide the financing. FEMP and DOE are supporting the creation of a $300 to $500 million federally financed energy efficiency fund (FFEEF) for this purpose. The current proposal is for the fund to be capitalized over a four-year period; the cost savings accruing from the investment would be repaid to the federal treasury. Projects would be cost-shared through utility DSM programs.

The benefits from having the federal government finance the fund, as opposed to using private sector capital, are huge. Using the federal cost of capital can result in as much as four times the investment and three times the aggregate savings that would occur with a privately financed program. Using federal financing would also dramatically increase the sales and market penetration of many more emerging energy technologies.

3.8 IMPLEMENTATION AND DEPLOYMENT PROGRAM

GROUP PARTICIPANTS

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OVERVIEW

The objective of the Implementation and Deployment Program is to foster the adoption and utilization of energy-efficient and renewable technologies. The strategy emphasizes both direct contact with producers and service providers to keep a focus on societally relevant issues and maintenance of strong working relationships with key professional and trade associations and other research groups that serve as intermediaries and brokers in reaching diverse and fragmented building sector industries, manufacturers, and consumers.

The Implementation and Deployment Program has evolved from the OBT technology transfer program; two of the principal components of the FY 1991 effort—outreach to professional trade groups and product information dissemination—address the original technology transfer objectives to transfer the results of research to the private sector. However, Implementation and Deployment should have a broader thrust than the current program, a thrust that addresses the full range of issues associated with not only information transfer but also with efforts such as barrier mitigation, technical assistance, and ensuring that future expertise is available. These thrusts should be expanded and developed further through a detailed planning effort that clearly defines the overall objectives, target audiences, activities, and effectiveness evaluation process.

DISCUSSION

In FY 1991, the Implementation and Deployment Program has coordinated and cosponsored conferences and workshops such as the ACEC Institute on Energy and Engineering Education and the ACEEE Summer Study on Energy Efficiency in Buildings. It has translated a great deal of technical information into reports, design tools, and other products adapted to the needs of nontechnical users. These include the *Energy Conservation Technical Information Guide: Residential Buildings*, *Building Energy Technology*, and several program overviews. It has also begun work on the HERS/EEM projects and has continued to work on the Integrated Resource Planning program. The consensus among the working group was that the current program is reasonable, but not broad enough. The group felt the exception was the funding of the Oregon Art Institute project, which does not fit the scope of the Implementation and Deployment Program. However, because they do not reflect the full spectrum of activities to implement and deploy building technologies, new key activities have been defined for which the existing activities become subactivities.

Table 15. Recommended FY 1993 Funding Plan for the Implementation and Deployment Program. ($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Planning and Evaluation	I	0.5	5.0	0.5
Education	R	1.0	5.0	1.0
Information Dissemination	R	2.0	5.0	2.0
Technical Assistance	I	1.5	5.0	1.5
Barrier Removal	R	0.9	5.0	0.9
TOTALS	--	5.9	-------	5.9

Key: N = Existing, R = Revised, I = Initiative

The working group did identify a broad spectrum of activities that should be included in the Implementation and Deployment Program. However, it was strongly felt that a much more detailed plan needs to be developed. This plan needs to address the overall objective, the target audiences, audience characterization, the methods/approaches applicable/required to reach each audience or objective, and methods to evaluate the degree of success of the Implementation and Deployment efforts. This planning/evaluation effort is considered to be the first priority in Implementation and Deployment.

The working group identified four major activity areas for Implementation and Deployment (the fifth activity is planning and evaluation, discussed above), which are shown in Table 16. These include the existing FY 1991 activities, with the exception of the Oregon Art Institute, shown as subactivities. They can be categorized in terms of the timing of their effects. The longest-term payoff accrues from the education activity, which should be designed to ensure that U.S. educational institutions, from grade schools to graduate schools, emphasize scientific expertise and generate a public interest in and awareness of energy issues. This activity can be significantly enhanced through collaboration with other interested parties such as U.S. AID and the Rockefeller Foundation.

