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A Case Study: Proposed Insulation Requirements for Ceilings and Opaque Walls

Fourth in a Series of Studies on Government Regulatory Activity

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FOREWORD

In recent years, increasing concern has been expressed both inside and outside government about the social and economic impact of government regulatory activity. On the one hand, the regulatory process itself has been faulted for being insensitive to public needs and opinions while, on the other hand, doubts have been expressed concerning the efficiency and effectiveness of particular regulations, standards or guidelines. More specifically, with the onslaught of serious inflationary problems, it has been argued that regulations may be unnecessarily adding to costs and prices. In fact, it was in the context of the establishment of the Anti-Inflation Board and the resulting debate on controls and post-controls policies that the Cabinet directed the Department of Consumer and Corporate Affairs and the Treasury Board Secretariat to assess the feasibility of applying cost-benefit and related methods of analysis to government social regulations, and to suggest modifications to the regulatory process which might encourage greater public participation.

In response to this mandate, a Working Group on Social Regulations, chaired by François Lacasse of the Treasury Board Secretariat, was established. In the Department of Consumer and Corporate Affairs, the project was originally directed by Lawson Hunter and subsequently by Dale Orr. Other members of the Working Group included Harry Baumann (Project Manager), Bruce Montador, Michel Proulx, André Morin and Joan Huntley (Treasury Board Secretariat) and Lee McCabe and Ron Hirshhorn (Consumer and Corporate Affairs). As well, the Working Group received advice on legal matters from Allan Rosenzveig (seconded to CCA from the Department of Justice). The Federal-Provincial Relations Office made available the services of Richard Schultz as a consultant on jurisdictional problems between levels of government in the regulatory area. In addition, the Working Group received considerable help on technical matters from the Departments of Transport, Environment, Health and

Welfare, Energy Mines & Resources as well as the National Research Council and the Atomic Energy Control Board.

Because of the nature of the mandate and the limited resources, the Working Group pursued the following operational strategy. First, it concentrated on health, safety and fairness regulations leaving aside economic or rate-setting regulations. This decision proved to be fortuitous since little research on social regulations has been carried out in Canada, and more extensive provisions exist for public participation in the rate-setting process. Second, the Working Group decided to study both the allocative and non-allocative effects of regulations. In other words, the Working Group was concerned not only with the impact of regulations on economic (market) efficiency, but also their impact on (a) the distribution of income - who pays, who benefits (b) technical progress (c) international competitiveness (d) regional balance (e) market structure (f) inflation. Third, the Working Group decided to prepare two types of background papers. The first type were general studies on the reasons for social regulation, the US experience with regulatory reform, the regulatory process in Canada and techniques for the evaluation of regulations. The second group of papers consisted of case studies of representative regulations of recent vintage in the health, safety and fairness area.

Since a major purpose of this project was the examination of various mechanisms for encouraging greater public input into the regulation-making process, we have decided that selected background papers and case studies prepared by the Working Group should be published in order to increase public awareness of this very important aspect of government activity.

Sylvia Ostry
Deputy Minister-CCA

Maurice LeClair
Secretary-TBS

TO THE READER

The analysis presented in this paper was completed in early 1977. It examined the original draft proposals for a new, stronger set of energy guidelines within the Residential Standards prepared by the National Research Council of Canada. These proposals had been made by the Division of Building Research of the NRCC in their internal report No. 433. The final proposals prepared for the Associate Committee on the National Building Code were contained in <u>Canadian Code for Energy Conservation in New Buildings - Draft for Public Comment</u>, NRCC, June 1977.

In their final form, the proposals affecting insulation requirements were not exactly the same as those analysed in this study. The original draft had suggested minimum insulation (R) values for walls and ceilings in buildings facing heating seasons of varying lengths. Each minimum R value was assigned to a <u>range</u> of heating-season lengths: for example, walls would require insulation of R value no less than 17 in buildings facing heating seasons of 6,300 to 9,000 degree-days Fahrenheit (for a definition see Part 2 of the study). To assess the proposed new insulation requirements, a specific heating-season length rather than a range had to be chosen. The proposed requirements for each range were originally calculated for a heating season towards the lower end of the interval (in our example, 7,200 degree-days Fahrenheit). We examined the value of the new levels for a heating season 8,100 degree-days long, to be as fair as possible to the proposals (since the profitability of a given insulation level increases with the length of the heating season).

However, in their final form, the proposed guidelines were changed: instead of assigning an R value to a <u>range</u> of heating seasons, they assigned it to the upper limit of the range with which it had originally been associated (in our example, 9,000 degree-days). Intermediate values were to be determined by interpolation. As a result of this change, the cost of the proposed guidelines is less than in the analysis presented here, since the insulation required is less for almost all heating-season lengths.

The impact of the change is to partly offset the negative conclusions drawn by the study. The original proposals were found to be too severe because they were based on what were felt to be a too rapidly rising price of energy and a discount rate that was too low. The modified proposals still appear overly severe but they differ from the optimal level only by an amount less than that explained by the difference in the choice of discount rate. This can be seen by examining Table 2 in Part 3, where a two-per-cent annual increase in real energy prices and a 10-per-cent discount rate imply an optimal R level in our example of 12.43; with a five-per-cent discount rate the optimal R level rises to 16.34. The new required R level for 8,100 degree-days would be, by interpolation (see Appendix A), about 16.1.

At the time of writing, the Associate Committee on the National Building Code had not yet made a final decision on the proposals.

SUMMARY

This case study examines proposed changes in insulation standards, which would apply to all NHA-financed homes and eventually, through changes in provincial and municipal building codes, to most new houses in the country. A particular but representative example was studied in detail. It was found that, from an economic standpoint, the increases in the requirements are either too large (ceiling insulation) or unjustified (wall insulation). This conclusion arises because the regulations were designed using a discount rate that was excessively favourable to future generations (compared with the consideration given to them in other government undertakings) and were based on an assumption about real world energy prices of the future that was substantially more pessimistic (over the next 30 years) than assumptions made by other government agencies working in the energy field.

In a less economic framework it might be possible to justify the larger increases in required insulation levels. To do so, however, would require more explicit assumptions about the "special" nature of energy, explaining why and by how much Canadians should make extra-economic efforts to conserve energy. Moreover, once this explanation were given, the implications would affect not only the new-housing sector of the economy, but all energy-using sectors (transportation, packaging, etc.). To justify the additional, non-economic levels of insulation is to justify many other forms of government intervention to conserve energy. If this is the case, an attempt should be made to quantify the "premium" that these proposals implicitly attach to energy in order to permit the uniform evaluation of all projects designed to conserve or produce energy.

