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ENERGY CONSERVATION AND BUILDING REGULATIONS

by H.B. Dickens and A.G. Wilson

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5.1 ENERGY CONSERVATION AND BUILDING REGULATIONS

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ABSTRACT.- The implications of including energy conservation as an additional major objective of building codes are considered in relation to the traditional concern of codes with the safety and health aspects of buildings. Mention is made of alternative or complementary forms of regulation utilizing fiscal measures or rationing but it is noted that these could substantially complicate enforcement by necessitating their own special control process. This is cited as a compelling reason for using the traditional building regulatory approaches. The status of USA and Canadian activities with respect to the development of regulations to control energy use in buildings is reviewed with the particular reference to ASHRAE Standard 90-75 and the National Building Code of Canada. The relative merits of prescriptive and performance approaches are discussed with emphasis on the problems of application and enforcement. Reference is made to the technical problems that can arise from retrofitting of existing buildings to conserve energy which could lead to higher maintenance costs and unsafe conditions.

SOMMAIRE. - Les implications d'inclure la conservation de l'énergie comme un autre objectif principal des codes du bâtiment sont étudiées en rapport avec l'intérêt traditionnel des codes - les aspects de sécurité et de salubrité dans les bâtiments. Il est fait mention d'alternatives ou des formes complémentaires de règlement en utilisant des mesures fiscales ou de rationnement mais il est noté que celles-ci pourraient compliquées substantiellement l'application en nécessitant leur propre méthode particulière de contrôle. Ce qui précède explique la raison pour laquelle on insiste sur l'obligation d'utiliser les approches traditionnelles de règlementation du bâtiment. L'état des activités des Etats-Unis et du Canada à l'égard du développement des prescriptions pour contrôler l'utilisation de l'énergie dans les bâtiments est revisé en référant particulièrement à la Norme ASHRAE 90-75 et au Code national du bâtiment du Canada. Le bien fondé relatif des approches basées sur des prescriptions et sur la tenue en service sont discutés en insistant sur les problèmes d'application et de mise en vigueur. On réfère également aux problèmes techniques qui peuvent survenir lors de la modification de bâtiments existants en vue de la conservation de l'énergie qui peut mener à des coûts plus élevés d'entretien et des conditions dangereuses.

INTRODUCTION

Increasing world price of petroleum and limitations of domestic reserves relative to demand have focused attention in Canada and the USA on the need to conserve non-renewable energy resources or, more specifically, to reduce energy waste. Reduction of such waste is regarded as the most cost-effective of various steps being taken to reduce dependency on foreign supplies and to provide the time required to develop alternate renewable sources of energy. As 1/4 to 1/3 of prime energy consumed in Canada is associated with the operation of buildings, this is one of the areas receiving much attention relative to energy conservation.

Those responsible for energy-use policies have concluded that some form of positive influence, beyond normal market forces, is necessary to improve the energy-use efficiency of buildings. Price of petroleum is already subject to regulatory forces but this mechanism is not of itself sufficient to ensure that the design and operation of buildings will be adequate with respect to energy conservation. Attention is being given, therefore, to other mechanisms for reducing energy use in buildings, including regulation of design and construction through building codes.

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Buildings are quite different from most consumer products in relation to the way in which they are produced, marketed, and used. Buildings in general have a much longer life cycle than other man-made products. They may be used by more than one generation. They are generally fixed to one location. They are very often owned or used by people who had no choice in committing the original design or purchase. They cannot be readily discarded if they are less than satisfactory. Society, therefore, has an interest in buildings that transcends the individual. The design of a building may commit the energy required for its operation for a long term. This may be of some concern to an individual owner but it should be of greater significance to society as a whole. Measures to promote energy conservation in buildings are therefore not to protect the consumer in the normal sense, but rather for conserving an essential but dwindling resource for the broader welfare of society. In our type of society such control has usually been limited to times of national emergency when extraordinary measures are considered necessary and where it is assumed that the duration of control would be relatively short. Such regulation is normally exercised by a central authority through control of distribution (to whom and how much).

