A RESEARCH PLAN FOR COMMERCIAL SECTOR RETROFITS*

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ABSTRACT

A plan for a Retrofit Research program at the Department of Energy covering commercial buildings was developed in 1985. The purpose of the plan was to define whether a Federal role was justified for retrofit research and, if so, what work should the program cover.

Estimates developed as the program has progressed indicate that the technical potential for energy savings in commercial buildings from retrofit measures may be as high as 40% of total sector energy use. This implies a total potential savings of 5 Quads/yr or $30 Billion/yr. "Technical" potential means that simple payback periods are 10 years or less. However, savings for solar or other renewable energy retrofits are typically not included in the estimates. Achievable savings, which means that simple payback periods are 5 years or less, are estimated to be in the range of 20% of total use.

A national panel of experts on energy in buildings and building retrofits was assembled to develop a sense of whether a Federal role was justified and to formulate recommendations for the planned program. The panel stated that a Federal role would be beneficial if the research met the needs of users. The research recommendations of the panel formed a key part of the coverage of the resulting program.

Numerous potential research areas were considered and evaluated (over 40 from the panel alone). Many of these were dropped, but the plan has about 25 areas that were selected at a later planning meeting of representatives of DOE and several national laboratories as having medium to high priority. About 10 areas have high priority (ranked 9-10 on a scale of 1-10 by the panel or by DOE/Lab staff). With the limited Federal resources available, research is presently conducted in only 6 of these 10 areas. Standardization of procedures for evaluating the energy performance of retrofits is emerging as the most important area for the program.

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INTRODUCTION

The Building Energy Retrofit Research (BERR) program of the Department of Energy (DOE) was initiated to more directly conduct conservation research on existing buildings. (Past research tended to cover both new building design and existing building retrofit together). A planning effort was initiated in 1985 to develop multiyear plans for the research program. The plan was to define whether a Federal role was justified and, if so, what work should be performed that would not likely be performed by others (including the private sector and other governmental organizations). The output of the plan included justification for a Federal role, recommendations for areas of research the program should cover, and priorities for the research areas.

DOE decided to divide the BERR program research efforts according to building type - single-family, multifamily, and commercial. This paper discusses the multiyear plan and present program direction for commercial buildings. Sometimes a distinction is made between institutional buildings and other buildings in the commercial sector, but for this paper references to commercial buildings include both commercial and institutional buildings. A retrofit research panel of experts on energy use and building retrofits in commercial buildings was assembled to recommend what research the planned program should consider and to assist in the development of research priorities. This panel had participation from 11 national associations. Three association representatives provided written suggestions but did not attend panel meetings. The other eight association representatives provided suggestions and attended at least one of the two meetings of the panel. The 11 associations are:

- American Consulting Engineers Council
- American Institute of Architects
- Association of Physical Plant Administrators of Universities and Colleges
- American Society of Heating, Refrigerating, and Air Conditioning Engineers
- American Society of Hospital Engineers
- Electric Power Research Institute
- Federal Construction Council
- Gas Research Institute
- Institute of Real Estate Management
- Lighting Research Institute
- National Conference of States on Building Codes and Standards

The panel indicated that a Federal role was justified because there was no national focus for energy retrofits in existing buildings. One recommendation was that Federal research should address the needs of users. The panel had many recommendations regarding potentially useful Federal research. Based on the panel recommendations and later recommendations developed by representatives from DOE and several national laboratories, the research plan identified about 25 research areas that were considered medium to high priority. Numerous research areas were considered in arriving at these 25. The retrofit panel identified 44 areas overall and recommended 16 as having medium to high priority. In the present plan about 10 research areas can be considered high priority as a result of recommendations by the panel or by DOE and laboratory staff (ranked 9-10 on a scale of 1-10). However, with the limited Federal resources available, research is presently being conducted in only 6 areas. Special efforts are aimed at obtaining the best use of resources, and cost-sharing from other entities is sought on most major studies. The 6 research areas are:

- Developing an understanding of how to motivate building owners, users, operators, and design professionals to retrofit in the most energy efficient manner
- Conducting field studies of the energy performance of retrofits
- Developing standard procedures for conducting such field studies
- Improving the capabilities for retrofit design analysis, audit, and diagnostic tools
- Evaluating emerging and potential advanced technologies for developing improved instrumentation and controls equipment and techniques
- Developing and maintaining an information network on building retrofits available to all interested users

These research areas, presnt efforts to address the needs they represent, and the goals of the present program will be discussed in the section below on "Research Needs and the BERR Program."