1. INTRODUCTION

Originally the regulations and guidelines in the National Building Code and the Residential Standards were designed to ensure that construction practices produced sound buildings. More recently, there has been concern that buildings, and dwellings in particular, be constructed so as to provide good value for consumers. Of particular importance was the desire to prevent a repetition of the unpleasant surprise that homeowners received from the energy price rise that occurred after 1973. Homes that had been designed for a world of low (and falling real) energy prices suddenly seemed inadequately insulated. Although the federal government has no direct authority over provincial building codes, the National Building Code, which serves as a model for many provincial and municipal building codes, was equipped with an energy guideline annex, which was incorporated into the CMHC's Residential Standards. These standards must be met by all buildings financed under the National Housing Act. (Since new houses are only a small part of the total housing stock and will remain so for many years, the standards themselves will not initially mean a very large energy saving. However a large publicity program has been launched to encourage the "retrofitting" of existing houses by upgrading the efficiency with which they use energy.)

Since the 1975 Residential Standards were written, work has continued, and a new set of energy guidelines has now been drafted. The proposals include restrictions on lighting and on the size of windows, as well as lower limits for the thermal resistance (insulation) of the building envelope. However, this case study will consider only the insulation requirements for opaque walls (i.e., excluding doors and windows and their frames) and for ceilings or roofs of combustible structures. Moreover, to simplify the estimation of the cost of additional insultation, it will be assumed that the houses are of wood-frame construction.

In order to analyse the regulations this study deals with, it is necessary to consider their raison d'être. There appear to be two, possibly three, justifications for government intervention requiring a certain level of insulation in homes. First, there is the question of consumer protection: the house-building industry, on both the demand and the supply sides, may be slow to react to new energy prices or it may not react at all. At present, the most important financial characteristic of a house is the monthly payment of principal, interest, and taxes (PIT). With the increasing importance of home energy use, this figure should be increased to include the cost of heating (PITH). If PITH becomes a universally accepted formula for calculating the cost of buying a house, the resulting effect on market demand would make it profitable for builders to increase insulation to the extent justified by current energy prices. Since this change has not yet taken place, regulation may protect home buyers from inefficient insulation levels during the transition period. A less universally accepted justification is the assumption that a proportion of home buyers are ignorant and therefore need to be protected. This argument goes much further than consumer protection against rusting cars, for example, as the housing industry is less monopolistic than the automobile industry and is not, by insufficiently insulating its products, creating additional demand three or four years later. Nevertheless, it is probably one of the major valid arguments for regulation, in the medium term, as the heating-cost factor does not yet appear to be affecting housing prices significantly.

Secondly, there is the energy conservation aspect of insulation. Because the world price of energy (not the artificially low Canadian price) represents the true cost of energy for Canada, there is an argument for ensuring that the investment in insulation be geared to it rather than to the Canadian price. This argument will remain valid for as long as the Canadian price remains significantly below the world price, since individuals will not use the world price to estimate their present savings and are unlikely to use it to estimate their future savings. Moreover, if the _real_ world price of energy is going to rise in the future, then intervention may be needed to ensure that investment decisions are made with this in mind. This assumes that individuals will not be aware of the correct rate of price increase, nor be able to capitalize the value of their investment should they sell their house. This argument is open to dispute because of the widely varying opinions on the future of the world price of oil and other forms of energy. (The conservation justification is _a fortiori_ valid if energy requires a "shadow" value higher than the world market price; see below and Part 5.)

It is the future world supply and price of energy that are the critical variables in the analysis of energy conservation projects and alternative energy sources such as tar sands, nuclear plants, and northern pipelines. In this study it is assumed that the future world price of energy will reflect the increasing scarcity and the increasing cost of new energy supplies. In other words, the standard methods of economic analysis will apply -- energy is a commodity like any other and none of its sources will be entirely exhausted.

The energy-value assumption of this study is that non-renewable energy sources will not be exhausted because possibly large price increases will prevent the total elimination of reserves of oil and natural gas in the foreseeable future, i.e., 30 to 60 years. (Coal is also a non-renewable resource, of course, but its known reserves are very much larger.) The basic assumption of the study will be a constant or slowly rising _real_ world price of energy over the next 30 years. This may appear incongruous when discussing energy conservation programs but it is the assumption used to analyse new, conventional energy-source projects. Moreover, the change in the energy component of the Consumer Price Index, in real terms, has only been about 20 per cent in the last six years. It is worth noting that the very large increases in energy prices at the source have a much smaller impact on final-product prices, even of energy or energy-intensive products, because of labour and capital costs and sales and excise taxes, which are included in final prices. As a result, the change in the relative price of energy may well do more to encourage conservation within the industrial process itself than at the level of the individual consumer, as firms attempt to substitute capital or labour for energy.

Once the Canadian price has reached the world price it may, for some time, grow slowly or not at all in real terms, as projects like nuclear plants and tar sands development appear to be reasonable prospects at that price. Nevertheless, the study will undertake a sensitivity analysis for differing rates of real price change, from -2 per cent a year to +6 per cent a year. Because of the dampening effect of fixed costs on changes in the price of crude oil, these differing rates -- which refer to the price of energy to the consumer -- reflect a much wider range of fluctuations in the price of crude pertroleum. One way to decide which assumption is appropriate is to remember that the same pricing hypothesis should apply to all energy projects.

The probability of the eventual exhaustion of fossil fuels and of constrained growth of energy supply in the long term has led some observers to recommend that, in analyses of energy problems, energy should be assigned a "shadow" price that is higher than its market value. No attempt at this has been made here. It should be noted that the removal of the sales tax on building materials from insulation materials, which is reflected in the cost figures, implicitly assumes that there is a "shadow" value for energy that is higher than the current Canadian price. Given the current gap between Canadian and world prices, however, the tax change does not imply that a premium above the world price is appropriate for purposes of analysis.

A final note -- many economists would argue that the provision of adequate information about the energy consumption required by different houses and, if necessary, about future movements in real energy prices, would be sufficient to create a "market" for energy efficiency as a housing characteristic. Some steps in this direction are being considered in other areas (see, for example, Ron Hirshhorn, A Case Study of the Proposals for Energy Consumption Labelling of Refrigerators, Policy Coordination Branch, Consumer and Corporate Affairs). The critical factor is the speed of adjustment in buying habits after an extensive campaign to publicize the value of the additional information. The decision to impose insulation standards implies an unwillingness to wait for the public to change its habits, or a scepticism about the possibility of such a change. If the adjustment were left to the marketplace, there would be more scope for a general approach to energy saving (the energy budget idea discussed in Part 5), but this paper will not attempt to compare the proposed regulatory changes with the alternative of "creating" a new market. Such a comparison would be highly subjective, as too little is known about the response of the consumer to additional information of this type.

This study has several parts. The next section contains a benefit-cost analysis of the proposed change in insulation standards. It is followed by: a calculation of optimal (in a sense to be defined) insulation standards; a socio-economic analysis of the impacts of the change in regulations; and comments on alternative means of conserving energy. A concluding section deals with the results of the evaluation.