Two more direct Implementation and Deployment key activities include Information Dissemination and Barrier Removal. Information Dissemination includes a wide range of subactivities directed at ensuring that the appropriate information with respect to current energy use, possibilities for reductions in energy use, emerging technology characteristics, environmental considerations, etc., is transferred to the proper parties. Information Dissemination subactivities require the continuation of current projects such as emerging products dissemination and trade group outreach efforts, along with a broad expansion that includes an emphasis on innovative education methods such as videos, traveling exhibits, kiosks in public facilities, and compact disks; international activities; more utility interaction; and staff exchanges with industry. Regional demonstration of advanced houses is also recommended, but needs to be coordinated with prototype development and testing under the

Table 16. Revised Key Activities for the Implementation and Deployment Program

Planning and Evaluation
Education
Curriculum Development
Information Dissemination
Outreach to Trade Groups Emerging Products Advanced Houses Demonstration International Innovative Methods Staff Interchanges Utility Interactions
Barrier Removal
HERS/EEM
Technical Assistance
BETAAC Professional Fellowships

Building Systems research program. No consensus was reached on manufactured-housing testing facilities, but care should be taken to ensure that this issue was also considered under the Building Systems research program. While the group felt that OBT should continue with international activities, it did not advance any new ideas because of the uncertain CE policies on international collaboration.

Barrier Removal is a broad area of activity for which only a HERS/EEM subactivity is defined at this time. Current HERS efforts are directed at coordination with national players such as mortgage lenders, NAHB, and HUD and interaction with selected state efforts. This area should be expanded to include the development of a universal HERS that is derived from existing programs but enhanced with advanced technologies and that is calibrated using current simulation methods. Other specific barrier mitigation possibilities were not explicitly addressed but should be included.

The most near-term Implementation and Deployment effect is achieved through technical assistance to architects, builders, engineers, and product manufacturers. This is also a broad activity for which only one specific subactivity was explicitly discussed in this planning—Buildings Energy Technologies Application Assistance Center (BETAAC). This is conceived as a closely coordinated effort making use of assistance contributions provided by all the national laboratories that have expertise in building energy technologies. It will emphasize assistance to larger private and regional/state organizations with large building inventories, which can apply the technical assistance to many buildings with potential for large reductions in total energy use.

The activities proposed for a FY 1993 funding level of $5.9 million are shown in Tables 15 and 16 and are based on a qualitative assessment of both the importance of the different activities and the number and content of subactivities under each. Planning and Evaluation was budgeted at $0.5 million to emphasize its importance. Information Dissemination is the largest single item because of the diverse multiple subactivities that could be pursued. Technical Assistance is at $1.5 million because to be useful it requires detailed and therefore expensive work. Generally, these levels of effort are anticipated for FY 1994-1997 as well, although Barrier Reduction and Technical Assistance might be expected to grow with the identification of other efforts and the success of the initial HERS/EEM and BETAAC efforts.

Since the proposed FY 1993 budget for Implementation and Deployment was large, no enhanced level above $5.9 million was considered.

Brief descriptions of the new initiatives and expanded program activities submitted as inputs to the workshop for the FY 1993 Implementation and Deployment Program are provided next. The new initiative "Technology for Demand-Side Management," discussed in the Heating and Cooling Program section, probably more appropriately belongs in this section.

Implementation and Deployment Planning. The CE Strategic Plan establishes goals for changes in the way energy is used in buildings; major improvements in the efficiency of energy use and increases in the contribution of renewable energy are seen as desirable for both economic and environmental reasons. To achieve the goals established by the plan, a major effort will be needed to overcome the market impediments that have hindered the wider use of renewable energy and energy-efficient technologies and practices.

The current Implementation and Deployment Program—a collection of activities evolved in large part from a program designed to disseminate the results of research—should be strengthened and expanded to ensure that the goals set forth in the Strategic Plan can be achieved. The role of the Implementation and Deployment Program in achieving OBT's goals must be defined, objectives established, and a plan developed to accomplish them. This planning effort is a necessary first step in the creation of an effective OBT Implementation and Deployment Program.