BACKGROUND AND DISCUSSION

Some background information is presented to provide a perspective on the commercial sector and the potential energy savings for retrofits in commercial buildings.

Energy Use Data and Trends

Source energy consumption by the commercial sector is estimated to have been about 11.5 quads of source energy in 1985, or 15% of total U.S. consumption. For comparison, the residential sector is estimated to have been about 15 quads in 1985. The rate of growth in energy consumption has averaged 0.4% per year from 1974-1984 and projected to be 1.3% per year for 1985-1995 for the commercial sector, while the rate for the residential sectors has averaged -0.7% per year for 1974-1984 and projected to be 1.2% per year for 1985-1995. (EIA, 1986) Total annual expenditures for energy in the commercial sector are estimated to approach $70 Billion in 1985. (MacDonald, 1986) The total floor space in the commercial sector was about 50 Billion sq.ft. in 1983 (EIA, 1985), while total (heated) residential floor space was about 120 Billion sq.ft. (EIA, 1984)

Energy use per unit floor area was about 120 kBtu/sq.ft.-yr for site energy use and 230 kBtu/sq.ft.-yr for source energy for the commercial sector in 1985. (MacDonald, 1986) The comparable values for the residential sectors (for heated area only) are 70 and 120 kBtu/sq.ft.-yr in 1983 (derived from EIA, 1984 - source energy includes generation and transmission losses for electricity, while site energy does not). Electricity accounts for 40% of site energy consumption in the commercial sector in 1985 and is expected to grow to a share of 45-50% by 1995. (EIA, 1986) Electricity is expected to grow from 30% to a 35% share in the residential sectors from 1985-1995. (EIA, 1986) Commercial buildings are significant users of energy, and that energy use is about twice the residential use on a per sq.ft. basis.

High use of electricity that coincides with utility system peaks also makes commercial buildings of interest. However, my sense of the state of knowledge concerning the use of energy and the performance of conservation retrofits is that much more is known about the residential sector. Commercial buildings conservation research appears to present a significant challenge, and perhaps research on retrofits of existing commercial buildings should be emphasized more than it presently is.

An analysis of commercial sector energy use and costs was performed as part of the development of the research plan. This analysis indicated that from 1970-1985 site energy use per unit floor area decreased about 16%, while energy costs have risen 96% based on constant 1985 dollars per unit floor area. Source energy use per unit floor area appears to have increased slightly, probably due to increased use of electricity. Energy use per sq.ft. for the sector appears to be decreasing 1% for every 6% increase in real cost. One problem with these data is that the energy use per unit floor area is very sensitive to the floor area used in the calculation, and the information on commercial floor area is questionable. However, the ratio of 1/6 comparing energy reductions to cost increases is independent of floor area. This information provides some indication of the importance of understanding how energy is used in this sector and what motivations affect decisions to conserve energy or not.

Estimates of Savings Potential

Indications are that potential savings are in the range of 40%, though this does not reflect typical energy users' investment criteria. This estimate is refered to here as the "technical" potential energy savings and means that the simple payback periods for installation of retrofits is 10 years or less. A lower estimate for these savings is presented here that is based on a simple payback period of 5 years or less and refered to as "achievable" savings. Previous work at Oak Ridge (Kedl and Stovall, 1985) indicated that retrofits with a simple payback of less than 5 years could be combined into a package with a typical combined payback of 2-3 years, which is in the range of acceptability for many businesses. (Similarly, the combined or average payback period for a package of measures with less than a 10 year payback period is probably 4-5 years.) These payback criteria are not absolute but provide a simple way of picturing what the savings categories indicate. The trend of the potential energy savings estimates is the important point to consider, since any one estimate may be questionable but taken together they reinforce one another. Savings for solar or other renewable energy retrofits are typically not included in the estimates. A summary of estimated (and actual in some cases) technical and achievable potential savings from several sources is provided in Table I.