2. BENEFIT-COST ANALYSIS

The existing residential insulation standards and the proposed new guidelines are given in Appendix A. These standards are established for specific heating seasons, while the levels for seasons of intermediate length are obtained by interpolation. The proposed new requirements are constant for intervals of 1,500 degree-days Celsius (ddC) long, or 2,700 degree-days Fahrenheit (ddF). (The length of a heating season is measured in degree-days. Each day constitutes that number of degree-days by which its average temperature falls below 18.3^{o}C, or 65^{o}F. N.B. All the calculations in this study will use the Imperial system of weights and measures in order to present the results in familiar terms. See Appendix A for additional explanations.) The standards were actually calculated for heating seasons 900 ddF longer than the lower limits of these intervals. For this evaluation the proposed insulation levels will be assigned to heating seasons that are 900 ddF shorter than the upper limits of the intervals. This section considers the case of a single heating season length of 8,100 ddF, approximately that of Kingston, and, because of the nature of the cost of construction data, examines only the regulations that apply to the roof/ ceiling and wood-frame walls of detached and row housing.

Since the methods of calculation that were used to derive the new guidelines were applied uniformly, such a calculation will be a reasonable indication of the overall value of the proposed insulation levels. The existing standards distinguish between electrical and all other forms of heating, but a change in the relative costs of different forms of energy has eliminated the need for this. The benefit-cost analysis will compare the old and new insulation levels for oil-heated homes. This <u>overestimates</u> the value of the change, as many home are already being built with insulation levels exceeding those currently required, particularly in the case of ceiling insulation.

The cost figures for the addition of insulation are given in Appendix B. They may not exclude all the fixed costs of building a wall without insulation, but this will not affect the analysis, as it is the change in cost for a change in the insulation (R) level that is important. The other important data required are present and future energy prices and the average operating efficiency of oil furnaces. The estimate of the operating efficiency of oil furnaces that will be used is 60 per cent; the actual efficiencies vary between 60 and 65 per cent and have not changed significantly in recent years. (The average operating efficiency of a furnace is defined as that fraction of the energy embodied in a fuel that is transformed into useful heat). The relevant current price of energy is the world price of oil. Since fuel oil currently sells in Canada for approximately 47.5 cents a gallon, its world-price equivalent has been estimated at 60 cents a gallon or approximately 3.6×10^{-4} cents per British Thermal Unit (BTU). As discussed above, the analysis will show the sensitivity of the return on insulation investment to differing assumptions about movements in the <u>real</u> world price of oil.

The Costs and Benefits

Regression analysis of the data given in Appendix B indicates that the cost of insulation is a function of the level of thermal resistance R; for wood-frame walls this function is: cost = $(14.60 + 6.47R)/100 ft^2; for ceilings it is: cost = $(0.52 + 1.93R)/100 ft^2. The cost for walls rises more steeply because more labour is used and because expensive adjustments to the wall structure are required for R values above 12 to allow for the thickness of the insulation. The costs of increasing the insulation level from 11.9 to 17.0 for walls and from 11.9 to 32.3 for ceilings are thus \$33.00 and \$39.37 per 100 square feet respectively. It should be noted that the cost functions are only valid for R values in the range for which point estimates are available. Higher levels of insulation may well be more expensive and lower levels less so. Since the bulk of the analysis deals with R values within the appropriate range, the warning only applies to the cases where the lower extreme is being considered.

The increase in R values will reduce the amount of heat loss through the walls and ceiling. The heat loss is the reciprocal of the thermal resistance, and so the energy saving will be, for walls: $\frac{1}{11.9} - \frac{1}{17} = .0252$ BTU/^{o}F hr ft^2 and for ceilings $\frac{1}{11.9} - \frac{1}{32.2} =$ .0530 BTU/^{o}F hr ft^2. Since the heating season is measured in degree-days, the heat saving must be changed from BTU/hr to BTU/day. For a reasonably well insulated home, the change is made by multiplying the hourly heat saving by 18 rather than 24 (see D.G. Stephenson, Determining the Optimum Thermal Resistance for Walls and Roofs, Building Research Note No. 105, National Research Council of Canada). Thus, the annual heat saving that results from the change in standards is 18 x 8,100 x 100 x .0252 = 367,416 BTU/100 ft^2 for walls and 18 x 8,100 x 100 x .0530 = 772,740 BTU/100 ft^2 for ceilings. To get the current value of the fuel savings, these figures must be multiplied by $\frac{1}{.6}$ (because only 60 per cent of the fuel consumed is converted to useful heat) and by the value of fuel oil when adjusted to reflect the current world price of oil, 3.6×10^{-4} cents/BTU, to get an annual saving of $6 \times 10^{-6} \times 367{,}416 = \$2.20/$ 100 ft^2 for walls and $6 \times 10^{-6} \times 772{,}740 = \$4.64/$100 ft^2 for ceilings. These annual savings will increase in real terms if the real price of oil increases.

The Net Present Value

The net present value of the proposed changes over the next 30 years (the economic lifetime of a new house) is thus:

$$- 33.00 + \sum_{i=1}^{30} \frac{2.20}{(1+r)^i} (1 + e)^i \quad \text{dollars/100 ft}^2$$

for walls and

$$- 39.37 + \sum_{i=1}^{30} \frac{4.64}{(1+r)^i} (1 + e)^i \quad \text{dollars/100 ft}^2$$

for ceilings, where r is the real social discount rate (which excludes general inflation) and e is the annual rate of change of the real price of energy. (The factor $\frac{(1+e)^i}{(1+r)^i}$ can be expressed as $(1 + \frac{r-e}{1+e})^{-i}$; $\frac{r-e}{1+e}$ is the net rate of discount.) Table 1 gives the net present value of the changes in insulation requirements for varying values of r and e. The accompanying graphs illustrate the sensitivity of the net present value to changes in the discount and real energy-price growth rates. It can be seen that, at a 10-per-cent real discount rate (the rate used for government investment projects) and with either a constant real energy price (the central assumption being used to evaluate the major energy projects in this country) or a two-per-cent real price growth, the change in wall-insulation requirements is clearly unprofitable. At this discount rate, the rate of increase in the real price of energy would have to be at least 4.5 per cent per year to justify the change. Such a growth rate implies a nearly fourfold increase in the real world price of oil over 30 years to something over $50 (1977) a barrel. On the other hand, the change in ceiling insulation levels has positive economic consequences.

The data that have been used have, with one exception, been relatively favourable to the guidelines; the one exception is the cost of insulation, where relatively pessimistic assumptions were made. The unfavourable effect of this pessimism is limited, however. This can be seen from Table 1, where a single (respectively double) asterisk against the net present value associated with a discount rate-energy price assumption indicates that the change in insulation levels is economically viable with a 10-per-cent (respectively 20-per-cent) reduction in the installation costs (per unit of resistance) as estimated in the cost function.