Building Energy Technology Application Assistance Center (BETAAC). A BETAAC would be established at all participating DOE laboratories active in building energy technology and air quality research. The purpose of the centers would be to provide an interface between the laboratory research community and the intended audience for DOE research. The centers would be proactive in identifying opportunities to transfer technology and provide technical assistance in situations where a high degree of leverage and/or replication can be achieved; the centers would act in the role of "wholesaler" of information and assistance, rather than "retailer" as has been common in the past. The centers would focus on activities that would have measurable impact in terms of quantifiable energy savings, and would provide a feedback path that is effective in defining research needs based on first-hand applications experience. The centers would work closely with the private sector, supplementing available capabilities as necessary to ensure more rapid penetration of emerging energy technology.

Universal Home Energy Rating System (HERS). The objective of this project is to develop, validate, and disseminate a PC-based universal home-energy rating system tool. This tool will incorporate the

Automated Residential Energy Standards (ARES) as a base-case reference point. The user can describe his/her building description including any conventional or energy-efficient conservation or solar features, and the program would analyze this description and compare it with the standards. Built-in capabilities will include cost comparisons, mortgage loan and repayment cash-flow implications, routine HVAC analyses, and comparisons with local performance or prescriptive codes and standards.

Demonstration of Advanced Houses. The potential exists for savings of up to 80% in new residential buildings, and also for greatly reducing utility peak loads, if existing technology and design strategies are properly employed. However, builders are slow to adopt innovative measures because of their unfamiliarity and fear of higher first costs. This project would design, construct, and evaluate advanced houses in several regions of the country to demonstrate the use of innovation in a credible way to convince skeptical builders, the public, and local utilities. these projects would be carried out as collaborative efforts with industry.

International. The objective of this project is to develop a coherent international component of OBT's RD&D program. Such a venture would be characterized by a two-way linkage with both the developed and the developing countries on key elements of RD&D pertaining to building technologies.

Evaluating Technology Transfer Effectiveness. Indicators of the effectiveness of OBT technology transfer activities would be compiled and a system would be developed for periodically updating them. Requests for information resulting from articles in trade journals, *OBT Research-In-Progress*, and other publications would be monitored. Information concerning the number and nature of requests for CAREIRS fact sheets and assistance from NATAS and SERI's Technical Inquiry Service would be analyzed. Statistics would be compiled on other indicators, such as the number of copies of OBT software packages sold through the National Energy Software Centers, the number of users of the OSTI standard distribution list for reports, the number of requests for technical reports from NTIS, etc. Such evaluation measures would help direct OBT's future activities.

Curriculum Development in Technical Schools. One of the major problems encountered today is the quality of installation or dedication to operation and maintenance of building energy conservation retrofit measures. This problem is encountered during installation of building equipment such as heat pumps or building systems such as low-E windows. A program is needed to develop curriculum for two-year technical schools that can be used to train both energy conservation retrofit installers and personnel that will operate and maintain energy management systems and equipment.

Professional Fellowships. The objective of this project is to support graduate study in academic disciplines related to energy conservation and renewable energy sources and to influence career choices in fields related to DOE's conservation and renewable energy mission. A good example of the potential for this program is in the area of absorption heat pump technology. There are very few scientists with expertise and only three centers of excellence working in this vital area. A fellowship in absorption technology could encourage young scientists to explore this area, working either with national laboratories, private industry, or both. Although barrels of energy saved cannot be calculated for this program, the long-term benefits should be substantial. This program will raise the status of scientists working on energy efficiency research and develop a cadre of highly trained scientists committed to pursuing endeavors to increase knowledge about energy.

