Energy Audit Manual for Use in the Operation of Buildings

Table of Contents

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Foreword

As developing countries become industrialized and their populations grow, the need for increasing amounts of energy is placing a heavy burden on energy−supply systems. The migration of workers from rural to urban areas creates a demand for housing and transport in cities, resulting in increased fuel consumption − especially of petroleum−based fuels. Hence, there is an urgent need for maximum conservation of existing energy supplies and maximum efficiency in their use. Energy conservation is a means by which the demand for energy can be significantly reduced without causing discomfort or diminishing the quality of life. It is estimated that approximately 15 per cent of energy per unit of output can be saved, with a correspondingly lowered level of expenditure, through sound energy−management practices. In fact, countries that have developed energy−conservation programmes have reported savings of up to 25 per cent per unit of output.

Energy auditing is an integral part of any energy−management programme and an essential step in the process of energy−conservation, since it facilitates the optimum use of available energy resources. It can be a valuable tool in developing countries where emphasis is being placed on reducing consumption of commercial and non−commercial energy through energy−conservation measures. Some governments of developing countries have already adopted energy−conservation measures but not always in accordance with a systematic national policy on energy conservation which would bring benefits through (a) a reduction of the load on overall energy−supply systems; (b) an increase in time available to develop new indigenous energy sources; (c) a reduction of foreign−exchange demand; and (d) a reduction in overall costs of operating human settlements.

With the purpose of examining the various aspects of energy conservation and energy management, the United Nations Centre for Human Settlements (Habitat) and the Regional Centre for Energy, Heat and Mass Transfer for Asia and the Pacific convened a Workshop on Energy Auditing in Human Settlements in Madras, India, in 1987. The Workshop noted that, in developing countries, per capita energy consumption is on the increase and that energy consumption in residential, commercial and public buildings constitutes a significant portion of total energy consumption in urban areas, thus justifying the implementation of energy−conservation measures. It concluded that there was scope for initiating energy−auditing procedures which would lead to energy conservation in these sectors and recommended, inter alia, the development of national and local−level energy−audit manuals, both for the user and the auditor, applying, with suitable modifications where necessary, the experience already gained by developed countries in the field.

This manual has been prepared in response to the recommendations of the Workshop. It is a local−level energy−audit manual and is addressed primarily to houseowners and managers of small, medium and large buildings in the public and private sectors. It deals with a practical methodology for reducing energy use in buildings and provides information on energy−auditing procedures in a non−technical manner. Application of the principles given in the manual will enable users to evaluate energy−use patterns and carry out energy−saving programmes at minimum cost, while helping national efforts at energy conservation. The manual should, therefore, be useful to policy−makers and planners concerned with the energy sector in the developing countries.

I wish to acknowledge the contribution of Mr. R. Walterson to the work of UNCHS (Habitat) in the preparation of this publication.

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Introduction

A. Background

In developing countries, about 40 per cent of operational expenditure is estimated to be incurred in human settlements, and costs for supplying energy accounts for a significant portion of this expenditure. These costs place a severe strain on the national economy of almost all developing countries: hence, there is an urgent need for initiating sound energy management. This calls for innovative approaches to management aimed at energy conservation. Energy users need to be convinced of the financial benefits they can derive through energy management: it is often not realized that resources spent on conserving energy and on reducing energy waste are sound investments and that there are several measures which can be undertaken at minimal costs. This manual presents some of these measures.

The manual is addressed primarily to houseowners and managers and operators of small, medium and large buildings in the private and public sectors. It has, therefore, been written in a non–technical manner suitable for laymen who might not be very conversant with the field of energy technology but who could, nevertheless, benefit by following the methods and measures contained herein. This manual does not deal with renewable sources of energy, such as solar radiation and wind, nor with computerized management systems, in which the technology is developing rapidly.

Interspersed throughout the various sections of this manual are examples of possible savings that can be made by changing operating and maintenance procedures and, in many cases, by installing energy–efficient equipment. It should, however, be borne in mind that each building is unique. Its location in relation to prevailing winds, the number of its windows and many other factors influence how a building can be made energy–efficient. Implementing the ideas and suggestions presented in this manual will provide energy savings for most buildings, although the savings might not be the same as those cited in the examples.

B. Purpose of the manual

This manual provides information on energy management both for houseowners and for building managers. It is designed to be used in the analysis of energy–consumption patterns of buildings, large, medium or small. It is not intended to be used in the design and construction of new buildings. The methods used are relevant to hot or cold climates, in developed or developing countries. Climatic differences will generally affect only the total amount of energy used and change the mix of fuel types consumed.

The manual assembles recent information on energy management and presents it in a non–technical manner that is understandable to building operators and houseowners who cannot consult in–house engineers or energy specialists. It proposes many no–cost and low–cost methods for reducing energy consumption. Procedures and techniques to eliminate energy waste and to reduce energy use, especially in large buildings such as hospitals, hotels and multistorey office buildings, are proposed.