In considering building codes as a vehicle for regulation there is an implicit assumption that the provisions will be developed by some process of consensus, that they will evolve as a result of the interaction of various societal forces, and that they will be of indefinite duration. This is the general philosophy that lies behind the development of the National Building Code of Canada which now forms the basis for practically all building regulations in effect in Canada. It is also well to recognize that traditionally building codes have been concerned with the regulation of buildings primarily in the interest of safety and health. This has been the basis of most of the regulations developed for consumer products as well. In recent years there have been demands for more protection for the consumer in relation to quality of manufactured products, but such protection has not yet been a principal factor in the development of building regulations. There is, in principle, no obvious requirement that control of energy use in buildings should be exercised through the mechanisms currently used to regulate the design and construction of buildings from the standpoint of safety and health. There is however a compelling pragmatic reason for employing traditional building regulatory authorities for this purpose - namely, that they are now providing an effective regulatory medium and thus additional administrative organizations for this purpose may be difficult to justify.

Alternative or complementary forms of regulation can, of course, be envisaged, comprising financial incentives. For example, tax advantages or subsidies could be used to encourage capital investment in building design or components that reduce demand on non-renewable sources. Penalties for consumption beyond an established energy budget have also been proposed. Although such measures are attractive from the standpoint of encouraging good operating practices and increasing the probability of achieving desired efficiency in energy utilization they add substantially to the complication of control. They would require a budget and penalty system, a mechanism and techniques for obtaining verified records of consumption under carefully specified conditions and an associated control process and accompanying bureaucracy. This approach can be applied where specific energy use targets are laid down, as in the case of the federal government's "in-house" program currently calling for zero over all growth in energy use after an initial reduction of 10%. It is also applicable where design of new buildings and operation of existing ones are under the control of a single owner, as in the public sector. It is not evident, however, that such an approach is appropriate at this time for national application. As a minimum it would seem prudent at this stage to develop acceptable procedures for establishing normalized energy-use figures for existing buildings and to ensure that new buildings incorporate means for determining actual annual energy use.

In considering methods of control it will be useful to examine the status of current efforts to regulate energy use in buildings in both the USA and Canada and to consider the nature of standards developed for this purpose both from the standpoint of what is desirable in principle and what is suitable for effective application.

USA ACTIVITIES

With reference to the USA situation the Federal Government is actively seeking to establish legislation by which it can encourage the preparation and adoption of energy conservation standards for buildings but it is at the State level that the most direct activity is taking place. A report published in March 1976 by the Center for Building Technology of the National Bureau of Standards indicated that States with authority to control energy use through regulation of the design and construction of new buildings at that time covered 54% of the United States population. The report noted that although local governments could regulate building energy conservation in the absence of State authority, few local governments had chosen to do so. State authority has been legislated through either Statewide Building Codes or through Acts dealing only with building energy conservation. In Statewide Building Code Acts, authority may be granted specifically through working in the Act or by administrative interpretation of the health, safety and welfare clauses of the Act. The report indicated that only three States had energy authority separate from the Building Code Act and noted that most States without a Statewide Building Code find it difficult to justify and establish an additional administrative organization to regulate energy in new building, design and construction.

Several States have also made use of financial incentives to encourage energy saving measures in buildings. These take the form of tax exemptions, subsidies and low interest loans for energy-conserving activities and include solar energy and thermal insulation bills introduced in State legislatures which call for sales or property tax exemptions or lower assessments for reductions in the use of fossil fuels. At the Federal level the proposed energy conservation Act would require the adoption of energy conservation standards for buildings by all communities wishing to avail themselves of federal funds for new residential and commercial construction.

ASHRAE STANDARD 90-75

The development of appropriate energy conservation regulations for adoption under the State enabling legislation has proved difficult and has given rise to considerable controversy. Much of this controversy has centred around the Standard produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers known as ASHRAE 90-75 and entitled "Energy Conservation in New Buildings." The National Bureau of Standards developed the technical base for this document which was then turned over to ASHRAE for processing as a consensus standard. The document was issued as a formal ASHRAE standard in August 1975 following many thousands of man-hours of work by ASHRAE members and three extensive reviews. It covers all types of buildings and is the only comprehensive standard on energy conservation developed to date. Its first nine sections are prescriptive in nature and cover the building envelope, heating, ventilating and air-conditioning systems and equipment, water heating, electrical distribution and lighting. Section 10 is performance oriented and allows the designer to consider alternative building systems and equipment design providing they do not exceed the total energy consumption derived by applying the first 9 sections. Thus it is basically a prescriptive standard with some performance options.