3.9 MANAGEMENT PROGRAM

GROUP PARTICIPANTS

Facilitator: Jerome LaMontagne

Jeff Christian
George Courville
Bill Currie
Art Rosenfeld
Walter Short

OVERVIEW

The Management Program provides analytical processes, facilities, and personnel to conduct the OBT program. It currently consists of three key activities: Evaluation and Planning, which compiles the data needed and prioritizes and evaluates program components; Facilities; and Program Direction, which supplies personnel to manage the sector programs. Evaluation and Planning identifies R&D needs and quantifies the contributions that can be made by energy efficient and renewable technologies within the buildings sector. Program results will be used to redirect projects to fill the needs identified for the buildings sector, will improve data quality and completeness, and will result in a program more likely to lead to accomplishment of long-range (year 2030) goals.

Table 17. Recommended FY 1993 Funding Plan for the Management Program. ($ Million)

Key Activities	N R I	FY 1993 Recommended Budget (Full cost)	Prioritization Vote	FY 1993 Recommended Budget (Restricted)
Evaluation and Planning	N	3.1	5.0	1.1
Facilities	N	1.5	NA	1.3
Program Direction	N	5.1	NA	4.3
TOTALS	--	9.7	-------	7.8

Key: N = Existing, R = Revised, I = Initiatives

DISCUSSION

The working group first discussed the planned FY 1991 activities. The group stressed the need for a strengthened Evaluation and Planning key activity.

The National Energy Strategy (NES) calls for significant increases in energy efficiency in all sectors. The Conservation and Renewable Energy (CE) Strategic Plan establishes the specific and ambitious goal of no increase in the amount of nonrenewable energy required for the buildings sector through

2030. It is the responsibility of OBT Management Program to define the level of resources necessary to achieve this goal and to ensure that these resources are applied in the most effective way possible. The Evaluation and Planning key activity provides the analytical foundation for the decisions necessary to achieve the CE objective. Evaluation and Planning identifies R&D needs, quantifies the contributions that can be made by energy-efficient and renewable technologies within the buildings sector, and defines the most effective approaches to ensure their acceptance. Program results will be used to redirect OBT projects, develop new activities to meet the needs identified in the National Energy Strategy, improve data quality and completeness, and define a program for buildings which will lead to the accomplishment of long-term national goals in the most efficient manner possible.

The consensus among the group was that the process and criteria provided for the prioritization were inappropriate for ranking Evaluation and Planning activities. The energy security, economic competitiveness, and other benefits achieved by the OBT program will be the result of activities undertaken by other program elements; benefits cannot be attributed directly to Evaluation and Planning. However, the degree to which the overall program succeeds in achieving national objectives is highly dependent on the quality of the planning and evaluation activities contributing to program design. Without a strong and effective evaluation and planning activity, there is little likelihood of an effective and successful OBT program. Elements of the Evaluation and Planning key activity are illustrated in Table 18.

The group decided that recommendations for Capital Equipment should originate with individual program areas—no prioritization attempted. There was some sympathy in the group for the general proposition that facilities and capital equipment funding should be increased. This area was also deemed a significant issue by all of the workshop participants and as such is discussed in Section 2.

The Program Direction activity provides funding for DOE Headquarters Staff; the group consensus that it was inappropriate to address this area. A brief description of the Evaluation and Planning key activity is provided next.

Evaluation and Planning

Activity Descriptions. The overall objective of the Evaluation and Planning key activity is to provide the information necessary to select the appropriate level and mix of activities which will achieve the national goals for energy efficiency and the use of renewable energy in buildings. Evaluation and Planning activities fall into four categories: 1) data collection and analytical tool development, 2) technology assessments, 3) analyses, and 4) management support and publications.

The outputs of the above activities are (or are incorporated in) strategic planning documents, program plans, operating plans, and budget submissions. These in turn shape the federal buildings program. Plans are reviewed and updated on an annual basis to account for changes in national priorities and to include information gained through the conduct of program activities. Areas receiving increased attention compared with past OBT planning and analysis activities are 1) expanded data collection and analysis activities to meet needs identified in the preparation of the National Energy Strategy; 2) increased renewable energy planning and analysis activities, and the integration of this effort with energy efficiency activities; and 3) greater attention to leveraging analysis activities with OBT program activities, other CE activities, and PE and EIA activities.