Table 1

NET PRESENT VALUE OF PROPOSED CHANGES IN
WALL AND CEILING INSULATION REGULATIONS

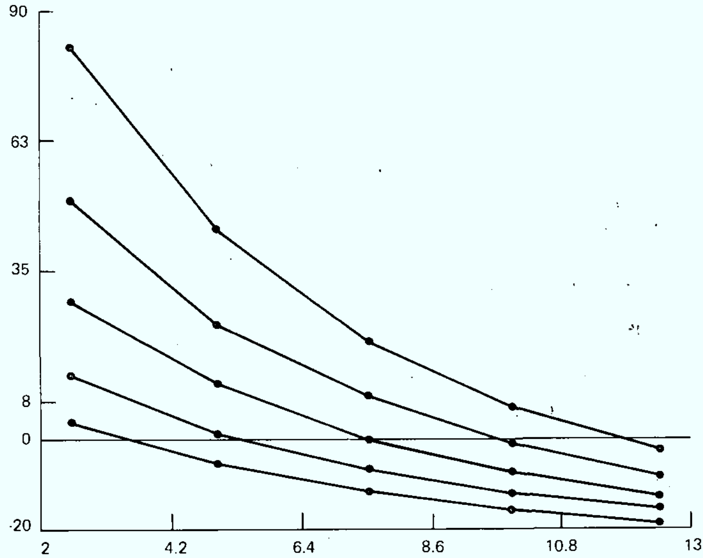
Discount Rate	Real Energy Price Change (per cent per year)	Net Present Value of Wall Insulation ($ per 100 ft^2)	Net Present Value of Ceiling Insulation ($ per 100 ft^2)
12.5	-2	-18.37	-8.58
	0	-15.91	-3.38*
	2	-12.76	3.23
	4	- 8.62	11.93
	6	- 3.15*	23.46
10	-2	-15.60	-2.67*
	0	-12.25	4.39
	2	- 7.85	13.67
	4	- 1.96*	26.10
	6	6.12	43.13
7.5	-2	-11.73	5.50
	0	- 7.02	15.43
	2	- 0.64*	28.88
	4	8.16	47.44
	6	20.48	73.43
5	-2	-6.09**	17.38
	0	0.81	31.95
	2	10.45	52.27
	4	24.11	81.08
	6	43.69	122.38
2.5	-2	2.44	35.38
	0	13.05	57.74
	2	28.25	89.81
	4	50.31	136.37
	6	82.81	204.88

* profitable with variable insulation costs reduced by 10 per cent

** profitable with variable insulation costs reduced by 20 per cent

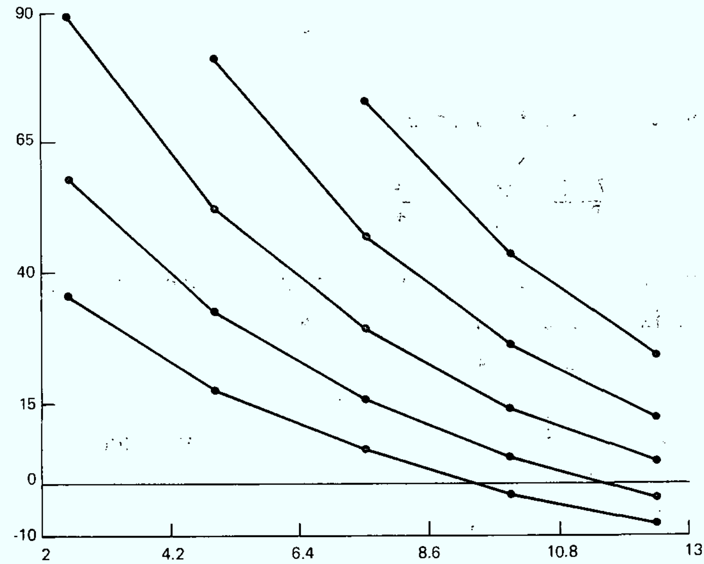
Graph 1

Net present value (in dollars per 100 ft^2) of proposed change in wall insulation requirements as a function of the discount rate



Graph 2

Net present value (in dollars per 100 ft^2) of proposed change in ceiling insulation requirements as a function of the discount rate



Note: The five different levels in each graph correspond to the five different assumptions about the future changes in the world price of oil, ranging from – 2 per cent per year (bottom line), no change, + 2 per cent, + 4 per cent to + 6 per cent per year (top line).

3. OPTIMAL INSULATION LEVELS

This section describes an alternative way of using the data and the assumptions of the benefit-cost analysis. Instead of examining the costs and benefits of the proposed change in standards, we have derived optimal insulation levels for walls and ceilings. Optimal in this context means those insulation levels which minimize discounted life-cycle (30-year) costs for heating and insulation. To put it another way, we have found those insulation levels which, as new, compulsory levels, would maximize the net present value of the change in regulations. It is the value of the standards in purely micro-economic terms that is maximized however; no consideration is made here of larger, macro-economic issues, such as national security or the balance of payments.

The insulation cost functions are, as before, in dollars per 100 ft^2, cost = 14.60 + 6.47 R for wood-frame walls and cost = 0.52 + 1.93 R for roofs or ceilings. The heating cost per 100 square feet and per year is

$$\frac{1}{R} \times 100 \times 18 \times 8{,}100 \times \frac{1}{.6} \times 3.6 \times 10^{-4} = \frac{\$87.48}{R}$$

The discounted present value of 30 years of such heating bills is

$$\frac{\$87.48}{R} \sum_{i=1}^{30} \frac{(1+e)^i}{(1+r)^i}$$

where e and r are as defined in the previous section. The optimal value of R is thus the insulation level that minimizes the discounted life-cycle cost functions:

$$\$14.60 + \$6.47\ R + \frac{\$87.48}{R} \sum_{i=1}^{30} \frac{(1+e)^i}{(1+r)^i} \qquad \text{for wood-frame walls and}$$

$$\$\ .52 + \$1.93\ R + \frac{\$87.48}{R} \sum_{i=1}^{30} \frac{(1+e)^i}{(1+r)^i} \qquad \text{for roofs}$$

In Table 2 these optimal values are shown for the same combinations of discount rate and growth rate of real energy prices that were used in Table 1. It is apparent that the optimal levels, for both walls and ceilings, are substantially below the proposed new standards if a 10-per-cent discount rate and a 0 or two-per-cent rate of real growth in the price of energy are used. They remain below the standards for all combinations of r and e that give a net discount rate $(\frac{r-e}{1+e})$ of at least 2.5 per cent. The accompanying graphs indicate the functional dependence of the optimal insulation levels on r and e as well as the relationship between optimal levels and the existing and proposed standards.

