Research & Development Highlights

ENERGY EFFICIENT WINDOWS, LIGHTING & HUMAN HEALTH

Introduction

In a well-insulated building the greatest percentage of heat loss occurs through windows. This has created a large industry to improve the thermal performance of windows. Of the many technological advances in this area, the most heavily promoted windows are thermally sealed units containing one or more panes of glass with a low-emissivity coating also known as low-E windows. Other advances include the development of insulated frames, thermally efficient spacers, inert gas filler between panes, and multiple pane assemblies.

Spectral transmittance of glazing is defined as a measure of the fraction of light that passes through it. Coatings or tintings on the glazing act as a filter, changing the glazing's spectral transmittance and therefore, the light that is available to the occupants. No attention has been given to how the altered transmittance may affect occupants. Due to the widespread use of low-E windows, the possibility of an impact on occupant health demands attention. As well, building codes should be examined as current codes reflect window materials that have been used in the past, namely clear glass, and do not account for these new types of glazing.

CMHC has initiated a number of projects to examine this issue. This document was created to provide an overview of this research and includes a synopsis of ***5*** recently completed projects which investigate various aspects of lighting, low E windows and health.

Lighting and Human Health examines the known effects of light on human physiology, specifically vision, endocrine system, and general physiology. While the visual system can adapt to a wide range of light levels, the non-visual processes involving light seem to work best under higher absolute light levels. The non-visual effects of light include influences on mood, synchronization of daily rhythms to the cycle of night and day, and production of hormones.

The report provides an overview of current knowledge in this area. Topics discussed in this review include:

- the physical characteristics of light and methods of measurement;
- the structure and function of the visual system and physiological mechanisms involved in
- colour perception, brightness, and
- contrast sensitivity;
- the physiological processes involved in light exposure;
- the influence of light on mental health and sleep patterns; and
- the use of windows in the home and workplace.

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Research is required to gain a better understanding of the impact of light (in terms of intensity, spectral range and duration) on health. This is particularly important for those at risk of inadequate exposure to light such as the aged, institutionalized, and individuals with sensitivities to light.

The Spectral Transmittance of Glazing Used in Canadian Houses examines a variety of glazing types used in Canada. Clear, tinted and low-E glass were tested for their spectral transmittance, based on glazing thickness and number of panes used in the window assembly. Samples of clear glazing gave visible transmittances in the visible around 90%, while lower transmittances (as low as 50%) were seen for tinted glass and glass with increased glazing thickness. The low-B glazing samples had visible spectral transmittances around 80% while the double-glazed window assembly with argon gas fill had a transmittance of 70% in the visible. Transmittance in the short wavelength region was lower than for clear glass.

Regulations and Standards for Daylighting in Housing in Northern Latitude Countries This report examines standards for daylighting in housing in Canada and other countries. Current and future design regulations are presented, as are current and future rating systems and regulations for window glazing.

Criteria for light can be categorized under intensity, duration and quality. The daylight factor addresses the issue of lighting intensity and has been used extensively in research and building design. The duration of light is not regulated in housing but is controlled in art museums and the like. Quality of light, in terms of spectral transmittance through windows, is still under much study.

Regulations for daylighting in housing have historically been based on window opening size. Canada, Denmark, Finland, the Netherlands, Norway and the United States all stipulate minimum window size as a percentage of floor area usually around 10%.

France, Germany, Japan, and Sweden include a number of alternate criteria to window size. These include stipulations for area of window opening, transmittance of diffuse light, depth of room, minimum duration of exposure to sunshine, daylight factor, and illumination distribution. Sweden and the United Kingdom have standards to ensure good daylighting for new and existing buildings.

Of the countries surveyed, France has corrected the window opening size for transmittance. Denmark is planning changes to their daylighting criteria based on the effects of high performance glazing systems. Sweden is moving towards a minimum transmittance of 0.60.

A Survey of Effects of Low-E Windows on the Well-Being of Home Occupants lists the responses to a survey- of 51 homeowners living in homes built or renovated with low-B windows. Of this group, 37 were new houses, 11 had some windows replaced with low-B windows, and 3 had all windows replaced with low-E

windows. The questionnaire used in the survey was based on standard questionnaires which look at human responses to seasonal changes. The purpose of the questionnaire was to assess homeowner satisfaction with their windows. Questions directly pertaining to their health were not asked.