The OTA study (Office of Technology Assessment, 1982) indicates impressive potential savings, and this study is often cited regarding the potential energy savings in commercial and multifamily buildings. The NIBS estimates (National Institute of Building Sciences, 1983) cover only part of the commercial sector (the lack of data was cited as a factor affecting the incomplete coverage). The values in parentheses for the NIBS entry represent the study values divided by 0.54, which is my estimate of sector coverage for that study. (MacDonald, 1986) The SERI study (Solar Energy Research Institute, 1981) shows a somewhat lower estimate for retrofit savings potential. The percentage shown in Table I is derived from the SERI study based on 11.5 quads of consumption in 1985. The BECA-CR estimate is from data maintained at Lawrence Berkeley Laboratory. (Harris, 1986) The estimate based on data obtained from Servidyne, Inc. (Servidyne, 1986) is of most interest because it is based on studies and retrofit implementation for many commercial buildings. These estimates are based on dollar savings rather than energy savings, and Servidyne includes savings resulting from reduced maintanance costs as well as reduced energy operating costs. However, they are very useful because of the comparison they offer.

One problem with all these estimates is the uncertain treatment of operations and maintenance (O&M) improvements. It appears that some of the sources listed above do not include O&M savings. The BECA-CR data cover savings that substantially result from O&M changes. However, the retrofit research panel and the SERI study both stressed how important proper O&M was in reducing building energy use and maintaining energy savings from other retrofits over the years. BECA-CR findings indicate that almost no data exist on the performance of retrofits past the first year. Servidyne indicated that O&M was the cornerstone of their cost savings programs for commercial and

industrial customers, and one of the problems with O&M in buildings is that either there are no service personnel or the service personnel are forced to deal with so many other matters that no time is left for proper O&M planning.

The sources discussed above indicate that the "technical" conservation potential appears to be in the range of 35-40% of total energy use for the sector. The 40% value implies a potential savings of 5 quads/yr or $30 Billion/yr. However, the achievable savings are more realistic and appear to be in the range of 20% or slightly less. The 20% savings implies a total potential annual savings of perhaps $12-15 Billion in 1985 dollars or 2-2.5 quads. These significant potential savings, together with the low response to cost increases and the recommendations from the retrofit panel that a national focus on conservation in commercial buildings was needed, provided justification for a Federal role in this area.

RESEARCH NEEDS AND THE BERR PROGRAM

DOE conservation programs are aimed at reducing energy use, but with limited resources the BERR program cannot expect to pay for the commercial sector to achieve the conservation potential indicated above. The magnitude of potential savings is perhaps dwarfed by the magnitude of potential requirements for investment. If $15 Billion is to be saved with an average 2.5 year payback, it implies an investment of $37 Billion. The magnitude of these values is a good indicator that a Federal program will need significant help to make a difference.

Because of these limitations, the present program is trying to provide information about the performance of retrofits and to develop standardized procedures for evaluating retrofit performance. Retrofit performance information will serve to reduce uncertainties about expected savings. The standardized procedures will allow other organizations to perform technical field evaluations with hopefully comparable results. The program is pursuing methods to provide more detailed information than is available from utility billing data, and eventually we hope to limit the expense of obtaining this information. As more performance information is obtained, the need for more extensive data will be reduced. The goal is to achieve the potential savings that exists. A discussion of the research areas presented in the Introduction is given below.

