ASSESSING THE POTENTIAL FOR THE IMPLEMENTATION OF A HIGH-PERFORMANCE WINDOW INCENTIVE PROGRAM BY MANITOBA HYDRO

BY

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A Practicum
Submitted in Partial Fulfilment of the
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MASTER OF NATURAL RESOURCES MANAGEMENT

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Pathology	0571
Pharmacology	0419
Pharmacy	0572
Physical Therapy	0382
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Radiology	0574
Recreation	0575
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Psychobiology	0349
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ASSESSING THE POTENTIAL FOR THE IMPLEMENTAION OF A HIGH-PERFORMANCE WINDOW INCENTIVE PROGRAM BY MANITOBA HYDRO

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of Master of Natural Resources Management.

By

Henry P. Carriere

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ABSTRACT

Manitoba Hydro, through Power Smart Demand-Side Management initiatives, sponsors programs to reduce energy use and peak demands for the purpose of delaying major capacity additions. The end result of this effort is to reduce the impacts on the environment associated with energy production.

As part of this initiative, the utility wants to establish whether it is economically feasible to promote high-performance windows. Only customers with electrically-heated homes who upgrade to high-performance windows in new and retrofit house construction may qualify. Manitoba homeowners generally purchase triple-glazed windows which have become the standard windows in Manitoba. This study establishes whether it is economically feasible for the utility to offer incentives to cover part or all of the extra costs of high-performance windows over the cost of standard triple-glazed units. The study also analyzes whether it is financially feasible for homeowners to purchase high-performance windows rather than triple-glazed windows.

The research employed a multi-approach methodology: related literature was reviewed; a survey of window prices was undertaken to establish the incremental cost for each high-performance window option; computer simulations to calculate the energy savings (or losses) for each window option for specific conditions were performed; and finally, drawing on the results of the above, utility economic analyses and consumer financial analyses were calculated for a range of window conditions.

The results of calculations were very scattered due to a wide selection of window prices and varying energy savings for each condition. Very few high-performance windows passed the utility economic screening tests or the homeowner financial analyses. The study recommends that Manitoba Hydro not promote high-performance windows through financial incentives at this time.

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I would also like to acknowledge Manitoba Hydro which provided financial and technical support for the study. I am also grateful to the consultants, public sector employees, and window manufacturers and installers who offered information to make this research possible.

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

FIGURE

LIST OF TABLES

Page

TABLE

ACRONYMS & SYMBOLS

ACRONYMS

The following acronyms are found in this practicum:

Ar → argon gas

CI → confidence interval

CSA → Canadian Standards Association

DSM → Demand-Side Management

ER → window energy rating for average heating conditions

ERS → window energy rating for the heating season, for specific location, and orientation

GST → goods and services tax

HM → Heat Mirror

HPF → high-performance frame

HPW → high-performance window

IES → insulated edge spacer

IRR → internal rate of return

KW → Kilowatt

KWh. → Kilowatt-hour

Low E → low-emissivity

MRC → Measure Resource Cost

NA → not applicable

NPV → net present value

PST → provincial sales tax

SES → Simple Economic Screen

SGI → solar heat gain index

SHGC → solar heat gain coefficient

SPP → simple payback period

TRC → total resource cost

SYMBOLS

The following symbols are found in this practicum:

A → annual fuel cost savings, \$

A_{fl} → total above grade floor area in house, m^2

A_w → complete window area for the reference size window, m^2

A_{wt} → total area of windows above grade in house, m^2

F_s → solar radiation incident on a window for a specific location and orientation condition during the heating season, W/m^2

F_w → solar heat gain coefficient for the reference size of the complete window product with reference surface conductances, dimensionless

i → interest rate, %

L_{75} → window air leakage rate at a pressure difference of 75 Pa for the reference window size, m^3/h

n → number of samples, dimensionless
→ payback period, years

P → incremental costs, \$

q_i → average rate of heat loss through the window by infiltration, W/m^2

q_s → average rate of useable solar heat gain through unit area of the window during the heating season, W/m^2

q_t → average rate of heat loss through the window by transmission, W/m^2

s → standard deviation of a random sample size

s_x → standard deviation of mean deviation of a random sample size

$t_{\alpha/2}$ → t value with n-1 degrees of freedom

t_i → average indoor air temperature during the heating season, °C

t_o → average outdoor air temperature during the heating season for the specific location, °C

