Chapter 1. An Overview

Most energy conservation literature begins with a variation on the standard litany: the days of cheap, readily available energy are over or are ending fast. Energy price increases, supply uncertainties, the vulnerability of U.S. (or Western) foreign policy to our reduced but still substantial oil imports, and the environmental consequences of energy production and use will all persist or worsen in the coming decades, rendering a business-as-usual path increasingly tenuous and costly. More recent books point out that these pressures have eased somewhat in the early 1980's due to the combined effects of worldwide recession and, apparently, some initial steps to improve energy efficiency.

However, we are told, this respite is only a temporary one. Over the long term, energy efficiency and the appropriate use of renewable resources offer an important strategic alternative to a future of continued reliance on conventional energy sources, with their attendant costs and risks.

All of these arguments are by now familiar. They are also essentially correct, and we feel no need to elaborate on them here. Our theme is a different one, but complementary: what have we learned, as practitioners, as policy-makers, and as consumers, about how to improve the energy efficiency of our homes and commercial buildings? From the evidence in this book, the answer is that we have learned a great deal in recent years but have also defined many new questions.

The evidence compiled here is distilled from over 2500 pages of material presented at the Second ACEEE Summer Study on Energy-Efficient Buildings, held in August 1982 at the University of California, Santa Cruz. The title of this book echoes the Summer Study's theme: documenting what works to save energy in buildings.

Attendance at the 1982 Summer Study was one indicator of the relevance of this subject. Despite the recession and the major budget cuts that had recently been imposed on both conservation research and programs, over 250 people joined in the week-long Summer Study. Those attending represented utilities, research centers, leading private practitioners, non-profit conservation groups, and government agencies at the local, state, and federal level. Collectively, their efforts represented over five person-years of thoughtful presentations, discussion, and lively debate. In Part One of this volume, we summarize key findings from the Summer Study. Part Two contains 35 selected papers that best represent the range of participants' contributions to the Summer Study theme: documenting what works.

Looking at the record of energy conservation in buildings over the past several years, one at first may be elated at the evidence of progress. There are now hundreds of well-documented cases (many of which are discussed in the chapters and selected papers) showing that conservation strategies can be effective--although not uniformly so. Moreover, we have seen: continuing innovation in both energy management techniques and delivery systems, a growing seriousness and professionalism in monitoring and evaluation efforts, and a policy climate that is finally beginning to not only support, but actually insist on well-documented results, rather than hypotheses or estimates about what works to save energy.

On the other hand, the failures and missed opportunities are disheartening. From our perspective, the worst "failures" are <u>not</u> simply programs or technical measures that produced less (or cost more) than expected, but those that were tried and abandoned without any attempt to learn from them or to help others avoid repeating the same mistakes. There are also failures in the sense of missed opportunities: failures to implement promising new technologies, to reach under-served populations and building subsectors, and to further optimize large existing programs such as Low-income Weatherization and Institutional Conservation Grants. These last two are examples of programs that are popular with constituents and Congress but are largely unexamined in terms of: their long-term, net contribution to cost-effective

energy savings, the range of results achieved, or the factors that have made some projects more successful than others.

These two conflicting views are both justified. The combination should not be surprising, if we look at buildings energy conservation as a field still in its adolescence--growing and maturing rapidly in some ways, but still tentative, experimental, and undeveloped in others. It is a frustrating stage, but also one full of promise. The halt in rapid growth of federal, state, and utility funding for conservation may actually have some long-term value, if the interim period is used to objectively evaluate past efforts and refine them for the next round. Eventually, the credibility of conservation as a long-term energy resource will require a "post-adolescent" approach to the design and management of efficient buildings.

The post-adolescent period will be characterized by a more consistent emphasis on empirical results, an ability to distinguish more important from less important questions, and a willingness to invest resources in serious, sustained efforts to get better answers. There will also be a broader tolerance for acknowledging failures--the essential first step in learning from them and avoiding their recurrence. Technical options as well as program strategies will become more complex and diversified, matching the inherent diversity of both physical features and occupancy characteristics in the buildings sector.

