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CONSIDERATIONS IN THE DEVELOPMENT OF A NATIONAL ENERGY CODE FOR CANADA

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ABSTRACT

This paper describes the fundamental considerations that are shaping the two new energy codes that will be published by the National Research Council in 1996 - the National Energy Code for Houses and the National Energy Code for Buildings. It begins by describing the rationale for having such codes in the first place; i.e. why do provincial governments wish to regulate those aspects of buildings that determine their energy efficiency? It goes on to explain why, based on experience in other countries, the approach of having a fixed energy budget based on only the type, size and location of a building was not adopted but the design flexibility of the performance approach is provided nevertheless. The life cycle costing process used to develop cost-effective requirements is outlined. The effect of these considerations on the general structure and make-up of the resulting codes is reviewed, including the result (surprising to some reviewers) that the codes set different requirements for different forms of construction.

INTRODUCTION

In early 1996, the National Research Council (NRC) will publish two new national model codes for use by provincial and municipal authorities in regulating the energy-related characteristics of buildings. The National Energy Code for Houses will address houses and the National Energy Code For Buildings will address all other buildings.

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BACKGROUND

In 1978 and 1983, the National Research Council published a model energy code for buildings entitled "Measures for Energy Conservation in New Buildings." (ACNBC Measures, 1983) NRC's Associate Committee on the National Building Code (ACNBC) had reluctantly agreed to develop this code during the "energy crisis" of the early 1970's because it was believed that, in the absence of a national model code, most provincial governments would enact their own codes. However, by the time it was first published in 1978, the crisis atmosphere had cooled off and all provincial governments except that of Quebec had lost some of their enthusiasm for regulating this aspect of building design and construction. Thus only Quebec (in 1983) adopted energy regulations based on the Measures for Energy Conservation in New Buildings.

In view of this situation, by 1989, the ACNBC was on the verge of abandoning the document and disbanding the Standing Committee on Energy Conservation in Buildings (SCECB), its by-then dormant subcommittee that had developed the document. However, the ACNBC was encouraged not to do this by the Provincial/Territorial Committee on Building Standards (PTCBS), a committee of senior officials from all the provincial and territorial ministries responsible for building regulation. These officials were aware that their counterparts in energy ministries had not completely lost the desire to regulate energy-related characteristics of buildings; they felt that, when and if their provincial cabinets should decide to proceed in this area, it would be best to have available an up-to-date national model developed and maintained by the ACNBC's well-proven participatory consensus process.

By 1989 the document was 6 years out of date and energy-related building technology had made significant advances. A number of lessons had been learned from efforts to regulate energy in buildings in other jurisdiction such as the USA and especially California. Updating the model energy code would not be a trivial task and the ACNBC stated that it would not be able to accede to the PTCBS' request to maintain an up-to-date national model energy code unless a source of funding for the needed background research could be found. At the last minute, $1.5 million of funding was made available to NRC's Building Performance Laboratory to fund this background research; this funding came from Energy Mines and Resources Canada (now Natural Resources Canada), all 12 provincial and territorial energy ministries and the Canadian Electrical Association. This allowed the Standing Committee to be re-activated and work to begin on development of a new energy code.

Thus the project is primarily an initiative of the provincial and territorial governments and the resulting codes will only go into effect in those provinces and territories where the provincial or territorial government decides to adopt them.

WHY ARE ENERGY CODES NECESSARY AT ALL?

Ever since the early 1970's when the ACNBC first agreed to undertake development of an energy code for buildings, this question has arisen. The answers offered by those agencies that have encouraged the development and adoption of energy codes include the following:

- Buildings are long-lived, usually outliving their original occupants. Therefore a longer perspective than that of the original purchaser is needed in making decisions that affect the on-going energy consumption of a building. Often those who make the decisions on the physical characteristics of buildings they are purchasing or constructing are not even willing to look as far ahead as the expected occupancy term of the first occupants since they are pre-occupied with first costs.

