BACKGROUND AND MAIN FEATURES
OF
CANADA'S NEW MODEL NATIONAL ENERGY CODES
FOR BUILDINGS AND FOR HOUSES

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ABSTRACT:

Codes have a role in energy conservation as they can ensure at construction time that buildings will be capable of making efficient use of energy. The "Measures for Energy Conservation in New Buildings", a model code, was first published by the National Research Council of Canada in the late 1970's; a new set of Energy Codes has been released by the Canadian Commission on Building and Fire Codes to update the old "Measures". The new Energy Codes are based on ASHRAE/IES Standard 90.1 and deal with houses in a document separate from other buildings. This paper presents highlights of what the new codes are like.

The Energy Codes offer users three compliance paths: a prescriptive approach, trade-offs and a building performance comparison based on "weighted" energy. They also present customized regional requirements adapted to climatic, economic and environmental conditions. The designers of the Codes have considered implementation issues such as ease of compliance and ease of enforcement as criteria for writing the Codes and have provided tools and procedures to facilitate their use. The Codes make extensive and innovative use of computers: each is accompanied by two pieces of software, one for code users to readily trade-off energy conservation features and the other to assess building performance compliance.

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INTRODUCTION:

The Canadian Commission on Building and Fire Codes (CCBFC), the senior committee in a national consensus structure dedicated to the writing of model codes under the auspices of the National Research Council of Canada (NRC), has released a new set of National Energy Codes to replace the Measures for Energy Conservation in New Buildings, published in 1978 and 1983.

BACKGROUND:

Role of Codes in Energy Conservation: Limited but Valid

One may ask why a code for energy efficiency, after all the incentive programs that have been made available to Canadians in the last twenty years.

Codes are an essential tool to ensure a minimum degree of efficiency at time of construction for the energy-related characteristics of a building. They are particularly valid for construction elements which are difficult to change afterward, such as envelope insulation and airtightness, or are installed to operate for an appreciable number of years, such as heating and cooling equipment and systems. The advantage that codes offer is that they can easily be implemented through provincial and municipal infrastructures that already exist for administering building codes. When extended to energy, the building code enforcement structure can provide a convenient and existing administrative framework, including an accepted form of penalties: if it cannot be proven, on the basis of the building plans and related calculations, that the building meets the minimum energy efficiency requirements, a building permit is not issued; if the building is not built according to the approved plans, an occupancy permit is not issued.

But codes cannot eliminate all energy waste in a building; they only deal with a building at the design/construction stage and thus cannot address the building's actual, on-going energy usage, which is occupant-dependant and unlikely to become the object of enforcement by public authorities. It is widely recognized that improper operation can entirely wipe out energy savings made possible by designing and constructing the building to be efficient. So codes can only be one part of a larger action plan for energy efficiency.

Codes are an "imperfect tool". They cannot ensure integration and optimization of all energy efficiency measures, but can effectively define a "baseline," for a building's basic energy characteristics, which is enforceable at time of construction.

History:

• **1974.** The idea of a national code for regulating building energy efficiency originated in 1974, when the federal government formed an interdepartmental committee to draft a set of guidelines for the design of government buildings to improve their energy efficiency. The Division of Building Research, precursor of the Institute for Research in Construction (IRC), played a prominent role on that committee.

• **1976.** However, it was realized that more could be achieved in terms of energy conservation if these guidelines could be turned into a model code, available to provinces and municipalities for local implementation and enforcement, and applied to all buildings, not just to federal government buildings. The Associate Committee on the National Building Code, now replaced by the Canadian Commission on Building and Fire Codes, provided model codes in Canada. It was therefore asked to take over preparation of the guidelines and publish them as a code for energy conservation in buildings that could be used by provincial and municipal building regulation officials. The Standing Committee on Energy Conservation in Buildings was therefore formed and first met in November 1976. The Committee felt from the start that it would be most desirable to develop a performance or "energy budget" type of code. It concluded that such a code could only be enforced through the submission of computer modeling results at the time of building permit application and that the science of computer modeling of building energy consumption was not sufficiently advanced at that time for such a procedure to be reliable. It therefore set out to develop a prescriptive code and decided to base this code on the then recently published ASHRAE 90 Standard (Ref. 1).

• **1978.** After circulation in 1977 of a draft for public review, a great deal of comment was received and was duly considered in finalizing the first edition of the "Measures for Energy Conservation in New Buildings" in 1978 (Ref. 2).