Table 2

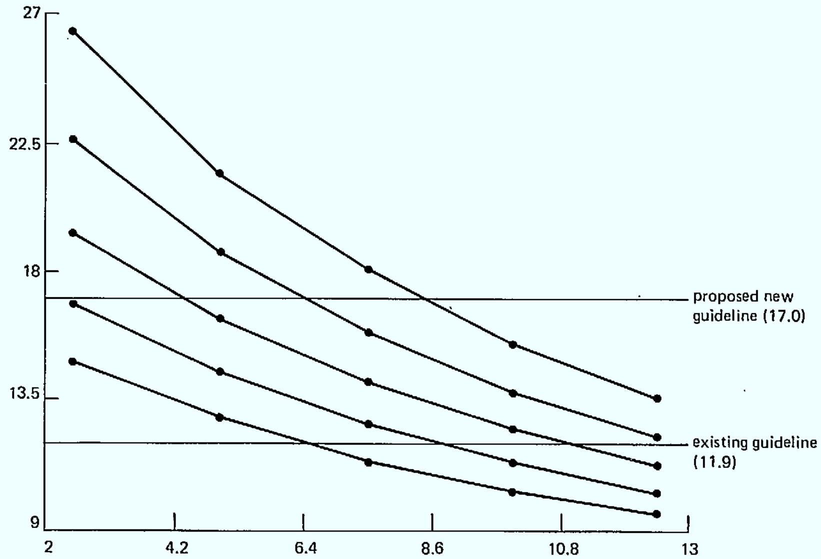
OPTIMAL INSULATION LEVELS
FOR WOOD-FRAME WALLS
AND CEILINGS

Discount Rate	Real Energy Price Change (per cent per year)	Optimal R Value Walls	Optimal R Value Ceilings
12.5	-2	9.48*	17.36*
	0	10.25*	18.77*
	2	11.15*	20.42
	4	12.24	22.41
	6	13.55	24.78
10	-2	10.34*	18.93*
	0	11.29	20.67
	2	12.43	22.76
	4	13.81	25.29
	6	15.50	28.39
7.5	-2	11.43*	20.94
	0	12.64	23.14
	2	14.10	25.82
	4	15.91	29.12
	6	18.13	33.19
5	-2	12.86	23.54
	0	14.42	26.39
	2	16.34	29.92
	4	18.74	34.30
	6	21.53	39.42
2.5	-2	14.76	27.02
	0	16.82	30.80
	2	19.40	35.52
	4	22.63	41.43*
	6	26.68*	48.85*

*Indicates an optimal insulation level outside the range of R values for which cost functions have been estimated.

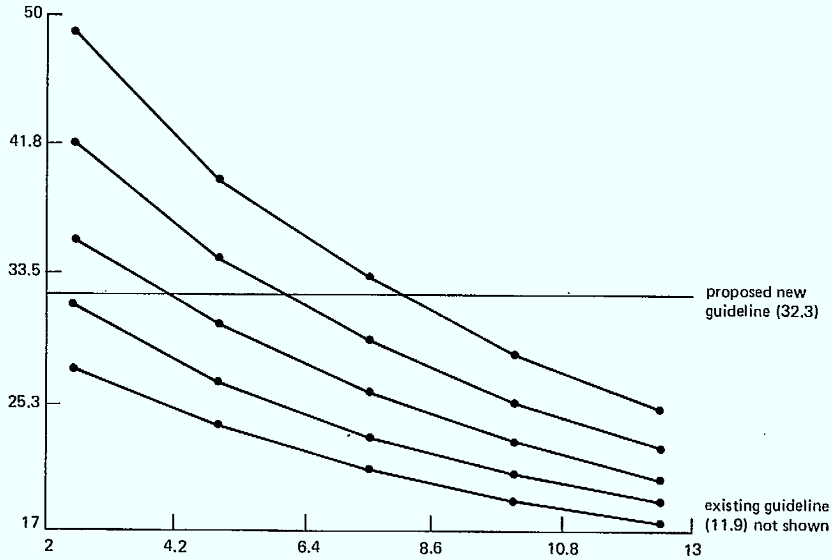
Graph 3

Optimal wall insulation as a function of the discount rate



Graph 4

Optimal ceiling insulation as a function of the discount rate



Note: The five different levels in each graph correspond to the five different assumptions about the future changes in the world price of oil, ranging from − 2 per cent per year (bottom line), no change, + 2 per cent, + 4 per cent to + 6 per cent per year (top line).

4. ANALYSIS OF THE NON-ALLOCATIVE EFFECTS

A regulation cannot be studied thoroughly by the purely mechanical methods of benefit-cost analysis or related techniques. Regulations, social regulations in particular, are made in response to problems for which market or market-type solutions -- taxes, subsidies, etc. -- are inappropriate or impracticable. To some extent, the impact of a regulation on these problems and its effects on the market or markets involved can only be discussed in a framework less rigid, or more descriptive, than benefit-cost analysis. This section will attempt to describe the new insulation regulations from this wider point of view; we will look at the impact of the new regulations on inflation, market structure, income distribution, international trade, and the dynamic efficiency of the Canadian economy.

Inflation

The proposed regulations will raise the price of houses and, to a lesser extent, of apartments, but the extent of this increase is unclear because the price of housing is far from being entirely supply determined. Nevertheless, one can assume that over time the increase in costs will have some effect on the price of housing. To get an idea of the impact of the changes, one can examine the additional cost of meeting the new standards as compared with the old (recalling that this will overstate the impact, as many new houses already exceed the existing standard, particularly for ceiling insulation). If one considers a one-storey detached house with a heating season of 8,100 ddF, 20 feet by 40 feet, and 10 feet high, then there are 800 square feet of ceiling to be insulated, and the walls are 1,200 square feet of which perhaps 900 square feet are opaque. The increased cost of meeting the new guidelines is then about 8.0 x 20.2 x \$1.93 + 9.0 x 5.1 x \$6.47 = \$608.86 for the insulation alone (using the cost estimates from Appendix B.)* Because some of the non-construction costs of houses (such as interest paid by the builder, realtor's and lawyer's fees, etc.) depend on the value of the house, the impact on housing prices might well be larger than this. However, the impact on the Consumer Price Index (CPI) would probably be negligible, as home ownership costs are derived from indexes of construction wages and prices of building materials. Unless the building materials price index were affected by increased use of insulating materials, and it is not, the increase in costs (resulting from an increase in the use of the materials with no accompanying price rise) would go unreflected in the CPI.

Another price problem that may arise is the production of 2-inch x 6-inch lumber. Such lumber may be needed to satisfy the new requirements in the absence of new types of insulation (see below). This could have major short-run price implications, as capacity to produce "two-by-sixes" is limited at present.

The important factor to remember is that the inflationary impact is there whether or not the project is beneficial. The benefits are in terms of energy saved, and it is unrealistic to expect a reduction in, for example, oil consumption by Canadian households to affect the world or the Canadian oil price. This is true for many regulations and should be remembered when using changes in the CPI to measure the "inflationary impact" of new or changed regulations.