The first part of the manual – the Energy Audit Manual – is, as the name implies, devoted to the energy audit or survey. A first step in undertaking an energy–management programme is to identify energy–consumption patterns, to determine: (a) where energy is used; (b) how energy is used; (c) what forms of energy are used; (d) how much energy is used; and (e) when energy is used. The energy audit will present an accurate picture of the premises' energy profile. The second part of the manual – the Energy Management Manual – provides suggestions and examples of possible savings. It has been broken down into three categories needed to develop an energy–management programme: (a) management; (b) operating procedures; and (c) maintenance procedures.

C. Measuring the results of energy conservation

Before changes are carried out to improve the energy performance of a building or group of buildings, it is essential to have a starting point from which to evaluate the effect of proposed changes. The energy audit provides this starting point. The auditor selects a base year and measures that year's performance of energy−consuming units and corresponding financial cost. Then, the current year and future years are measured in an identical manner and compared with both the performance of the base year and the previous year. In this way, the owner/operator can evaluate, both in energy units and financial terms, the effects of a conservation programme, procedural changes required and the impact of the project on energy consumption. The historical energy audit is used to measure the overall energy performance of the complete building, whilst the diagnostic audit analysis is used to measure the energy−consumption pattern of energy−consuming equipment within the building, such as boilers, cookers and lifts. After completing the energy audit, the auditor should turn to the Energy Management Manual which proposes changes that can be made to energy−consumption patterns so that energy is used efficiently.

D. Strategy for applying energy−conservation methodology

Generally speaking, the overall strategy for applying energy−conservation methodology in human settlements is to identify and eliminate wasteful practices, then look for ways of reducing energy consumption in items of energy−using equipment. The following gives a step−by−step strategic approach for achieving energy conservation. Although the approach generally applies to large buildings, individual houseowners can still make use of the same general approach to achieve reduced energy consumption in their premises.

1. Commitment

Top−level commitment to start an energy−conservation programme should first be obtained. Without the owner's or building manager's involvement and commitment, the programme will have a poor chance of success.

2. Energy uses and losses survey

In order to provide a trend in the use of energy in a building, a base year for the historical energy audit should first be established, and then a current historical energy audit should be carried out. A first survey, aimed at identifying energy wastage that can be corrected by maintenance or management attention, should be conducted. Another survey, to determine where additional instruments for measurement of energy flow are needed and whether there is economic justification for the cost of their application, should then be carried out. An energy balance (diagnostic) on each item of energy−using equipment, such as a boiler, a stove or a water heater, should be developed to determine energy−efficiency.

3. Setting targets

Once the survey is complete, the findings should be reviewed, and consultations with the building manager or operator undertaken. Potential energy savings should be estimated, and reduction−targets for the first year set. Experience shows that it is possible to achieve a 10 to 15 per cent reduction in the first year of an energy−conservation programme. Further examination of energy−conservation options will show additional potential that will require, most likely, investments in energy−saving projects that will have large payback periods. It is advisable to establish a five−year target and measure, historically, each year's progress towards that goal. Each year's savings will become the justification and support for an ongoing programme and future investment.

4. Corrective actions to save energy

Energy wastage should be eliminated or reduced, and energy−conservation projects that evolve from the surveys should be listed. Projects for implementation should be evaluated and selected, starting with projects having the shortest payback period.

5. Continuing energy conservation efforts

The energy audit should be continued on a regular basis, and corrective action should be taken when unit energy−use deteriorates. It is important to report progress towards an established goal on a yearly basis.

Part one – Energy Audit Manual

I. Introduction to energy audit

An energy audit, sometimes referred to as an energy survey or an energy inventory, is an examination of the total energy used in a particular property. The analysis is designed to provide a relatively quick and simple method of determining not only how much energy is being consumed but where and when. The energy audit will identify deficiencies in operating procedures and in physical facilities. Once these deficiencies have been identified, it will be apparent where to concentrate efforts in order to save energy. The energy audit is the beginning of and the basis for an effective energy–management programme.

Human settlements encompass a variety of buildings. Regardless of the building involved, the audit procedure is basically the same. If more than one facility is involved (as in the case of apartment buildings), an audit of each will be necessary.

No two buildings are identical regarding energy usage. This is due to the possible variables affecting the buildings, e.g., occupancy rates, the building's size and orientation, its geographic location, the type of heating and cooling systems, the amount and types of equipment in use, the type of construction, the level of insulation and so on. Because each building is unique, it is difficult to generalize about energy–consumption patterns, and so it is necessary to conduct an energy audit for each building. Most buildings were probably designed, built and equipped when cheap energy was readily available. Little attention was paid to energy efficiency. Consequently, there is a great potential for improving operating costs of existing buildings.

The chapters that follow explain the procedures and computations necessary to understand all phases of energy consumption. The data compiled will be suitable for use in both manual and computer–assisted energy audits. The emphasis is on the do–it–yourself approach, and the worksheets have been designed accordingly.

Conducting the energy audit

In order to audit energy consumption, several steps are necessary. The basic procedures to be followed are:

(a) The historical audit summarizes all types and amounts of energy used in the past. Data should be compiled and analysed on the totals of both energy consumption and costs. This analysis, then, becomes the base with which future energy use will be compared.

(b) The diagnostic audit is carried out to identify the users of energy and to discover any deficiencies in operating and maintenance procedures as well as in physical facilities. This part of the audit is usually done in two parts: an equipment survey and a building survey.