- Even if a shorter perspective were valid, building purchasers are not in a good position to make informed decisions regarding the energy-related features of the buildings. For example, home buyers especially, but also investors in other types of buildings, do not normally have access to the kind of sophisticated cost/benefit analyses tools on which the National Energy Codes' regionally sensitive requirements are based. They are thus unable to evaluate how these energy-related features might impact on their future heating costs. Also, even if they subscribe to societal conservation and environmental goals, they are unable to judge how their buying decisions might contribute or detract from these goals. They therefore tend to rely on governments to enforce appropriate regulations to ensure that such features as insulation levels and equipment efficiencies are neither —

  - too low in relation to these goals, nor
  - too high in relation to the share of the cost of attaining these goals it is reasonable to ask individuals to bear.

- The characteristics of buildings have major implications for energy suppliers, many of which are public utilities; e.g. they influence the need for colossal public investments in new electric generating facilities. These energy suppliers are not always free to change prices in order to regulate demand because increased prices can have other effects that may be disruptive (e.g. reduced competitiveness of domestic industry). Regulation of building construction provides an alternative means of controlling demand.

- Another alternative available to energy suppliers is the use of incentive programs which pay grants to building developers to encourage energy efficient design, but such programs have not proven to be very effective in terms of the number of buildings whose design they have influenced. Also, if regulation does not exist to define a reasonable baseline on which to base such incentive programs, these programs can be very expensive since participants can claim incentive payments just for bringing their buildings up to moderate levels of energy efficiency.

- The regulatory approach creates a "level playing field" so that conscientious designers and builders interested in providing an appropriate level of energy efficiency are better able to compete with others who achieve construction cost savings by eliminating energy saving features.

- The federal government has certain objectives regarding limiting energy consumption and its related environmental impact. Like the energy utilities, the federal government is constrained in its use of energy prices as a means to achieve these objectives. Encouraging the adoption of energy regulations for buildings is one of the few means available to the federal government to accomplish its objectives in this sector.

- After extensive trials of other available strategies, which include technology transfer programs and incentive programs, the regulatory approach is now recognized as being the strategy likely to be most effective in achieving societal goals regarding limiting energy consumption of buildings with the least expenditure of public funds. To some extent, the cost effectiveness of this approach (from the public perspective) is due to the fact that part of the cost is transferred to purchasers of new buildings; however, this transferred cost is spread quite thinly and is compensated for by the fact that, if the regulations are crafted wisely, they also pay dividends to these purchasers in terms of reduced operating costs.

- Regulation is a reasonable choice for implementing government policy in an industry that is accustomed to regulation (the need for health- and safety-related building regulations is universally accepted) and in which an extensive regulatory infrastructure already exists. This is especially true in Canada where the consensus-based National Building Code process, with its fifty year history, provides a forum where regulators and those regulated can agree on appropriate levels of regulation. The extensive technical support available to this process, due to its relationship with the National Research Council, ensures that these levels will, to the greatest extent possible, be chosen rationally and not solely on the basis of judgment and/or emotion.

ESTABLISHING A BUILDING ENERGY PERFORMANCE TARGET

One of the criticisms of the Measures for Energy Conservation in New Buildings was that it was essentially a prescriptive code. It set criteria for all building components which affect energy consumption and left the designer little flexibility. During the period of work on the 1983 edition of the Measures and following its publication, the Standing Committee did a fair amount of thinking and work towards a performance code. A pure performance energy code would set some sort of energy target to be achieved and leave the means of achieving that target to the building designers with no restrictions on how individual components are handled.

The document envisioned towards the end of those discussions would have had two basic components:

1. tables of maximum levels of overall building energy consumption in $MJ/m^2 \cdot year$ (or similar units)

   - There would be a separate table for each of several different types of building (office, school, mercantile, etc.) and the maximum permitted energy consumption would be related to climate and, possibly, duty cycle (e.g. 8, 16 or 24 hours of occupancy per day).

   - Figure 1 is an example of what such a table might look like.