Market Structure

The impact of the new insulation guidelines on the market for insulation materials is difficult to estimate. The production of

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* On this estimate, the construction of 100,000 homes (for which this calculation is typical) per year would imply an annual impact of the change in regulations of $60,000,000.

conventional types of home insulation is fairly concentrated, and one firm -- Fibreglas Canada Ltd. -- is the clear market leader. The growth in demand has been rapid in recent years, and so the industry should be in a position to cope with continued growth. The effect of the new regulations would not be as dramatic as the magnitude of the change in regulations would lead one to believe. Many houses already exceed the existing requirements, and only N.H.A.-financed homes would be affected initially. There does not appear to be too much danger of increased concentration in this already very highly concentrated industry as a result of the increased demand for insulation. Moreover, present and past capacity appears sufficient to allow the industry to meet this additional demand, unless retrofitting of older homes is undertaken at too rapid a pace (see Part 5).

Distribution

The impact of the changes in standards on the real incomes of various groups should not be too large. The cost of building apartments will rise less than that of new houses, but the energy savings will also be less. One distributional consequence from economically justified insulation increases would be the reduced accessibility of home ownership at the margin. Government mortgage assistance is only available at incomes above a certain minimum level, which depends upon the PIT (principal, interest, and taxes) payments on the house. These payments would increase because of the increased cost of housing, and no allowance would be made for the reduced energy costs. Therefore fewer lower income people would be eligible for such assistance. On the other hand, those whose incomes were high enough to allow them to purchase a house would benefit from increased interest subsidies if they were eligible for such subsidies (and more higher income people would be so eligible), the lower costs of heating notwithstanding. Such an effect can be entirely neutralized if housing authorities move to the use of PITH (principal, interest, taxes, and heating) as a measure of ownership costs instead of PIT. (Note: The shift involved here is not large -- if the costs of buying the house went up by $700, and the mortgage rate was 11 per cent, then the annual interest charges would rise by $77. Home buyers whose incomes were up to $308 per year more than the previous limit would then no longer be eligible for interest subsidies.)

A more important potential redistribution is from new home buyers to future owners of today's new houses. The proposed insulation standards were chosen on the basis of an assumption of rapidly rising real energy costs. If this is valid, buyers of today's new houses will get, during the first years, substantially less in savings from the marginal unit of insulation than they will pay in interest on the cost of that unit. Unless housing prices come to reflect more accurately the energy efficiency of otherwise identical homes, there will be a net redistribution from the first to subsequent owners of new houses. Should energy prices fail to rise as expected, the redistribution will be more of a misallocation of resources. However, future house buyers would presumably still benefit if the lack of change in real energy prices kept "energy consciousness" low enough to prevent the full capitalization of the value of the excessive insulation installed in 1977.

The regional impact of the change should be relatively neutral, as the very bulk of insulating materials requires their production at points close to potential markets. As a result, there are factories in all the major regions of the country.

International Trade

The balance on current account should be favourably affected by the change, as the vast majority of insulation materials are domestically produced (an exception is a company in western Canada, which imports to maintain its market share while building a new plant), and the energy saved is either exportable or will reduce imports, depending on the region being considered. The only caveat to this is the degree to which energy is required to produce insulation, fibreglass in particular. As long as the level of insulation is increased to an economically justifiable level, the net impact on the energy trade account should be favourable, at least in the long run. Suppose the house described earlier is typical of the ones affected by the new regulations and that the heating season of 8,100 ddF is representative. After 10 years the impact of the regulations on 150,000 such houses a year would be a saving of the energy equivalent of over four million barrels of oil per year, assuming that all the houses meet the new standard and that, in the absence of the regulations, would have only met the old standard. This is less than one per cent of our current annual consumption of oil.

Dynamic Efficiency

Since the regulations do not imply major technical changes, it is unlikely that the dynamic effects will be important. There is one exception to this: in most houses wall insulation must fit into a four-inch space; present types of wall insulation require more space to satisfy the proposed new levels. Given the existing market structure, it is unlikely that thinner insulation, should it be produced, would significantly affect the level of competition in the industry.

5. ALTERNATIVES

The conservation of energy in the home is actually a far more complex question than would appear from the discussion so far. Insulation is only one example of the measures that can reduce the energy resources consumed in the home. Broadly speaking, there are two quite distinct aspects to the question.

The first, of which the insulation guidelines are an example, is the redesigning of homes to take into account the change in the relative price of energy. If the appropriate level of insulation is chosen, a consumer will be better off; he will in fact have more money left to purchase goods and services, without having lost anything in the process. Similar results could occur with more efficient furnaces and household appliances, better weatherstripping, double glazing of windows (as long as one could open them in the summer) and, possibly, redesigned buildings with most windows facing south.

A quite different method of tackling the problem is by a change in consumers' attitudes. They would have to abandon or reduce activities that at present they prefer to the alternatives. Such changes could include accepting houses that are cooler than at present, making less use of electrical appliances, and self-rationing of hot water and electricity. This type of change can only occur without implying a loss in welfare if it takes the form of a gradual adjustment. In policies designed to encourage conservation in existing homes, it is important to take note of this, as attempts to equate improved insulation with setting the thermostat at a lower temperature (which identifies in the public's mind a profitable investment entailing no loss in welfare with something that "hurts but is good for you") might well lead to an understandable, if regrettable, reluctance to upgrade the insulation in one's home. Retrofitting might be seen as yet another example of the government trying to tell people what to do.

There is an intermediate position between these two extremes; it is probable that consumers are not yet fully aware of the new higher cost of their energy-intensive consumption habits. Some downward adjustment in energy demand could be expected to follow increased awareness of the new, higher price of these habits. A more rational attitude towards energy pricing could also lower peak energy demand and thus lower capacity requirements. Peak-load pricing in particular could reduce daily fluctuations, although seasonal fluctuations are less amenable to such treatment.

The current set of proposals includes other conservation measures in addition to the insulation guidelines. Upper limits on window areas and lighting fixtures are included. The window restriction involves an imposed reduction in consumption. The limits on lighting are somewhat ambiguous; they do not prevent portable fixtures, and there has been some argument in favour of a reduction in lighting intensity for health reasons. The most important point to note about the current proposals is that they treat each aspect of conservation separately. Work is continuing on the development of an energy-budget approach, which would permit a building to mix various forms of energy conservation so long as the total energy use (per unit of floor area) is below a certain limit.

The following discussion shows in a simple fashion how the interaction of different conservation measures can change the results of each measure considered separately. The alternative conservation measures to be considered are the improvements in wall and ceiling insulation already discussed and a possible investment to improve the average operating efficiency of oil furnaces from 60 to 70 per cent. (Note: There are proposed and working innovations that would increase the efficiency of oil burners, in particular a device to prevent heat from escaping up the flue when the burner is not firing. However, the improvement and the required investment discussed below are entirely hypothetical.)