Because it specified limited U-values for components of the enclosure, shading coefficients for glazing, and illumination levels for the lighting subsystems, Standard 90-75 has been classified as a component-performance standard. The heating, ventilating, air-conditioning and elecrical systems are called up either in prescriptive terms or as guidelines; minimum performance levels are given for certain individual equipment components. One of the concerns about such an approach is whether the requirements for the components and subsystems are always rational in terms of optimizing over all building performance, and whether they are unduly restrictive. The ideal objective is to permit flexibility of design in relation to functions and yet protect the public interest in relation to energy use.

ASHRAE Standard 90-75 attempts to overcome the criticism of inflexibility by offering the option of any alternative building design that can be shown by computation to have no higher annual energy consumption than a similar one designed to meet the component-performance requirements. In effect it permits the establishment of a maximum annual energy consumption figure based on the component performance requirements. This feature is an innovative approach to standards writing, but one could question whether the component performance and prescriptive requirements of the Standard necessarily offer the best basis for establishing a realistic energy budget. At the same time the standard has been subjected to broad public review and one must assume that the requirements represent a consensus view of current acceptable practice and hence a compromise between what is technologically possible and economically and socially acceptable.

There is much interest in ASHRAE Standard 90-75 as a basis for energy conservation regulations but there is also some reluctance to adopt the standard in its original form because it is considered too difficult to enforce. The three model Code-writing bodies in the USA (ICBO, BOCA & SBCC) are agreed that the Standard is acceptable as a guideline for the generation of energy conservation criteria for the model codes but think that it needs to be rewritten in Code language and its content clarified for code adoption. They are currently developing a revised version that is more compatible with the enforcement process. These revised requirements will be processed by each body individually through its Code change hearings with the object of achieving a uniform approach to energy conservation. Since most State and local Codes are based on one of these model Code documents such action could have far-reaching effects.

A significant and parallel concern and one to which the various Code groups in the USA are also giving attention is the need to implement a program of training and education for those involved in applying and administering the new energy conservation requirements. It is claimed that most Code administrators do not have the expertise needed to evaluate building designs in terms of the energy requirements in ASHRAE Standard 90-75. The problem takes on even greater significance in the enforcement of full performance-type standards that are intended to encourage innovative designs and require a higher level of knowledge and a greater degree of judgment in their application. The energy budget approach, for example, will require the establishment of reproducible methods of computing annual energy consumptions capable of broad application by qualified practitioners and the acceptance of such computations by building authorities as the basis of Code enforcement. The establishment of courses to develop the necessary expertise of both Code officials and designers will be an important requirement and a key factor in the successful application of energy conservation standards.

CANADIAN ACTIVITIES

There have been a number of developments

taking place in Canada of relevance to energy conservation and building codes.

During the preparation of the 1975 edition of the NBC the ACNBC gave careful consideration to the role of the Code with respect to energy standards and concluded that no action should be taken until a comprehensive approach was developed. The committee had been specifically asked to include thermal insulation requirements but believed that to do so would only result in a fragmented approach to this important matter. Of concern also was the question of whether a building Code that traditionally deals only with matters of health and safety is the proper medium for promulgating energy conservation requirements for the country.

The Committee decided instead to request the National Research Council to oversee the development of criteria for energy conservation in buildings in conjunction with other interested groups and to make these available for possible processing on a national basis. This work was subsequently undertaken by a Federal Interdepartmental Committee* working in close association with the staff of the National Research Council. The Associate Committee on the National Building Code has agreed in principle to assume responsibility for developing a consensus standard utilizing the input provided by this Federal Committee and has established a Standing Committee on Energy Conservation in Buildings for this purpose. It has indicated, however, that it will probably want to publish the standard separately from the National Building Code in recognition of the fact that energy conservation requirements are based on a different set of premises than the safety and health regulations in the Code itself.