Table 18. Revised Evaluation and Planning Key Activity for the Management Program.

Evaluation and Planning
Data Collection and Analytical Tool Development
Data Collection Activities
Requirements Analysis
Renewable Energy Data and Analysis
Building Energy Compilation and Analysis (BECA)
Analytical Tools
Commercial Building Model
Residential Building Model
CE Spreadsheet Model
Technology Assessments
Analyses
Progress Toward OBT Goals
Building Portfolio Evaluation
Revised Estimates of Energy Savings from OBT Programs
OBT R&D Prioritization Exercise
CE Prioritization Exercise
Strategy Analyses
Strategic Value of Standards
Strategic Value of Incentives
Strategic Value of Information and Education Programs
Strategic Value of R&D
International Analyses
Planning and Support for OBT's International Activities
International Energy Studies
Environmental Analyses
Center for Clean Air Policy (CCAP)
Behavioral Analyses
Management Support and Publications
Analysis Integration
Strategic and Multiyear Plans
Annual Report on Analysis

Data Collection and Analytical Tool Development. This activity provides the foundation for conducting the analyses required to plan and direct the OBT program. Central to the activity is the conduct of a requirements analysis to identify and prioritize the key questions which OBT must address and to determine the data requirements and appropriate analytical approaches to address them. The requirements analysis will drive data collection, including data on renewable energy use in buildings, and the collection and evaluation of measured building energy performance data. Analytical Tool Development will include the upgrading of the residential and commercial building energy models and the revision of the buildings formulations in the CE Spreadsheet model, as well as the development of new analytical tools as appropriate.

Technology Assessments. These assessments seek out the scientific and technical breakthroughs that can transform the delivery of energy services in the buildings sectors. The activity provides support to program-level technology evaluations, and provides the technology characterizations used in program planning and R&D portfolio evaluation.

Analysis. The central focus of analysis within OBT is to monitor progress toward achieving the OBT goal of no increase in nonrenewable energy use in buildings, to evaluate the buildings portfolio of programs in the context of this progress and changing conditions, and to suggest modification of the portfolio where indicated. The activity also prioritizes the components of the R&D program and provides inputs to the CE prioritization exercise. The activity estimates the strategic value of policy options (standards, incentives, information and education, and R&D). Analyses of international trends in buildings energy use and technology and the impacts of changes in building energy use and technologies on the environment are also conducted to inform program planning and policy formulation.

Management Support and Publications. The analysis integration activity integrates the results of data collection and analyses performed by OBT and others, and uses the results in the preparation of the building sector's strategic and Multiyear Plans as well as in other activities such as preparation of OBT's contribution to the National Energy Strategy, reviews of proposed legislation, and responses to questions regarding the costs and benefits of policy options. The activity also provides an interface with other analytical groups both within and outside of DOE to ensure consistency and promote information transfer. Results of analyses and data development activities are presented in the *Annual Report of Analyses* to make this information available to others in government and industry.

APPENDICES

APPENDIX A: ATTENDANCE ROSTER

Name	Telephone/Facsimile
ORNL	
*Jeff Christian	(615) 574-5207/(615) 574-9338
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PNL	
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***John Rivera	(301) 588-9387/(301) 588-0854
SERI	
*Ren Anderson	(303) 231-1756/(303) 231-1331
*Walter Short	(303) 231-7721/(303) 231-1997
BNL	
John Andrews	(516) 282-7726/(516) 282-2359
*Jerome La Montagne	(516) 282-2831/(516) 282-2359
Roger McDonald	(516) 282-4130/(516) 282-2359
LBL	
*Joan Daisey	(415) 486-7491/(415) 486-6658
*Mark Levine	(415) 486-5238/FTS 451-6996
Art Rosenfeld	FTS 451-4834/FTS 451-5394
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Sandia	
John Finger	FTS 844-8089/FTS 844-3952
Argonne	
William Schertz	FTS 972-6230/FTS 972-4211
Los Alamos	
Don Neeper	FTS 843-3832/FTS 855-2137
Department of Energy	
Gary Moore	FTS 896-0515/FTS 896-9260