μ → window value mean, $

U → overall heat transmission coefficient, $W/(m^{2o}C)$

U_w → overall heat transmission coefficient for the reference size of the complete window product with reference surface conductances, $W/(m^{2o}C)$

x → mean deviation of a random sample

x_i → dollar value of option, $

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Manitoba Hydro introduced the Power Smart program in 1991 to reduce peak demand for electricity with the aim of delaying the construction of environmentally damaging capital intensive generation stations. As part of this program, the utility is promoting Demand-Side Management initiatives to customers with the goal of reducing electricity peak loads and conserving energy. Manitoba Hydro is evaluating and introducing a number of Demand-Side Management programs for the residential, agricultural, and commercial sectors. There is great potential in reducing demand for electricity as homeowners install high-performance windows. Through Power Smart, the utility is considering whether it is economically feasible to offer financial incentives to electrically-heated homeowners who upgrade to high-performance windows.

This research evaluated the economic feasibility of high-performance windows as a Demand-Side Management initiative. Consumers generally purchase triple-glazed windows since these are the standard windows in Manitoba. The research evaluated whether it is economically worthwhile for the utility to offer financial incentives to cover part or all of the extra costs of high-performance windows (over the cost of standard triple-glazed units) to persuade homeowners to purchase these windows. The study also analyzed the homeowners' financial feasibility of purchasing these energy-efficient windows.

1.2 BACKGROUND

A high-performance window (HPW) is an improved window with energy performance qualities such as reduced heat transfer, improved solar heat gain characteristics, and lessened air infiltration than conventional windows. In recent years, scientific approaches have been used to reduce overall window heat transfer by radiation, conduction, and convection through the glazing system, edge spacers, and frame (see Figure 1).

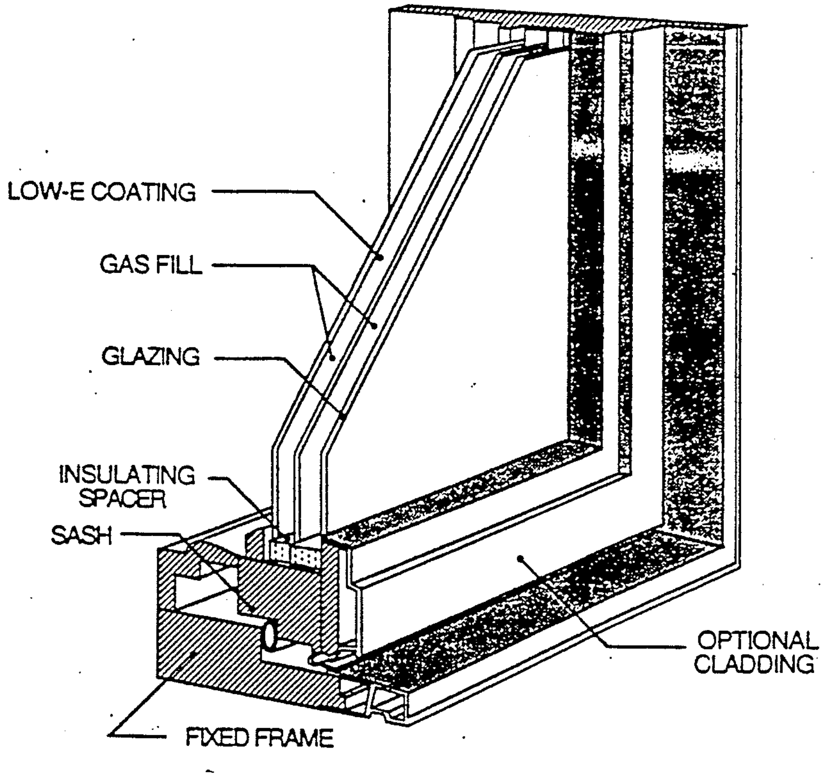


Figure 1. High-Performance Windows (CANMET 1991)

The resulting window improvements are functional, almost maintenance free, and reduce condensation. They also increase occupant comfort due to decreased heat loss and warmer inside window pane surfaces resulting with less chance of air drafts.