The provincial authorities have indicated an interest in such a document and its preparation under the ACNBC auspices should provide a uniform basis for adoption of energy conservation requirements by the various legislative authorities throughout Canada. In the meantime, some provinces, e.g., Ontario, have begun to introduce energy requirements through their provincial building codes but most action to date on energy conservation is confined to provincially funded construction. The development of requirements for this latter purpose is generally the responsibility of departments other than those concerned with building regulations.

At the Federal level it is expected that the draft requirements developed by the Interdepartmental Committee will be applied to all Federal buildings pending completion of the consensus standard by the Associate Committee on the National Building Code.

SOME IMPORTANT CODE CONSIDERATIONS

Although the energy situation has created strong pressures to introduce energy conservation measures in buildings as soon as possible, experience has shown that much time is required to allow the various parties involved, including the design professions, the material suppliers and the regulatory authorities, to adapt to new requirements. The hasty introduction of regulations in a new and complex area can lead to serious side effects such as market disruptions, undue or counter-productive design restraints and enforcement difficulties.

A good standard for purposes of building regulation should, ideally, be based on reasonably clear-cut objectives. Its requirements should be rational in relation to the achievement of these objectives and unambiguous. It should be within the capacity of competent designers to apply, and of qualified regulatory authorities to administer. Current regulations for safety and health fall short on one or another of these characteristics and it can be expected that newly evolving energy conservation standards will also have significant shortcomings.

A question currently being asked is whether a component-performance standard such as ASHRAE 90-75 is the most appropriate at this stage for Canadian conditions; or whether it is practicable to move directly to a second-generation standard based on a specified annual energy budget approach. It is generally believed that a comprehensive building performance standard based on specific energy budgets for different occupancies will allow the greatest flexibility of application. This may be so but there could also be some disadvantages with such an approach.

If the energy budget is uniform for all buildings of a certain occupancy type it may penalize those with smaller floor areas and lower storey heights. For example, energy budgets set to reduce substantially the present energy consumption of all buildings classed as residences could well be impracticable for small structures such as mobile homes. In extreme situations this could discourage the construction of such buildings in favour of traditional housing which is generally larger. The net effect would be the use of more energy not less. On the other hand if the energy budget is set to be practicable for small buildings then the overall energy saving may not be sufficiently high for larger buildings. Clearly these aspects must be considered if realistic energy budgets are to be established.

Over and above this, a standard based on the energy budget approach can be most difficult to develop and administer and its preparation will require extensive background information. It involves the setting of annual energy consumption targets for various building types on some well-defined basis such as life-cycle economics. It also requires the establishment of reproducible methods of computing annual energy consumptions which can be continually updated to

*The activities of this Committee are outlined in the paper by Dr. D.G. Stephenson in session 2 of this Conference.

accommodate new technology components and systems and be capable of broad application by qualified practitioners. The system must be accepted by building authorities as the basis of regulation. The framework of such a national computation system has been established by the Department of Public Works but it must evolve to encompass the private as well as the public sector since it is essential that a large number of practitioners quickly become capable of using the system and of contributing to its further development.

For these reasons the Interdepartmental Committee has adopted a two-pronged approach. The long-term building performance standard; in the short term, the Committee is concentrating on the development of a component performance standard based on ASHRAE 90-75. This latter type of standard may have less impact in terms of energy savings since the kind of energy and the operation of the mechanical services are not specified but it is easier to apply at this stage and more adaptable to code enforcement.

It is of interest to note that a study by A.D. Little Inc. has indicated that application of the ASHRAE Standard in the USA would result in small or insignificant reductions in annual energy consumption for single-family residences, but substantial reductions for multi-family residences, schools, office buildings and retail stores. No similar study has been made for Canadian conditions. However, energy-related requirements in Residential Standards, a document published under the auspices of the Associate Committee on the National Building Code and used by Central Mortgage and Housing Corporation for all construction under the National Housing Act, already provide for a higher level of energy conservation than does ASHRAE 90-75.