ENERGY BUDGETS FOR OFFICE BUILDINGS
MJ Equivalent of Delivered Energy/ (m^2 • year)

Number of Floors	Gross Floor Area m^2	8 h Duty Cycle		16 h Duty Cycle		24 h Duty Cycle	
		3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days
1	400 or less	1200	1800	2200	3400	3000	5000
	600	1100	1650	2000	3000	2750	4600
	800	1000	1500	1800	2800	2500	4200
	1000 or more	950	1400	1750	2700	2400	4000
2	800 or less	1100	1650	2000	3000	2750	4600
	1200	1000	1500	1800	2800	2500	4200
	1600	900	1350	1650	2550	2250	3750
	2000 or more	850	1275	1550	2400	2100	3550
3	1200 or less	1000	1500	1800	2800	2500	4200
	1800	900	1350	1650	2550	2250	3750
	2400	800	1200	1450	2250	2000	3350
	3000 or more	750	1125	1350	2100	1850	3100
More Than 3	1600 or less	900	1350	1650	2550	2250	3750
	2400	800	1200	1450	2250	2000	3350
	3200	700	1050	1300	2000	1750	2900
	4000 or more	650	950	1200	1850	1600	2700

Fig. 1: Example of Possible Energy Budget Table

2. a specified means of determining, at the plans examination stage, whether the building could be expected to comply with the appropriate overall building energy consumption table

   - The means specified would probably be a designated computer program, possibly the DOE program.

   - Building permit applicants would be required to submit the results of an analysis using the designated program.

   - The code would specify certain controls on the input assumptions used in the analysis.

One of the challenges in developing such a performance code is determining the numbers that should go into an energy budget table such as that shown in

Figure 1. The Standing Committee envisioned that these numbers would be derived by studying the range of overall energy consumption experience of various types of building, studying the factors that differentiate the efficient buildings from the inefficient buildings, studying how the energy consumption is affected by climate and duty cycle and picking levels towards the low end of consumption that would be reasonable to mandate. At the Committee's request, NRC's Division of Building Research (predecessor of the Institute for Research in Construction) had let a number of contracts for such studies.

However, for a number of reasons, this direction of code development was never pursued to completion. One reason was the daunting array of building types for which such tables would have to be developed. Another was the lack of success codes of this type had experienced elsewhere.

An attempt by the US Department of Energy to impose such a code on the states was stopped by determined opposition by professional organizations such as the American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE) and the American Institute of Architects. This opposition was based, in part, on doubts that tables such as that in Figure 1 could provide enough flexibility to take into account all the variables which determine a building's energy consumption and the resulting apprehension that designers could therefore be faced with energy budgets that would be extremely difficult to meet with particular buildings. These fears proved to be well founded as this situation arose frequently when the State of California enacted such a code. So many designers found reasons why their buildings should be exempted from the energy budgets that California abandoned this type of code.

Thus it is extremely difficult to determine, in any kind of abstract or generic manner, how much energy a certain type or class of buildings should use. Nevertheless, it appears that many of those who have submitted comments on the National Energy Codes had expected to find codes based on this approach. They were perhaps led to this expectation by the use of this approach in Natural Resources Canada's R-2000 Low Energy House Program. In this program the target energy budget was set entirely arbitrarily (e.g. no cost-effectiveness criteria) and the program applies only to a very narrow range of buildings. Also, the program is entirely voluntary so participants unhappy with the target need only drop out of the program.

For all these reasons, when the Standing Committee reconvened in 1990 it quickly decided to abandon the fixed energy target approach.

PRESCRIPTIVE-BASED PERFORMANCE REQUIREMENTS

A review of energy code activities in others countries led the re-convened Standing Committee to seek another approach to developing an energy performance code. The Committee settled on the approach used in the ASHRAE Standard 90.1, "Energy Efficient Design of New Buildings Except New Low-rise Residential Buildings" and, more successfully, in California's replacement for its fixed energy target code.:

- First, prescriptive criteria are established for all building components that affect energy consumption. (The method used to do this is discussed in the next section.)

- Then, where the designer is not content to follow the prescriptive requirements and wishes to use the performance approach, a custom energy performance target is set for the particular building by simulating the energy consumption of that building assuming that all of its components meet the prescriptive requirements.

- The designer is then free to deviate from the prescriptive requirements for any or all components, provided it can be demonstrated, using a parallel simulation, that the building energy consumption will not exceed the custom energy performance target.