If such an investment to improve furnace efficiency can be made, it will be socially profitable, with a constant real world price of oil and a 10-per-cent discount rate, if it costs no more than 80 cents per gallon of fuel oil used each year. The exact upper limit is $808.02 for a home that uses 1,000 gallons a year and is insulated to the existing rather than to the proposed standards. What is interesting is the effect on the profitability of insulation investment if the furnace has already been improved. In fact, the optimal levels of investment in wall or ceiling insulation are reduced by 7.5 per cent if the average operating efficiency of the furnace is 70 per cent instead of 60 per cent. Similarly, the maximum acceptable cost of the improved furnace efficiency would also fall if the insulation investment had already taken place. However, this sequential method of analysis should ideally be replaced by one that compares simultaneously the discounted net costs of construction and energy use over the lifetime of the house for all possible combinations of investment and energy utilization.

The discussion so far has dealt with alternative ways of reducing energy consumption in new homes. The stock of existing houses is far larger than the annual increment to that stock. As a result, the impact of measures designed to encourage the retrofitting of older homes to meet higher insulation standards could be much more important than that of severe insulation standards for new houses. Moreover, the cost of insulating older homes is much less than one might expect; cost submissions in the Ottawa area indicate a cost per square foot similar to that shown in Appendix B for wall insulation of about R12. The additional cost of insulating after the house is completed is offset by the labour savings that result from the more mechanized retrofitting process. It follows that calculations similar to those in Part 3 would show that optimal insulation levels for both walls and ceilings are roughly the same, whether one is retrofitting an old house or building a new one.

Since the marginal return on investment declines as insulation is increased, it makes more sense to improve the poor insulation in older homes rather than to go beyond the "optimal" level in new homes. However, it is not very practical to think in terms of regulation when dealing with retrofitting, and, in spite of its profitability, individuals may be unwilling or unable to undertake the retrofitting of their homes. A combination of information services and subsidies might be necessary to ensure that this socially profitable investment be undertaken. Nevertheless, it is important that individuals not be misled about the magnitude of the profit that an investment would yield, and that financial assistance of whatever form increase private retrofitting investment, and not just pay for what would be undertaken anyway.

The preceding discussion of alternatives was based on a strictly economic interpretation of the problems of energy conservation. Because of this narrow focus, attention was restricted to alternatives that addressed the problems of micro-economic maximization. The problems of energy conservation can be, and indeed often are, discussed in a macro-economic framework, with consideration given to problems such as the security of energy supply, the ecology, and the balance of payments.

If problems such as these justify intervention, then the alternatives to the insulation guidelines need not be as restricted as they were in the analysis above. The changes in life-style, which were given short shrift as purely economic alternatives, have greater credibility if macro-economic motives are to require a solution that is different from that suggested by micro-economics. Such a wide scope to the problem of conservation would mean, however, that alternative policies are not to be found solely in the area of the home, but rather that energy use should be regulated or restricted voluntarily across the economy. An obvious candidate for measures comparable to those in the residential sector is the transportation sector and, in particular, the private car. If private-car use accounts for 25 per cent of oil consumption, and if the average efficiency is 17 miles per gallon (both figures are approximately correct) then a 10-per-cent improvement in the average mileage would result in savings substantially greater than the estimated benefits of the insulation guideline changes. How do the costs compare? That is the important question.

With an acceptance of the importance of macro-economic considerations, the wider scope that would be opened to energy-conserving measures should still not be interpreted as a carte blanche to regulators. Just as with alternative energy-conservation measures within the home, the different options would have to be considered simultaneously in order to develop a global approach to the policy considerations. Such an approach would require that, to the extent that the best possible solution deviates from the purely micro-economic solution, it should do so to the same extent in all energy-using sectors. The reasoning behind this proposition is simple: if society requires energy use to be less than that which would normally take place at the prevailing (and expected future) prices, then the "cost" of this policy in a micro-economic sense should be borne equally by each unit of energy consumed. It is probably inequitable and certainly inefficient to impose the costs of energy conservation on some groups, such as new home buyers, and not on others. It is important that, where possible, conservation measures be coordinated between different sectors, such as residential use and transportation. Moreover, the increase in the value of energy, which is implicit in energy-conservation measures that exceed the micro-economic optimum, should also be used to evaluate the profitability of potential energy sources, as the macro-economic goals that are being pursued can be as well met by new supplies as by a reduction in demand.

6. CONCLUSIONS

Within the framework of micro-economic analysis, the evaluation of the proposed standards depends critically on the discount rate used and on the assumptions made about future energy prices. It has been government policy to use a 10-per-cent real discount rate as a reflection of the opportunity cost of the capital being used in a project. The opportunity cost to society is no less if the project is undertaken by private individuals to satisfy government regulations or standards rather than by the government itself. Using this discount rate, the change in regulations is too great at any of the rates of real energy-price change considered in Table 2. The best available judgement about the future course of real energy prices appears to be that they will change from 0 to two per cent per year, <u>on average</u>, from now until the end of the century. This average rate could well reflect a wide range of rates from year to year. The choice of such an energy price forecast is a perilous one. There are political, technological, scientific, ecological, economic, and even sociological factors that can affect the rate of change of energy demand and energy supply. If a rate of 0 to two per cent is appropriate, then the <u>current</u> standards for walls are approximately correct while the optimal level of insulation for ceilings is about half way between the existing and proposed standards. Moreover, the major justification for any regulation in this area is the need to ensure proper adjustment to the new, higher energy prices. Once this adjustment has been achieved, the major rationale for regulation no longer exists.

What if, in the framework in which these regulations are to be considered, energy conservation is more important than micro-economic calculations would lead one to believe? If macro-economic factors require a "shadow" price for energy that is higher than the market price, then the excess insulation may be justified. The important consideration is that the share of the burden imposed on the new-home sector of the economy not be disproportionate. As the section on alternatives indicates, the cost of meeting the social goals should be spread as uniformly and as widely as possible across all energy-using sectors, and the extra value of energy should be considered in all energy-production decisions. This point cannot be overemphasized. A Btu is a Btu, and there is no reason to treat it differently, at home, on the road, or in the tar sands. Current policies in other energy areas do not reflect the premium attached to energy by the proposed insulation standards, and this must cast doubt on the legitimacy of such a premium, and therefore on the value of the proposed standards.

APPENDIX A
EXISTING AND PROPOSED INSULATION STANDARDS

1. Existing Standards: Minimum R Value for Wood Frame Walls and Ceilings

Number of degree-days Fahrenheit*	Electrical heating Walls	Electrical heating Ceilings	Other than electrical heating Walls	Other than electrical heating Ceilings
≤ 6,000	11.8	11.8	9.8	9.8
≤ 8,000	14.0	14.1	11.8	11.8
≤ 10,000	14.0	16.0	13.5	13.5
≤ 12,000	14.0	17.9	14.0	15.0
≤ 14,000	14.0	19.6	14.0	16.4

* For heating seasons of intermediate length interpolation may be used.
Source: Residential Standards Canada 1975 NRCC No. 13991

2. Proposed Standards: Minimum R Values for Opaque Walls and Ceilings (of combustible constructions)

Number of ddC (ddF)	Opaque Walls	Roof/Ceiling
≤ 3,500 (6,300)	2.5(14.2)	4.9(27.8)
≤ 3,500-5,000 (6,300-9,000)	3.0(17.0)	5.7(32.3)
≤ 5,000-6,500 (9,000-11,700)	3.4(19.3)	6.4(36.3)
≤ 6,500 (11,700)	3.7(21.0)	7.0(39.7)

Source: "Proposed Guidelines for the Design of Building Enclosures" by D.G. Stephenson. DBR Internal Report 433.