Finally, both the design and evaluation of energy conservation activities will begin to pay more attention to subtle and multi-dimensioned effects. We will redefine the criteria for "what works," moving beyond the single index of annual energy savings towards a broader concern with:

- o The mix of fuel types saved, including electrical peak demand as well as energy
- o The detailed timing of energy savings, especially in the case of electricity, where the value of each saved kWh (or kW of demand) is a sensitive, utility-specific function of season and time-of-use
- o The predictability and reliability of savings, both initially and over a period of years (Once again, these dimensions affect the value of saved energy in the context of long-term gas and electric utility resource planning.)
- o The distribution of energy savings, how equitably both benefits and costs of conservation are spread across relevant sub-populations
- o The positive and negative side-effects of saving energy, in terms of health and safety of building occupants, impacts on other costs of building construction and operation, and changes in the level of amenity, comfort, and occupant productivity

These last parameters, in particular, are useful in distinguishing the single dimension of energy consumption from the more complex but also more relevant concept of energy efficiency: a relationship between energy, as an input, and an array of "building services," the desired outputs.

This is all an image of what lies ahead for the field of buildings energy conservation. Where are we now, what have we learned about "what works," and what are the important gaps that remain? A condensed, highly selective list might include the following items:

(1) Residential retrofits are increasingly well-documented, at least for shell measures to reduce heating energy use in single-family houses. We are also beginning to document the cost-effectiveness of heating system modifications for both single-family and multifamily buildings, but can still only speculate on (or simulate) the optimal combination of shell and system measures for various structures and climates. More extensive retrofits, and those involving energy use other than for space heating, are not well explored. These measures will become increasingly important as conventional insulation and glazing treatments saturate the market, yet energy bills continue to rise.

(2) For new residential construction, "super-insulation" and passive solar techniques are increasingly refined and well-documented, especially in cold climates. For mild climates and those dominated by sensible or latent cooling loads, there is far less sophistication in optimum residential design and construction techniques.

(3) Residential appliance technologies have advanced significantly, but more at the laboratory and prototype stages than in the marketplace. There is still a wide range of efficiency among appliances available to consumers; those least informed or least able to pay (tenants, low-income households, public housing occupants) are often stuck with the least efficient models. Little attention has been paid to improved maintenance or energy-saving retrofits of existing residential equipment, although some types have useful lifetimes of 10 to 15 years or more.

(4) In the non-residential sector, considerable attention is paid to the engineering of large air-conditioning and ventilation systems, but there are many examples of other equipment types, especially "package" units, with energy performance far below a cost-effective optimum.

(5) In general, there are more unknowns in non-residential energy conservation than in the residential sector. Reasons for this include ownership patterns among non-residential buildings, a reluctance to share "proprietary" data on energy performance, the diversity of the stock, and, at least for larger buildings (representing about half the floorspace), the scale and complexity of energy systems and usage patterns.

(6) The persistence of energy savings over a multi-year period is still largely a matter of conjecture rather than observed data, even though the useful lifetime of measures (or the stability of improved energy management practices) are often as crucial to cost-effectiveness as the first-year savings. The difficulty here is that observing savings over several years requires both sustained interest and stability of research funding, both of which are rare.

(7) In principle, efforts to improve the cost-effectiveness of conservation should be as concerned with reductions on the cost side of the equation as with increases in energy savings. In practice, however, the emphasis is placed most often on optimizing energy savings. More attention is needed to methods of reducing costs--while maintaining or improving the quality--of retrofit hardware, energy management practices, "delivery systems" such as energy audits, and, of course, monitoring and evaluation.

(8) Since 1980, an explicit aim of the ACEEE Summer Studies has been to develop stronger ties between behavioral and engineering approaches to energy conservation. There has been progress, but much ground remains to be covered. As we discuss in Chapter 3, more interaction between these disciplines promises to enrich conservation research and offer new insights to program design and management. However, this interaction will require deliberate effort on both sides.

(9) Better feedback mechanisms are needed to assure that the results of research, field measurement, and evaluation are in fact made more accessible to designers, builders, facility operators, and conservation program staffs, in a language they understand and a format they can readily use. In most cases these feedback channels will not be created spontaneously; the "market pressures" are not strong enough. Feedback will have to be carefully nurtured as an element of conservation policy, at least until it has become accepted professional practice for architects, engineers, and energy auditors to assume responsibility for following up with some percentage of their clients to determine whether predicted energy savings were in fact achieved.

In the pages that follow, we elaborate on these points and others. First, a note on the organization of the book. The topics used in Part One as chapter and sub-chapter headings are repeated in Part Two, as organizing categories for the 35 selected Summer Study papers. The Appendices which follow the selected papers contain: a complete listing (by topic) of all Summer Study papers, abstracts of the papers not included in this volume, a keyword index, and an author index. Throughout the chapters in Part One, text references to Summer Study papers include only the lead-author's name, in parentheses. Text references to sources other than Summer Study papers show both the author's name and publication date in parentheses. A list of these outside references is included in end-notes to each chapter.