Chapter 1

Introduction

Buildings account for 40 percent of U.S. energy use. A strong interest in energy conservation is motivated by concerns over climate change, pollution, energy costs, and reliance on fossil fuels.

Energy audits and improvements are being driven by an increasing number of bold goals to reduce energy use and carbon emissions. The widely recognized Architecture 2030 program has set a goal of reducing energy use in existing buildings by 50 percent. The federal government has had a goal of reducing energy intensity in federal buildings by 3 percent per year. States are also setting energy reduction goals. For example, New York State has set a goal to reduce greenhouse gas emissions by 80 percent by the year 2050.

An *energy audit*, also called an *energy assessment*, is an evaluation of a building's energy systems in order to identify opportunities for reducing energy. *Energy improvements* form the implementation of the work, actually reducing energy by making changes in buildings. By addressing both energy audits and improvements in one book, we seek to take the recommendations of energy audits and translate them into reality. We seek to transform our buildings.

This Book's Focus

The book's focus is how to reduce energy use in existing commercial buildings, including such buildings as offices, hospitals, multifamily dwellings, schools, universities, hotels, retail, religious, not-for-profit, institutional buildings, and more.

The book covers a broad variety of commercial building types, including both larger and smaller buildings (Figure 1.1), for all climates. This scope is intentional. Historically, energy audits for larger buildings have primarily been performed by engineers, and the focus has been on heating, cooling, lighting, and controls, while the building envelope (insulation, windows and doors, infiltration) has not received sufficient attention. However, audits for smaller buildings have largely been done by non-engineer energy auditors, with a strong focus on building envelope, and less attention directed to heating, cooling, lighting, and controls. This book is intended to bring the strengths of larger-building energy audits to smaller building energy audits, and vice versa.

The book goes beyond *energy audits* to also cover *energy improvements*—in other words, the installation of energy conservation improvements in order to deliver substantial and persistent energy savings—addressing such topics as project management, quality control, financing, and operation and maintenance. It also covers *portfolio programs*, in which government agencies, utilities, or owners of building portfolios seek to plan and implement energy improvements across multiple buildings.

Throughout, we maintain an interest in what we might call *transformational energy improvements*. We are interested in energy improvements that transform our buildings, which measurably reduce energy use, and which bring our aging building stock up to current standards of energy use, comfort, health, and safety.

Figure 1.1 Commercial buildings comprise a wide variety of building types.

Figure 1.2 Effective energy work requires not only good energy audits but effective energy improvements—the actual changes that can transform a building.

The book is intended for energy auditors, energy managers, energy engineers, building performance contractors, and students in these fields. The book may also be of use to energy policymakers and utility demand-side management professionals.

We frequently address both the energy auditor and the energy manager in the book. These two individuals can form a powerful team to address energy problems. The energy auditor brings a knowledge of many buildings, of best practices, of specialty topics like energy modeling, and more. The energy manager brings in-depth knowledge of their own building. The energy auditor brings specialty tools for diagnosing energy problems. The energy manager has the ability to take measurements in their buildings over time. The energy auditor might not include an inventory of every refrigerator in a 500-unit apartment complex, but such an inventory may already be maintained by an energy manager, or may be of interest to an energy manager, and will lead to a far better assessment of the potential for refrigerator replacements. The complementary skills and abilities of the energy auditor and the energy manager can be most effectively put to use through collaboration. This book, therefore, does not stop only at the information sought in a typical energy audit, but rather suggests deeper investigations to understand and reduce energy use in buildings.

The book is improvement-centric. We focus our attention on energy improvements. In much energy work, the excitement about new products and what we are proposing to evaluate and recommend for a building leads us to focus our attention extensively on the "thing that we want to install." In the process, we can make the mistake of paying too little attention to "the thing that is already installed," in other words, the baseline against which energy savings will be measured. If our evaluation of the baseline is inadequate, we run the risk of overestimating savings, if we assume, for example, that the baseline is worse than it really is. Conversely, if we assume that the baseline is better than it really is, we may underestimate potential savings, and prematurely rule out a good energy improvement. The baseline is fully as important, in estimating savings, as the new product about which we might be so enthusiastic. In this book, we try to direct equal attention to the baseline, to establishing what a building already is and has in it, and how each component of the building uses energy. We try to provide authoritative sources that will support energy calculations for these existing components, whether it is the average spray duration of a prerinse spray valve in a commercial kitchen, or how to estimate the efficiency of a 40-year-old chiller.