*Program Facilitator
**Host
***Cohost

APPENDIX B: AGENDA

TENTATIVE AGENDA
FIELD PROGRAM PLANNING WORKSHOP
BUILDINGS SECTOR

Building 3147 Conference Room
Oak Ridge National Laboratory

January 29, 1991

8:00 - 8:30	Coffee and rolls

Session I - Plenary

8:30 - 9:00	Introduction: purpose of workshop, agenda, and expected results. George Courville, Host
9:00 - 9:30	Office of Building Technologies: mission, objectives, strategies, and issues. John Rivera, Cohost
9:30 - 10:00	Discussion

Session II - Deliberations by Working Groups: funding, relative priorities, and new activities at key activity level

	Facilitator
Group 1 - Equipment	
Program 1 - Solar Technology	Ren Anderson
Program 2 - Heating and Cooling	Phil Fairchild
Program 3 - Lighting and Appliances	Mark Levine
Group 2 - Envelopes	
Program 1 - Materials and Structures	Jeff Christian
Program 2 - Indoor Air Quality	Joan Daisey
Program 3 - Building Systems Research	Mike Brambley
Group 3 - Analysis and Implementation	
Program 1 - FEMP	Bill Currie
Program 2 - Implementation and Deployment	Walter Short
Program 3 - Management	Jerome La Montagne

Schedule (Groups meet concurrently)

10:00 - 12:30	Program 1
12:30 - 1:30	Working Lunch
1:30 - 3:00	Program 2
3:00 - 4:30	Program 3
4:30 - 5:30	Preparation of summaries

TENTATIVE AGENDA
FIELD PROGRAM PLANNING WORKSHOP
BUILDINGS SECTOR

Building 3147 Conference Room
Oak Ridge National Laboratory

January 30, 1991

8:00 - 8:30	Coffee and rolls

Session III - Plenary

8:30 - 10:45	Presentation by Program Facilitators
10:45 - 11:00	Break
11:00 - 12:00	Discussion of Sector Initiatives and Issues
12:00 - 1:00	Working Lunch
1:00 - 2:00	Discussion of Sector Initiatives and Issues (continued)
2:00 - 2:15	Break

Session IV - Plenary

2:15 - 4:00	Preparation and Adoption of Sector Plan
4:00	Adjourn

January 31, 1991

Session V - Executive

9:00 - 11:00	Adoption of Workshop Report

END

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On January 29--31, 1991, 20 buildings research managers representing 8 national laboratories met in Oak Ridge, Tennessee, for the Buildings Sector Field Program Planning Workshop. The purpose of the Workshop was to provide the Office of Conservation and Renewable Energy (CE) with input from a coordinated field laboratory effort for the CE FY 1993 budget and planning process. Participants at the Buildings Sector Workshop reviewed the nine existing programs of the Office of Building Technology (OBT) at the key activity level and discussed a large number of initiatives that were new relative to the FY 1991 program. The 9 programs are as follows: Solar technologies; Materials and structures; Lighting and appliances; Heating and cooling equipment; Indoor air quality; Building systems; FEMP; Implementation and development; and Management. Participants did not suggest any changes in the number or names of OBT programs. However, modifications to incorporate new activities were suggested in all cases except for the Management Program.

Descriptors: *Buildings; *US DOE; Air Quality; Appliances; Building Materials; Cooling Systems; Coordinated Research Programs; Daylighting; Energy Conservation; Energy Consumption; Financing; Foundations; Heating Systems; Implementation; Indoor Air Pollution; Management; Materials; *Meetings; National Organizations; Planning; Roofs; Solar Energy; Solar Space Heating; Solar Water Heaters; Technology Assessment; Walls; Windows
Identifiers: EDB/320100; EDB/290500; EDB/291000; EDB/140900; NTISDE
Section Headings: 89B (Building Industry Technology--Architectural Design and Environmental Engineering); 70E (Administration and Management--Research Program Administration and Technology Transfer); 97GE (Energy--General)

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