The questions included house characteristics (i.e. house age, duration of occupation, window type, and number of windows replaced in retrofit), observations of interior space (i.e. brightness, use of interior lighting), impact of weather on occupant's mood, impact of seasonal changes on occupant's mood, and general observations.

The respondents expressed satisfaction with the thermal efficiency of their new windows. They also reported positive perceptions of spaciousness, comfort and brightness, but these may be due to improvements in house design, location or orientation with the previous house.

The survey found that occupants are affected by changes in the seasons, but it did not find correlation between seasonal effects and the type of windows.

Responses to a question of growth of houseplant ranged from improved growth, to no change, to poor growth.

Effects of New Window Glazings on Plants and People is a follow-up to the previous survey in order to assess the effect of glazing on plants. A second objective was to determine the effect of glazing types on a panel of environmentally hypersensitive individuals. Of the ***45*** responses to plant growth, ***25*** indicated no change, 16 indicated increased plant growth, and 4 indicated poor plant growth. Four additional cases of impaired plant growth were directly reported to CMIIC. These responses are due to a combination of factors including: window size and orientation, transmission capabilities of the window glazing, and individual plant requirements. Design features consisting of larger window size and better solar orientation in new houses will lead to increased amounts of light, while the lower transmittance properties of low-E windows will lead to decreased amounts of light.

The reported improved growth of houseplants in the new houses can be explained by a net increase in the amount of light, i.e. the positive effects of the design features exceed the reduction in transmittance due to the low-E glazings. In some cases, there is also a better fit of the lighting requirements of certain plants with the filtered light provided by the low-B windows. The lack of observed changes in plant growth in twenty-five houses is very likely due to a canceling of the two opposing effects. The reported impaired growth of plants in eight houses can be explained by a reduction of light and, in

the new houses where plants died, positive design features were not sufficient to offset the reduced transmittance of the low-B windows.

The blind testing in the second phase called for 13 hypersensitive individuals to indicate their sensory perceptions to 4 sets of window glazings. All but one individual, who is photoallergic, expressed a dislike for the low-E assembly. Responses included feeling ill, anxious, and panic stricken when looking through it. This was especially clear when ambient light levels were low due to cloud cover.

Windows Practical and Research Considerations

This final report provides a summary overview on the considerations involved with the use of low-B windows in current housing. There are variations in transmittance of low-B coatings; some have lower transmittance than others.

	Clear Glass Transmittance	Low-E Glass Transmittance
Single Pane	90%	50-80%
Double Pane	81%	*45-72%*
Triple Pane	72%	***22-57%***

Note: transmittances are in the visible range only; values are approximate and estimated from the product of the transmittances of the individual panes.

A triple-pane low-B window (with poor transmitting low-B coating) transmits less than a third of that transmitted by triple pane clear glass.

The contribution of low-B coatings to the heating load of a well insulated house (the Toronto Healthy House) was estimated. A high performance assembly (fiberglass frames, argon-fill, warm-edge insulating spacers) not using low-B will result in 11% increase in energy consumption, while lower performance spacers would result in a 22% energy increase.

Impact on the Housing Industry

It is evident from these preliminary studies that more research is needed into this area. The impact of lighting on physiological

processes is already established but more information is needed on
the impact of manipulating daylighting (through windows) on occupants. Some countries are already developing standards for daylighting in housing that reflect the reduced transmittance of low-E windows. Canada needs to review its daylighting regulations. Performance criteria will likely be a balance between lighting and energy efficiencies that meet health, safety, energy and comfort requirements. Until such time consumers should be made aware of individual glazing transmittance capabilities when building or renovating their homes.

Project Manager: Virginia Salares

Research Report: Energy Efficient Windows, Lighting & Human Health (1996)

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

*Housing Research at **CMHC***

Under Part IX of the National Housing Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This factsheet is one of a series intended to inform you of the nature and scope of CMHC's technical research program.

*The **Research and Development Highlights** factsheet is one of a wide variety of housing-related publications produced by CMHC.*

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