The field studies of retrofit performance are aimed at providing performance information and experience in standardizing the procedures for obtaining the data. Research will be conducted on recommended methods for analyzing the types of data collected in these studies and recommending what data are essential. Initial efforts on standardization will also include recommendations for the minimum and extended data sets that should be collected for these field studies. The BERR program is presently developing the first set of guidelines or protocols on the data parameters to be measured in field studies of retrofit performance. Three documents are to be completed covering commercial, single-family, and multifamily buildings. Potential

future documents should cover other aspects of conducting field studies. The commercial program has a project in the planning stages that will study the performance of major retrofits installed by energy service companies in commercial facilities located in the Northeast in the 50,000-100,000 sq.ft. size range. This study offers the potential to improve methods for evaluating energy saved from such major retrofits. Several current projects are aimed at developing initial data for a "Shop Doctor" program, which focuses on performing an audit and installing measures in small buildings. The needs of small commercial buildings have received high priority because so few existing services are available to these buildings.

Improvements in design analysis, audit, and diagnostic tools are aimed at practitioners in the field. Improvements are sought so that retrofits may be evaluated more easily and reasonably. The retrofit panel thought this to be one of the most important areas to pursue. As this paper is being written, a contractor is being selected to study what improvements should be considered for available auditing techniques for commercial buildings.

Developing an understanding of the motivations of different groups in the commercial environment was also highly recommended by the panel, and recent indications are that this area is receiving significantly more attention now. The BERR program can only address this area in a very limited way, but it is important for understanding the type of information that is needed by different groups and how that information can be effectively transmitted.

Advanced technologies are of interest to DOE because they usually represent higher risk research. The areas of present interest to the BERR program in this area involve daylighting and building controls. Daylighting is receiving considerable attention in other programs, but some work appears needed to follow the total building energy effects from these retrofits. The computer revolution has changed controls significantly, and improving the capabilities of these systems and existing control components for buildings appears to be an area of significant potential savings.

An information network for disseminating the information developed in this program is important if the goal of providing this information to potential users is to be met. A national network for groups interested in commercial retrofits should be quite extensive, and maintaining that network is a challenge.

At present the BERR program on commercial buildings has only started work on selecting the first facilities for initial field studies. Work on the guideline covering the data to be collected in field studies is underway, and we hope to have a published document within a year. The field studies will examine the process of conducting this type of research as well as the individual procedures used. We hope to build on existing knowlege gained from the major monitoring activities in the Pacific Northwest and build on that information to develop procedures more specifically directed at evaluating

retrofit performance. The standardized procedures that are developed will allow comparison of studies from different organizations and will provide more consistent data on retrofit performance.

Developing and disseminating data on the performance of retrofits will be important in establishing credible expectations about energy savings from conservation investments. Available data indicate that many buildings still require significant improvements in energy performance, and supporting efforts to achieve such improvements is where the BERR program is headed. This means partnerships must be created among building researchers, owners, users, designers, operators, and energy suppliers to arrive at a point where building energy performance can be documented and the value of reducing energy use and costs can be better recognized. Given the projected growth in energy use in this sector and the historical ratio of site energy reduction to energy cost of only 1/6, conservation in commercial buildings should play an important role in energy planning efforts. We have just begun.

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Table I. Estimates of savings potential for the commercial sector.

Source	Technical (%)	Achievable (%)
OTA	55	22
NIBS	22(40)*	13(24)*
SERI	33	NA
BECA-CR	NA	20-25
SERVIDYNE	30-40	16-20

OTA - Office of Technology Assessment, 1982
NIBS - National Institute of Building Sciences, 1983
SERI - Solar Energy Research Institute, 1981
BECA-CR - data base maintained at Lawrence Berkeley Laboratory, Harris, 1986
SERVIDYNE - energy company in Atlanta, Servidyne, 1986

* Since the NIBS study did not cover the whole sector, values in parentheses are author's estimates of savings for the whole commercial sector

Note: Technical savings potential implies that retrofits have a simple payback period of 10 years or less.

Achievable savings potential implies that retrofits have a simple payback period of 5 years or less.