• **1983.** The Measures was revised and updated in 1983 (Ref. 3). In addition to more stringent requirements in some areas, the changes included the addition of a section on "Houses." This was added in response to criticisms that the 1978 version was too complex for house builders. This perceived complexity was due in part to the fact that, although the requirements pertaining to houses were not complex in themselves, there were a large number of requirements not pertaining to houses that the user had to plough through to identify the ones that did apply to houses.

• **Limited success in terms of implementation by provincial and other building regulation authorities.** Only one province, Quebec in 1983, has enforced the Measures. The only other authority to adopt the Measures was Canada Mortgage and Housing Corporation, which made compliance with the 1978 edition mandatory for housing financed under the National Housing Act.

New Interest in Making Use of an Energy Code to Attain Energy Conservation in Buildings.

In the early 90's, interest in regulating building energy efficiency at time of construction started growing again. The 1990 Ontario Building Code included insulation levels for houses reported to be based on the 1983 edition of the Measures. The Province of Ontario, in their 1993 revisions to the Ontario Building Code, had also made compliance with ASHRAE Standard 90.1 mandatory for large non-residential buildings. The City of Vancouver implemented ASHRAE Standard 90.1 and utilities began making use of that standard in their incentive programs.

In 1989, a number of federal and provincial energy agencies and electrical utilities agreed to provide the necessary funding to support research associated with an in-depth update of the original Measures. Funding was first confirmed from the governmental energy ministries to support research towards the updating of the prescriptive version of the Measures. Soon afterward, Energy, Mines and Resources Canada and Canadian electrical utilities, through the Canadian Electrical Association, confirmed funding for research support for a performance-oriented version of the document. Both projects progressed together in a fully integrated way to produce what is now known as the new Model National Energy Codes.

Prospects for Federal and Provincial Implementation of a New Energy Code.

The fact that so many provincial energy ministries provided funding in support of a new energy code suggested that they intended to push harder for adoption of this code in their provinces. It was also presumed that there was greater chance of succeeding in view of increasing societal concern with energy as an environmental issue. Indeed, the endorsement by the Provincial/Territorial Committee on Building Standards (PTCBS), a committee of provincial code authorities, of the continued publication of the Measures indicated that provincial building regulation officials were not fundamentally opposed to regulation of building energy efficiency: they were only awaiting the appropriate signals from their political masters. On the other hand, they could not be expected to champion energy conservation in their codes, since they generally perceived their mandates as primarily related to health and safety. The federal government was expected to apply these codes to federal buildings, the only buildings where it has authority.

Helping the new energy code's potential adoption, were the facts that it was to be fully coordinated with the provincial and federal energy efficiency acts, which regulate appliances and energy-related equipment, and that the PTCBS had requested that the National Building Code include a mandatory cross-reference to the National Energy Code. Such reference, which would have made the Energy Code mandatory wherever the National Building Code is enforced, was to be included in the 1995 edition of the NBC. However, in 1995, the CCBFC abandoned the proposed reference in the National Building Code, since its newly developed Strategic Plan called for a freezing of the scope of the National Building Code. Therefore, the new energy codes are independent, but coordinated, documents that leave local authorities free to decide whether to adopt them or not.

MAIN FEATURES:

Two Separate Codes:

The need for a simple set of requirements for the housing industry had been identified in the preparation of the 1983 edition of the Measures and had led to the introduction of a distinct chapter dealing with houses. This time, the Standing Committee went even further in providing house builders with no more than what they need: while a more elaborate version of the new code covers all other buildings, a separate document presents a similar set of requirements, but written specifically for houses. The term "houses" is defined as including residential buildings of three storeys or less and having a building area not exceeding 600 square meters; this includes detached and semi-detached houses and most row houses.

Source:

The original Measures had been based on successive editions of Standard 90 of the American Society of Heating, Refrigerating and Air-Conditioning Engineers. Since then, that standard had evolved and its latest edition, ASHRAE Standard 90.1 (Ref. 4), was considered as a point of departure and guide for the development of the new National Energy Codes. A point of departure indeed because, with due respect to the efforts of the ASHRAE committees who produced this pioneering work with little resources other than the voluntary contributions of members, the Standard is not easy to understand and, having been written more as a guideline than a regulation, is not easily enforceable by law. Only later did ASHRAE produce a parallel code-language version of its standard. In Canada, significant resources and expertise were allocated to the new Energy Codes: this permitted definite improvements. We also drew extensively on the California experience in regulating energy efficiency, which proved helpful for adapting the requirements to Canadian climate and economic conditions and tailoring the wording and format of the Codes to the Canadian enforcement infrastructure.