This approach requires careful controls to ensure that the two simulations are carried out in a manner that provides a fair comparison. Apparently, when this approach was first implemented in California, lack of such controls created a situation where designers could make virtually any building appear to satisfy the code. Our National Energy Codes are being designed to avoid this situation.

Thus our National Energy Codes will offer the flexibility of a performance code without having established any fixed energy targets applicable to all buildings or to classes of buildings.

ESTABLISHING PRESCRIPTIVE REQUIREMENTS

Even before the Standing Committee was reconvened, the energy ministries and utilities that sponsored the background research recommended that the new Code's requirements be based on cost-effectiveness using current energy prices and taking into account regional differences in these prices. The Standing Committee readily agreed to this recommendation.

Once one has decided to base the codes on cost-effectiveness, one finds that many other decisions are already made. For example, one cannot then pick some arbitrary energy use target (e.g. in MJ/ m^2) out of the air or base it on some arbitrary reduction in energy consumption — it might not be cost-effective. Neither can one reject requirements that satisfy one's cost-effectiveness criteria just because they do not go beyond present practice. If the present practice satisfies those criteria, one must accept that.

Also, if the codes are to be based on cost-effectiveness, then one cannot ignore actual costs. In a country where energy costs vary greatly by source and by region, such a code must base requirements on actual regional energy costs. While it is true that energy costs can change in the future, perhaps even enough to lead to changes in energy source in some buildings, one cannot foresee the future well enough to take these possibilities into account. On the other hand, if all requirements for the whole country were to be based on one energy cost, they would not be cost-effective for large parts of the country. We can say this with some confidence because this is the approach used in developing the "Measures for Energy Conservation in New Buildings." It is believed that the result of this "broad brush" approach was one factor which led to the extremely limited adoption rate of those codes.

As noted above, the Standing Committee did not start out with any pre-determined notion of how much energy a building should use since no rational method of establishing such values had been identified. How much more difficult then to find some way of determining how much energy should be allowed to escape through a wall or roof or door, etc. How then could prescriptive requirements be established for these components' energy-related characteristics?

The Standing Committee decided to establish these requirements by answering such questions as -

> "For a given type of wall in a given area of the country in a building with a given space conditioning energy source, what is the U-value that represents the optimum balance between construction cost and energy loss over the economic life of the building?"

The answers were generated by hundreds of life cycle cost analyses carried out for a range of construction types and for 34 regions of the country and, for most regions, three different energy sources (Sander et al., 1995; Swinton et al., 1993). Figure 2 is an example of such an analysis. Each bar represents a particular wall assembly for which the construction cost and the annual heat loss have been estimated. For this region and energy source, 0.256 $W/m^2 \cdot {}^\circ C$ would be chosen as the permitted maximum U-value for Type X walls.

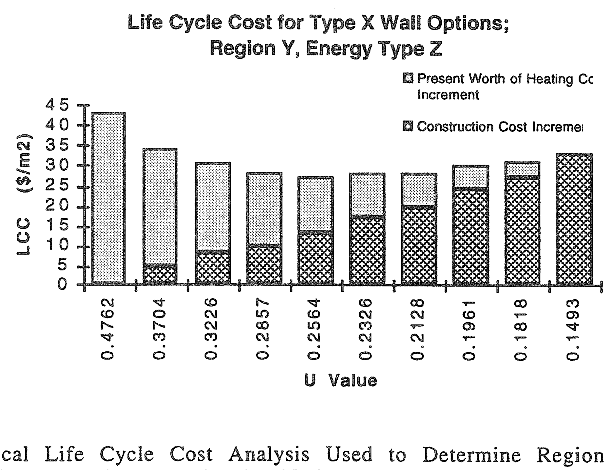

Fig. 2: Typical Life Cycle Cost Analysis Used to Determine Regionally-sensitive Envelope Requirements in the National Energy Code for Buildings

These analyses resulted in tables of regionally-sensitive requirements of minimum R-values or maximum U-values for all of the building envelope components.