In developing energy conservation standards for mandatory application it is important to establish clearly the basis on which energy-related requirements are to be selected. For instance, are they to be set on the basis of economic benefits to the owner or to achieve a certain specified energy saving? It is also important to assess carefully the impact of the proposed requirements on typical building practices and on the economics of construction. It was claimed by some that the requirements in the first draft of the ASHRAE 90-75 Standard would increase the cost of construction by as much as 33%. Such considerations cannot be ignored even in the pursuit of national or provincial objectives for energy saving.

The development of the thermal insulation requirements in the 1975 edition of Residential Standards provides an interesting example of the kinds of considerations that arise. The Committee's approach was predicated on economic benefits to the owner rather than on energy conservation per se. The thermal resistance (R) values were established by comparing the annual saving in heating costs resulting from added insulation with the cost of installing the extra insulation, assuming that it would be amortized over a 25-year period. In the course of the work, however, some decisions had to be taken which were necessarily arbitrary. These were as follows:

- since the annual total cost curve when plotted is relatively flat over a wide range of "R" values, the committee decided that the "R" values chosen would be those that give annual costs $5 above the annual optimum cost per 1,000 sq ft (93 m^2) of exposed surface (or about $10 per house per year above optimum). This approach was adopted to achieve significant annual savings without requiring excessive thicknesses of insulation.

- where stud wall spaces are filled with insulation, no additional insulation need be provided.

- the "R" values for masonry walls were established to permit the continued use of nominal 2 in. × 2 in. strapping. This is the largest size of strapping permitted for non-combustible construction, and the maximum size that can reasonably be required in practice.

These decisions were required to avoid serious impact on certain accepted construction practices and disruption of established markets.

In addition to revised wall and ceiling insulation requirements, the 1975 edition of Residential Standards also incorporated other changes related to energy conservation. All basement walls must be insulated to at least 1 ft (305 mm) below ground level regardless of whether or not they enclose habitable spaces. Heated crawl spaces must be insulated to at least 1 ft (305 mm) below ground level. In addition, there are requirements for double glazing, weatherstripping of doors, and limits on air infiltration around windows.

The document, Residential Standards, is not part of the Building Code, but its requirements are applied by CMHC to all residential construction under the National Housing Act and are used as a guide in much other residential construction not under the Act. It, therefore, influences much of the residential building in Canada.

Although not normally a topic included in building regulations, retrofitting of existing buildings to improve their energy use characteristics offers much greater total potential for energy savings than do new buildings. Those concerned with retrofitting should be aware, however that it can create situations that could lead to higher maintenance costs and even unsafe conditions.

The application of foam plastics, for example, is a popular method of improving the insulation characteristics of habitable rooms in basements, but the use of foam plastics as interior finishes can lead to increased fire hazards. Another example would be an electrical

system which was originally installed assuming that the wires would be exposed to air. Adding insulation to the walls could cause the wires to overheat in heavily loaded circuits by reducing air circulation. The practice of adding insulation to older buildings, which may have been built without vapour barrier protection, can also lead to serious problems through increased condensation with the structure unless action is taken to reduce the vapour and air permeability of the interior surfaces.

In new construction, the respective Codes provide protection by controlling the way in which such materials can be applied. In upgrading existing construction to conserve energy care must always be exercised to ensure that the practices followed do not create problems of a more serious nature.

CONCLUSIONS

It is quite clear that the preparation of adequate standards to regulate the design of buildings for energy conservation presents a complex technical problem with social, economic, and legal implications. It is similar, in this aspect, to the problem of preparing standards for regulating building design for safety and health. But, whereas modern fire, structural and public health regulations have been evolving for several decades, there is as yet no similar background in energy conservation regulations. Regulations that are not practicable or are difficult to enforce are of questionable value regardless of their ultimate objective. Regulations must always anticipate, and be tailored to, the practical and economic means of the society they are to serve.

Problems can be minimized (and perhaps avoided) by submitting the draft requirements to the consensus process as is normally done in developing model Code documents such as the National Building Code. This procedure will be followed in preparing energy conservation regulations under the auspices of the Associate Committee on the National Building Code. By making these requirements available for comment as part of the consensus process they will also be available for general use pending the development of a consensus standard.