Design Philosophy:

The new Energy Codes introduce new types of requirements. The code writers committed themselves to producing codes that are as easy as possible for designers and builders to conform with. Similarly, the requirements of the Energy Codes are equally easily enforceable by building officials. That philosophy implied that not all energy conservation measures could be covered by the codes and that a set of minimum requirements had to be defined that would still leave room for voluntary optimization of the building's energy efficiency features.

Adaptability to Regional Conditions:

The limited acceptance of the 1978 and 1983 Measures has been attributed, in part, to the fact that, being based on national average construction and energy costs and government priorities, they were appropriate for the country as a whole, but inappropriate for many of its regions. The Standing Committee resolved that the new national energy codes should, to the greatest extent possible, be based on defensible economic assessment. The codes had to be regionally sensitive, not only to the wide range of climatic conditions in Canada but also to the even wider range of energy prices and construction costs. Therefore, the codes were designed in such a way that the level of the requirements for many of the thermal characteristics of the envelope components would be tailored to reflect local conditions and economic parameters. The procedure was based on an energy analysis of a typical building or house and a life cycle cost evaluation of its construction and performance; it allows for regional variations in climate, energy rates and type of heating fuel, construction costs, other economic assumptions and environmental cost multipliers. A computer program was written to make the procedure easy to perform. Sander and Swinton, researchers from NRC, described this program and the procedure it follows in papers published in 1993 for houses (Ref. 5) and 1995 for other buildings (Ref. 6). Inputs to the program such as regional energy costs and economic assumptions were chosen in consultation with provincial and territorial officials.

• **Climatic Sensitivity.** Whereas the Measures' sensitivity to climate was based strictly on degree-days, the algorithms for energy analysis for the new codes are based on an energy analysis technique that accounts for internal gains, solar gains and heat loss through the envelope: NRC-developed correlations have been used for the analysis (Ref. 5 and 7). Below-grade losses were estimated using the proven Mitalas method developed at NRC. This allowed an evaluation of energy efficiency options for walls, roofs, windows and basement walls of buildings in a way much better related to local or regional climate.

• **Energy Sources and Costs.** Levels of requirements in the new energy codes have been set independently for each of the common fuel sources. Seasonal efficiency has been taken into account to ensure that results are based on equivalent energy costs. In regions where large differences in effective cost of the various energy sources make it awkward to have a single set of requirements, such separation of the energy sources has permitted the definition of envelope and related requirements which are economically justifiable, a feature that would have been impossible if the same requirements had applied to all fuel types.

• **Construction Costs.** A large number of typical construction assemblies for building envelope components (roofs, exterior walls, windows, foundation walls) have been identified and their construction costs carefully estimated. Taking the lowest estimated cost assembly as the base case for each envelope component, the cost increments for assemblies with higher thermal resistance were combined with the present value of the decrement in energy loss through each assembly over an estimated useful life. This is shown for exterior walls in Figure 1. The assembly with the lowest combination of first cost increment and life cycle energy loss decrement is the optimum choice. However, often there is no clear-cut winner or the total for the winner is only marginally less than for assemblies on either side. In these cases, the provinces and territories were able to exercise judgement in choosing which RSI value to make the minimum requirement. In many such cases, the logical choice was to favour a lower RSI value since these helps to minimize the effect of the codes on the affordability of buildings while having only a small effect on life cycle cost.

Figure 1

Life Cycle Cost of Wall Insulation

Toronto-Ont., Electric heated, 2 storey full bsmt. 1990$

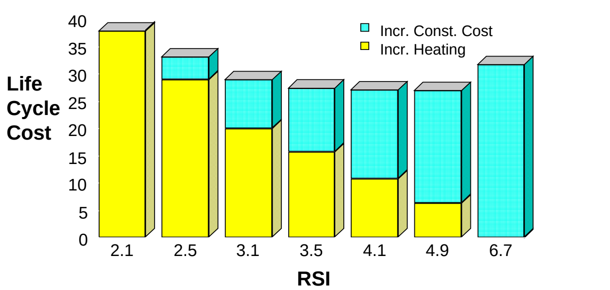
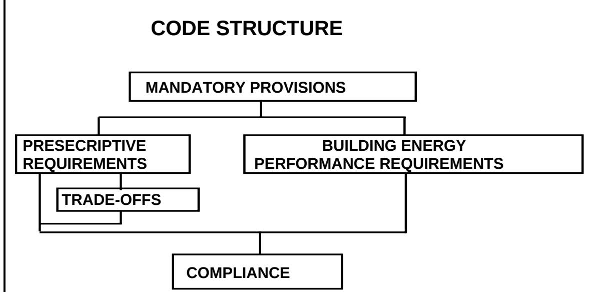