The book seeks to provide a broad set of solutions to the problem of building-related climate emissions, by offering technical and programmatic guidance to reduce energy use in buildings to as low as net-zero. Climate change has become the most pressing environmental challenge facing society. The book has as its goal to be an

evidence-based reference for energy conservation and associated climate emissions reductions in the building sector.

The book is based on fundamentals of building science, along with practical discussions of energy improvements, to broadly cover the emerging field of building performance as it relates to existing commercial buildings. It seeks to help energy auditors and energy managers deliver measurable savings for purposes of mitigating climate change impacts of buildings, reducing energy costs, and achieving related goals such as improved indoor comfort, human health, and air quality.

In seeking to support high-quality fieldwork to establish baseline energy conditions, we try to provide a comprehensive field guide for examining buildings and their energy components. An early chapter serves as a general field guide, and then detailed field guidance is integrated throughout the book on how to examine buildings and energy components of buildings. There is value to good fieldwork for energy audits. Extra effort in the field, rolling up our sleeves in buildings, will pay off with more improvements, better quality assumptions and measurements, and deeper and more accurate savings.

Seeing in Buildings

Energy work starts with knowing what we are seeing in buildings. We must learn to identify building components and energy-consuming equipment. We then need to move expeditiously beyond just recognizing these elements to understanding how much energy they might be using, and then, further, to identifying possible energy savings opportunities. As such, our end goal is not only to know what we are seeing, but a new kind of seeing, one that sees deeply, and sees the potential for transformational energy savings in buildings.

This book has photographs of real buildings and real energy components in real buildings: lighting, heating, insulation, windows, appliances, and more. We believe that it is important to recognize what we are seeing in a building, in the building's real state. It is important to be able to see through the rust, dirt, and deterioration, in order to assess the energy use of what is already there (Figure 1.4). We do not attempt to provide shiny photographs of buildings and new equipment. To the contrary, we seek to highlight the deficiencies that contribute to energy inefficiency, and that contain the potential for saving energy. We need to be able to distinguish between real energy inefficiencies and perceived energy inefficiencies. Sometimes, dirt and rust are covering perfectly good energy systems. Saving energy is our goal, and we seek to do it by understanding existing buildings and real energy components, along with what might replace deficient components, and so deliver energy savings.

Goals of Energy Improvements

What are the goals of energy improvements? There are many. Environmental goals include reduced carbon emissions, reduced reliance on depletable fossil fuels, and reduced pollution due to extraction and use of these fuels. Financial and economic goals include reduced energy costs, increased property value, and economic development. Political goals include reduced dependence on foreign fuels, reduced conflict over fuels, and reduced strain on electric power grids. Health and comfort goals include improved human health due to reduced pollution, improved indoor air quality, and improved comfort due to reduced drafts, glare, cold and hot indoor spaces, and light pollution.

Goals are often harmonized—when we save energy, we achieve multiple goals. But sometimes priorities are different for different individuals and organizations, or

Figure 1.3 Understanding what we see leads to better energy improvements.

Figure 1.4 Real energy systems of real buildings.

even individuals within one organization. In one building, the owner may first want to save energy, but the chief financial officer (CFO) may first want to save costs, while the facility manager may first want to reduce comfort complaints, and the occupants may first want a bright and healthy work environment. Recognizing different priorities, and sometimes different goals, and jointly navigating through these differences is an important part of energy work.

There are many potential pitfalls along the way, risks that cause energy savings to not be delivered, to be eroded before they are delivered. Knowing these risks helps us to prevent them. Erosion of potential energy savings occurs when energy auditors miss identifying or evaluating good energy improvements; when energy auditors overestimate savings; when owners decide not to implement good energy improvements; when contractors install inferior products or do not complete a job properly; when commissioning of improvements does not happen, for example, when controls are not properly set; and when equipment is not operated correctly or maintained.

The main goal of the energy auditor is to evaluate and prioritize energy improvements. The main goal of the energy manager is to deliver energy savings. Between the two, the potential arises to entirely transform our buildings.