Note: The new standards will make use of the metric system but for ease of comparison and understanding we have used the British-system equivalents. The R value measures the thermal resistance of a portion of the building envelope. The reciprocal of the R value measures the heat flow through a given area of surface. This is clear when the units involved are considered; the units of R (respectively RIS, the metric unit) are (ft^2 - hr - ^oF)/Btu (resp. m^2 - ^oK)/w) and so the reciprocal of the thermal resistance has the units Btu/(ft^2 - hr - ^oF) (respectively w/(m^2 - ^oK)).

APPENDIX B

CONSTRUCTION-COST ESTIMATES FOR VARYING LEVELS OF INSULATION

Wood-Frame Walls

These construction prices include a 15-per-cent cushion above the original estimates in order to approximate the level of cost overruns that have typically occurred on large projects that had no major problems. They are generally considered to be somewhat pessimistic. The different levels of insulation correspond to varying combinations of types of frame construction and insulating materials. The cost may include some fixed costs that have nothing to do with insulation, but these will appear in the constant (intercept) term of the estimated cost function rather than in the marginal cost (slope) estimate.

Table 3

R Value	Cost (per 100 ft^2)	R Value	Cost (per 100 ft^2)
11.6	$ 93.40	19.5	$128.20
11.9	80.70	18.8	133.20
11.9	92.30	18.9	137.20
12.6	79.20	19.4	125.50
13.9	120.20	19.2	164.60
14.6	108.90	19.7	147.90
14.2	111.30	19.5	153.90
14.9	96.10	20.0	137.20
14.6	121.10	20.0	150.40
15.1	107.30	20.8	135.00
15.3	122.50	20.6	165.10
15.7	109.70	21.1	150.80
15.6	121.90	23.8	192.70
16.3	108.70	24.5	177.10
18.1	141.80	24.2	165.90
18.8	127.70	24.9	153.20
18.8	142.30	24.8	166.40

Source: Scanada Consultants report to DBR, NRCC; November 12, 1976.

Note: The cost function for wall insulation estimate by simple regression was (14.60 + 6.47R) $/100 ft^2, with and R^2 of .82.

Ceilings

The cost estimates given here include ventilation costs for the thicker, loose-fill types of insulation. For greater realism, they are typical, rather than best possible costs.

Table 4

R	Cost (per 100 ft^2)
20.4	$37.00
20.4	36.90
24.6	48.60
24.6	54.40
28.3	55.10
29.3	58.50
32.8	61.50
32.8	68.70
40.2	75.80
41.3	80.40

Source: Scanada Consultants report to DBR, NRCC; November 12, 1976.

Note: The regression estimate of the cost function was (.52 + 1.93 R) $/100 ft^2, with an R^2 of .95.

APPENDIX C

INSULATION GUIDELINES IN THE CONTEXT OF THE STUDY ON SOCIAL REGULATIONS

This analysis of the proposed changes in the insulation requirements for new buildings was undertaken as a case study in the evaluation of social regulations. The implications of the study for the regulations project are assessed in this appendix.

Data

In comparison with most other social regulations the data problem in this case was relatively minor. The particular subset of the energy conservation guidelines that was chosen for analysis was one for which costs and benefits were easily quantifiable. In this respect the standards were probably atypical of social regulations generally, particularly with regard to benefits. In part, the abundance of data is a result of the economic nature of this social regulation. The motives that justify the intervention in the first place arise in part from a fear that the market will not correctly capitalize the value of the flow of benefits arising from insulation investment. The figures are available nevertheless, even if the market chooses to ignore them. It would be naive, however, not to recognize that this will not be true for most social regulations.

Analysis

The purely economic framework of the regulations permits a straightforward application of the benefit-cost methodology (see, for example, the manual Benefit-Cost Analysis Guide prepared by the Planning Branch of the Treasury Board Secretariat). The particular (continuous) nature of the possibilities facing the regulators (the range of possible minimum R values) is such that the best way to analyse the problem is to find the "optimal" insulation levels, in the sense defined in

Part 3 of the paper, through the use of benefit-cost techniques. The methodology used by the Division of Building Research (DBR) of the NRCC to develop the insulation guidelines is exactly the one that the Planning Branch manual would recommend.

Nevertheless, there were problems with some of the critical assumptions that were made in using the methodology. It is here that the value of an evaluation mechanism might make itself felt; some uniform guidelines appear to be required. In particular, the assumptions made by DBR with respect to the discount rate and the rate of real changes in energy prices are out of step with the assumptions being used elsewhere in the public sector.* These differences explain our relatively unfavourable conclusions about the particular proposed regulations.

Special Problem

Of the two principal justifications given for insulation regulations, the market's failure to capitalize future energy savings and the need to protect the country from some of the consequences of a decline in Canadian self-sufficiency in energy, the second has been dealt with somewhat summarily. The only way in which questions of security of supply and of payments balance can be easily incorporated into the economic analysis is by the definition of a "shadow" price of energy, greater than the world market price. No attempt has been made to define such a "shadow price", but, as is pointed out in Part 6 such

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* An effective real discount rate of about four per cent (a 10-per-cent nominal or mortgage rate) is at variance with the 10-per-cent real rate used to evaluate government expenditure decisions. The assumption of a six-per-cent annual increase in the real price of energy to homeowners (a 12-per-cent nominal rate) is completely at odds with the widely accepted forecast of a constant or slowly rising (on average over the next 25 years) real price that is being used to evaluate other energy projects such as the pipeline or the tar sands. Moreover, the six-per-cent annual increase in the price to homeowners means a much larger growth rate in the price of crude oil.

a premium should apply to all energy projects. To do so would, however, require government price guarantees, as with Syncrude, or direct government intervention, applying both to production and conservation.

If it is not felt that circumstances -- actual or potential -- justify regulations that in effect force conservation on Canadians (as these insulation guidelines do by going beyond the market "optimum") in all aspects of energy use (cars, packaging, appliances, etc.), then government support of experiments with alternative energy sources and alternative lifestyles may be more equitable and less inefficient in economic terms than attempts to spread unevenly the burden of ensuring against future energy shortages by only partial regulation of energy use. Moreover, and most importantly, if premiums are to be added to energy prices for evaluation purposes, no analysis can be undertaken unless the premiums are clearly specified in advance.

Conclusions

The study shows that some social regulations are amenable to economic analysis, and in this case, without any controversy about the value of life. On the other hand, the differences in assumptions (about energy-price movements and discount rates), with their implications for the desirability of the regulations, reinforce arguments for some kind of central direction of the economic aspects of the regulatory process.