Figure 2



- **Other Economic Assumptions.** Other economic parameters used for life cycle costing are as follows: expected inflation rate, interest above the inflation rate, expected fuel escalation above inflation, discount rate and economic life of the building components. Provinces and territories were able to adjust these parameters as they deemed necessary, although they responded well to NRC's encouragement to harmonize them across the country as much as possible.

- **Environmental Cost Multiplier.** The procedure for setting levels of requirements allowed provinces and territories to adjust code requirements regionally to take into account the environmental costs associated with energy generation, transportation and use. To achieve this, a multiplier has been applied in the life cycle cost process to the energy cost of each fuel. The provinces and territories generally applied a factor of 1.0, since there was little data available on which to base any other choice, although most believed that a higher factor would be justified.

Three Compliance Paths:

Beyond basic mandatory requirements that cannot be by-passed, the new Energy Codes feature the same alternate routes for compliance as ASHRAE Standard 90.1. Figure 2 shows the alternate compliance processes.

- **Prescriptive Requirements.** The first route is a prescriptive one, similar to the previous Measures, which generally dictates energy conservation measures that can be stated as specific instructions, such as minimum thermal characteristics for envelope elements and minimum efficiencies for mechanical equipment.

• **Trade-offs.** The second route is somewhat related to the several articles included in the previous Measures which gave some degree of flexibility to the requirements with respect to the envelope. It allows the user to reduce thermal resistance in one portion of the envelope, such as a wall, a window or a roof, provided that the thermal resistance in other areas is increased so that the heat loss of the building is not increased. This route is meant to be an easy way to make small adjustments to the characteristics of the building envelope without having to go the full performance route.

• **Performance Path.** The third route is a performance path: if one finds some aspects of the prescriptive route too limiting, one may design a building with any thermal characteristics desired, provided that the building as designed will not have a calculated energy consumption under standardized conditions that is greater than it would have been if the building had been designed in strict conformity with the prescriptive requirements, all other aspects of the building (which are not the object of a requirement in the Energy Codes) remaining the same in both cases. Developments in computers and software have made the eventuality of a performance-based energy code a practical possibility. The proof of conformity in the performance route can be made through two energy analyses, one on the building as it would meet the prescriptive requirements, giving the "target" performance, the other on the actual design for which a building permit is requested. There are no standard maximum energy budgets in dollars or gigajoules; the building is in fact compared to its own custom energy budget; this approach has freed the Energy Codes and the enforcement authorities from having to define budget values for all types of building uses, sizes and occupancies.

Use of Computers:

The new energy codes have been prepared with computer use in mind. Requirements and conditions for the trade-off and the performance path, where application was planned to be computerized, have been formulated so that they can be readily be ported to energy analysis software or turned into stand-alone programs without loosing their integrity. Specifications have been prepared which could be used for writing code-compatible compliance software. Prototypes have been developed for use with the codes, but this field is open to private sector developers and vendors.

• **Trade-off Compliance Software for Code Users.** Trade-offs is one area where ease of implementation is essential if this path is to be regarded as a valuable and quick alternative to the performance path and used readily by even less sophisticated users. Algorithms have been developed that allow trade-off within the building envelope requirements without need for calculating any component areas other than the building floor and window areas.

• **Performance Compliance Software for Code Users.** If compliance to the performance path of the new energy code can be done through the production of two energy analyses on the building, neither the designer nor the inspector want to wade through the standard input and output parameters that regular building energy simulation tools require. In order to simplify the input of information required to verify compliance and the output form to prove it to the authority, the CCBFC has prepared specifications for the development of front ends that can be added to commercial building simulation programs to restrict input parameters to what the codes need and allow. Standardization is essential to ensure that code compliance checks can be identical no matter what simulation package is used.

CONCLUSION:

Canada now has new model codes for regulating the energy-related characteristics of houses and other buildings. It is expected that these will be useful to the construction industry and to adopting authorities. They have been designed to facilitate adaptation to suit regional climates, economic conditions and government environmental priorities. The pioneering use of computers within a National code environment has facilitated this adaptation process as well as the achievement of the design flexibility offered by the codes' integration of prescriptive and performance approaches.

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