DISCUSSION

R.W. Racine (B.C. Hydro & Power Authority): Introduction of energy conservation considerations in building codes is logical and desirable; however, care is required that this doesn't do more harm than good as far as energy conservation is concerned. Building codes tend to minimums, very often subject to delayed impact, particularly where they are subject to country-wide consensus as is desirable and planned. Experience has shown that building code minimums tend to become the maximum level of construction in the main, thus building code energy conservation requirements could result in minimum levels of energy conservation in new buildings throughout Canada in the coming decades.

This is a highly probable fact-of-life; if so, we should recognize the situation and ensure that here is proper awareness and wide identification of the limits and intent of codes so that the promotion of the better construction really required for true economy and energy conservation is not rendered impractical by code requirements.

Possibly one of the answers will be to conspiciously identify code requirements as minimums and to provide recommended requirements for true long term energy conservation. Certainly a minimum requirement should be that energy conservation code requirements and associated permits and approvals be clearly identified as to their coverage just as if informative labelling laws were applicable to the situation also.

Building codes can contribute to energy conservation by establishing the minimums.... however, great care will be required to ensure that they don't inadvertently rob the country of the full economical energy conservation available by, in effect, establishing a low ceiling on the energy conservation in the majority of buildings. Now is the time to consider how this will be avoided or maybe we should ask "can this be avoided?"

H.B. Dickens: The concern expressed by Mr. R.W. Racine that minimum requirements for energy conservation may well become the maximums in actual practice and thus inhibit the adoption of higher levels of construction is one that can be raised whenever minimum standards are established by legislation.

One of the answers, as Mr. Racine himself has suggested, is to ensure wide public awareness of the intent of the document, the basis on which the requirements have been formulated, and the fact that they are minimums and in no way are intended to prohibit the adoption of higher levels of construction. A more basic concern, however, is to ensure that the levels of energy conservation established by legislation are, in fact, appropriate and necessary. There is little point in imposing requirements and establishing the related enforcement procedures if the resultant energy conservation standards are no higher than would be achieved under normal market forces. A fundamental problem faced by the developer of such standards is that of determining acceptable minimum levels in terms of both energy conservation and what is reasonable and rational for mandatory application. Having established these minimum levels of energy conservation through legislation additional energy saving measures may be encouraged through financial incentives.

It should be noted that the model Code for Energy Conservation, which is under development by the Associate Committee on the National Building Code, is to be published as a separate document since it is based on a different set of premises than the National Building Code. It will

be coordinated with the National Building Code, however, to ensure compatibility of requirements.

J.H. Collyer (A.D.I. Limited): There are not infrequent instances of buildings becoming factual reality without meeting the applicable building regulations. The plans are drawn showing compliance but their major purpose appears to be to pass the hurdle of obtaining the necessary building permit. Is there not a case for applying retroactivity in enforcing mandatory compliance with building regulations; i.e. a building owner could be at any time held responsible for upgrading his building to the regulations as they were in force at the time the building was built?

H.B. Dickens: The case of retroactive enforcement of building regulations, as proposed by Mr. Collyer, can be supported on the basis that it is the owner's responsibility under the building code legislation to construct his building in conformance with the code requirements. It is highly questionable, however, that the procedure offers a viable alternative to current practices of inspection during construction in view of the difficulties that would be faced in its implementation. In many instances evidence of non-compliance with the regulations can only be obtained through inspection during the various stages of construction and deficiencies may not be apparent in the completed building until some form of failure occurs. This tends to defeat the purpose of building code enforcement which is to ensure that the building as constructed provides a safe and healthy environment for its occupants.

Admittedly, the approach appears more practicable in the case of energy conservation whereby an annual energy budget could be established for a particular building and the owner allowed some latitude in its design provided he stays within the energy budget when the building is in use . In addition, such measures are attractive from the standpoint of encouraging good operating practices and increasing the probabilty of achieving the desired efficiency in energy utilization. There are still problems, however, as the paper by Dickens and Wilson points out. The approach will require a realistic energy budget for a variety of building types and a mechanism and techniques for obtaining verified records of consumption under carefully specified conditions. These can be difficult to establish and may add substantially to the complication of control.