Obviously, the answer to a question such as that above is likely to be different for different types of construction such as steel-framed walls versus masonry walls. Thus, a code based on this approach will have different requirements for different types of construction. The Standing Committee chose this approach in order to avoid the Code's having a significant impact on basic building design choices. If it had chosen, for example, to have one set of maximum U-values for walls and had based those U-values on life cycle costing for a type of wall construction for which it is relatively easy to achieve low U-values, it could have the effect of totally eliminating the possibility of using other types of construction for which it is more difficult to achieve low U-values; the permitted maximum U-values would be unattainable for these types of construction. On the other hand, if it had chosen to base the maximum U-values on life cycle costing for a type of wall for which it is relatively difficult to achieve low U-values, the results would be well below what could be economically achieved with other types of walls.

An example of the first of these possibilities actually occurred in the first draft of the National Energy Code for Houses (which uses R-values rather than U-values). In that first draft there was only one category of minimum wall R-values and those values were based on life cycle cost analyses for wood-frame walls. It is impossible to achieve these R-values with traditional log construction. The result, if this aspect of the National Energy Code for Houses had been left unchanged, could have been to rule out the use of log walls in areas where the National Energy Code for Houses is adopted. This has been corrected by adding a category of minimum R-values for log walls.

Concern has been expressed that this approach could lead to just the effect it is trying to avoid. It has been suggested that the differences in U-value requirements between component types may have enough impact on the relative costs of different types of components to affect design/purchase decisions. The Standing Committee considered this possibility but found that the differences in cost imposed by the differences in required U-values were much less significant than the factors which cause a designer to choose one type of construction over another, which include cost but also include several other factors such as durability, aesthetics, etc. For example, for Ontario Zone A and gas heating, the first public review draft of the National Energy Code for Buildings imposed a maximum U-value of 0.41 $W/m^2 \cdot °C$ for masonry walls and 0.51 $W/m^2 \cdot °C$ for steel-framed walls. The cost data available to the committee indicated that a masonry wall which would satisfy the less stringent requirement for steel-framed walls would have a cost premium of \$86.40/ m^2 over a steel-framed wall which would also satisfy that requirement and that the added cost to upgrade the masonry wall to satisfy the more stringent U-value requirement would be only \$1.08/ m^2.

Nevertheless, in reviewing public comment and preparing for a second public review draft, the Standing Committee decided to consolidate the wall categories in the National Energy Code for Buildings and permit the same maximum U-value for all types. This decision was based on a review of the life cycle cost results which indicated that -

- The low points on the life cycle cost curves for all wall types fell within a fairly narrow band of U-values.

- The life cycle cost curves for all wall types were quite flat in the vicinities of their low points, meaning that the optimum choice for each type is not clearly defined.

Another masonry-related change was made between the first and second public review drafts: In the life cycle costing for the first public review draft, it was assumed that all walls would have some type of finishing material applied to either the interior or the exterior surface and that this finishing material could just be spaced further from the structural backing to accommodate more insulation. Public comment received indicated that this is not always the case. In some types of buildings, generally categorized as warehouse and light industrial buildings (WLIB), masonry walls are often used without any additional interior or exterior finish. Therefore in doing life cycle costing analyses for this type of building, the cost of adding finishing must be added to the cost of the insulation. This tends to result in higher optimum U-values and could, in some cases, result in the added cost of finish and insulation being found uneconomic. Working with the Masonry Council of Canada, the life cycle costing analysis was re-done and it showed that, where an additional interior or exterior finish is not otherwise required, single wythe core-filled masonry walls with no additional insulation are often the economic choice, especially in mild climates and with lower cost energy sources. The second public review draft reflects these results.

CONCLUSION

The provincial and territorial governments have encouraged NRC to develop two new national model energy codes for regulating those characteristics of buildings which determine their energy efficiency. NRC will publish these codes — the National Energy Code for Houses and the National Energy Code for Buildings — in 1996. They will be quite different than their predecessor, the Measures for Energy Conservation in New Buildings, and quite different from many people's notion of what an energy code for buildings should look like. Their form is based on learning from experience in other countries and on extensive background research by NRC's Building Performance Laboratory sponsored by the Canadian Electrical Association, Natural Resources Canada and all 12 provincial and territorial energy ministries. That form has been shaped by a number of rational decisions made by the Standing Committee on Energy Conservation in Buildings. The main principle guiding the development has been that the requirements should be based on cost-effectiveness.

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