It is only since the mid-1980s that HPWs have been available to the general consumer. Presently, the standard windows purchased by consumers have three sealed panes of glass with aluminum edge spacers and wood frames. These windows are typically referred to as triple-glazed windows. It is only recently that computer simulations have been available to estimate quantitative data such as heat transmission, solar heat gain, and infiltration losses for these windows. It is appropriate and timely for Power Smart to evaluate an economic and technical study of HPWs.

1.3 RESEARCH OBJECTIVES

The purpose of this study is to establish whether Power Smart can offer incentives to persuade Manitoba homeowners, with electrically-heated homes, to purchase HPWs. This is achieved through an in depth economic and engineering study of HPWs.

The following tasks were performed in this research:

1. HPW prices were established from a survey of HPW manufacturers and installers;
2. computer programs were used to simulate (a) window performance and (b) household energy consumption for various window scenarios; and
3. an analysis of (a) economic benefits to Manitoba Hydro and (b) financial benefits to householders was performed for each window scenario.

The results will assist Manitoba Hydro in determining whether the promotion of HPWs is economically feasible for a potential Power Smart incentive program.

This study provides Manitoba Hydro with the information needed to establish whether a HPW incentive program is feasible based on the economic and financial analyses. Recommendations stemming from the study and general observations are reported. Incentive programs, like the potential HPW program, may lead to significant demand and energy reductions to the utility. Reducing electricity use may cut peak demand and reduce utility capital expenditures. As a result, the construction of major additions, attributed to environmental degradation, may be delayed.

1.4 LIMITATIONS AND ASSUMPTIONS

This study is limited in scope in the following ways:

1. the study is dependent on the integrity of computer simulations being used;
2. a standard window size of 915 mm x 1220 mm (3' x 4') is used in the study. This does not necessarily reflect sizes for all households;
3. HPW improvements are based on a triple-glazed window. The study focuses on two window types: fixed and operable (casement and awning only);
4. both HOT2000 and WINDOW 4.0 computer simulations do not differentiate R-values and solar heat gain coefficients between fixed and operable windows;
5. the window prices were based on the price of a single window and therefore do not reflect price reductions and economies of scale in replacing all windows in a house;

6. this study is an economic and engineering analysis of HPWs. It does not reflect other HPW qualities such as comfort levels, warranties, and maintenance; and

7. the method used to calculate the utility avoided costs, the savings created by the reduction in energy and demand of electricity, is based on Manitoba Hydro's projected generation expenses.

1.5 RESEARCH METHODOLOGY

The research methodology is divided into seven distinctive steps. Figure 2 illustrates the procedures in a flow chart:

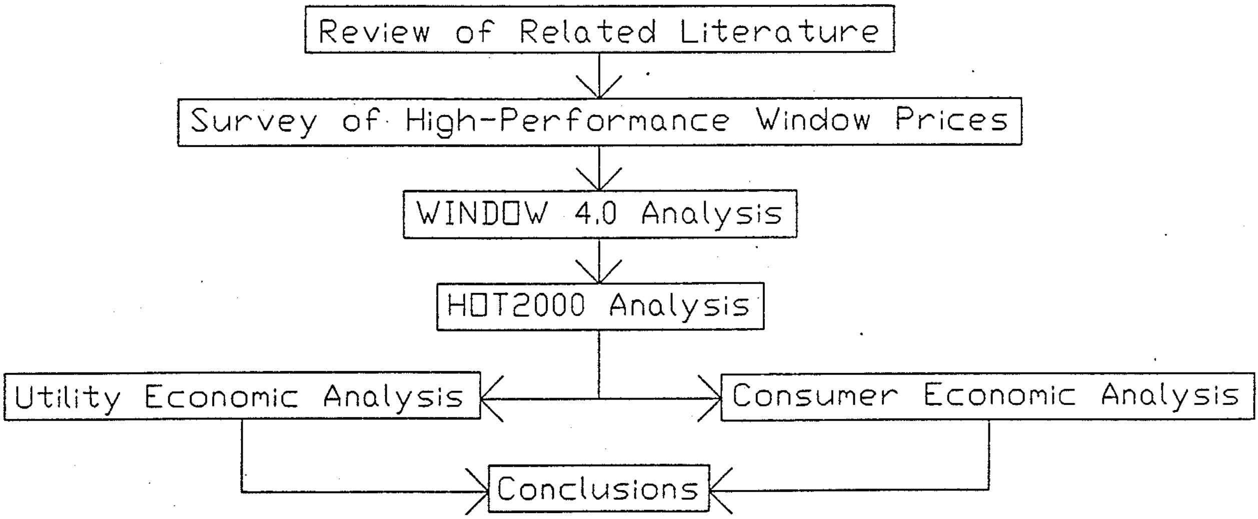


Figure 2. Flow Chart of Research Methodology

1.5.1 Review of Related Research and Literature

A review of related research and literature provided the basic knowledge needed to initiate a comprehensive and complete study. Energy conservation and window publications from Energy, Mines, and Resources Canada (EMR), Manitoba Energy and Mines, Manitoba Hydro, and Ontario Hydro were consulted for the necessary background. Further searches included Manitoba Hydro and Ontario Hydro publications and reports, window manufacturers and EMR energy rating specifications and reports, periodicals, and relevant texts on computer simulations, computer programs and financial analysis.

1.5.2 Survey of High-Performance Window Prices

A collection of HPW specifications and prices was necessary to determine the incremental costs of window options used in the analysis. The researcher visited each manufacturer to obtain installed price quotations on a selected window size (915 mm x 1220 mm) for different HPW options. Twelve window manufacturers in Winnipeg and in rural Manitoba were surveyed. A list of firms surveyed is found in Appendix B. Approximately thirty window installers in Winnipeg were anonymously telephoned in an effort to acquire installed pricing for the aforementioned windows. Prices quoted are the window installed costs. The quotations are directed towards two window types, namely fixed and operable windows (casement and awning). Upon delivery of all the HPW price quotations, the incremental costs for each HPW option were calculated. The survey, entitled "High-Performance Window Price

Questionnaire" is found in Appendix C.

1.5.3 Window 4.0 Analysis

Computer software programs were used to generate quick and cost-effective window energy performance results. WINDOW 4.0, a computer simulation program developed at the Lawrence Berkeley Laboratory, calculates optical and energy performance properties of user-defined windows. The use of WINDOW 4.0 in calculating the energy performance of windows is very applicable for this study. The alternative is to conduct expensive and time-consuming laboratory tests. WINDOW 4.0 is said to be the best generic computer program available. It is used by window manufacturers, energy consultants, and utilities.

WINDOW 4.0 was used to calculate the energy performance of twelve window types outlined in Section 3.1.2. The window properties were extracted from libraries found in the simulation program. More software package background is found in Section 2.7. The results of WINDOW 4.0 analysis are recorded in Section 3.2.

1.5.4 HOT2000 Analysis

The application of the WINDOW 4.0 results were then used to calculate the potential energy savings of windows for average Manitoba homes using HOT2000, a computer simulation software package of house energy consumption. HOT2000 was developed by Unies Limited under the direction of the "R-2000 Home Program" of Energy, Mines and Resources Canada (Canadian Home Builders'

Association 1991). This program is used by homebuilders, consultants, and civil servants to simulate the effects of house properties such as wall and attic insulation, house size and location on heating and cooling energy use. The program compiles the input and generates output of energy properties such as: house heating and cooling loads, hot water heating loads, and lighting and appliances load. Francois Dubrous at Energy, Mines and Resources Canada estimates that HOT2000 has up to 5-10% error when calculating energy performance of households.

Here, HOT2000 was used in calculating the energy savings of each of the twelve high-performance window options listed in Section 3.1.2 for two house types: with and without summer cooling as explained in Section 3.4.2 and in Appendix E. All input variables were kept constant except for the windows. First, the energy performance was simulated for houses with standard triple-glazed windows. Then one window at a time in each orientation was upgraded by a high-performance option (as shown in Section 3.1.2) while keeping all other windows as triple-glazed. This analysis simulated each of the high-performance window options for different conditions keeping all other variables constant. A total of 192 scenarios were analyzed. The applications of the HOT2000 program is explained in Section 2.7. The results are presented in Section 3.4.

1.5.5 Utility Economic Analysis

An economic feasibility study was conducted to establish whether high-performance windows (HPW) passed Manitoba Hydro's economic screens for possible inclusion towards an incentive program. This study used Manitoba Hydro's methodology in calculating potential energy savings. The Simple Economic Screen (SES), developed by Demand-Side Management consultants Barakat & Chamberlin for Manitoba Hydro, calculates a benefit/cost ratio for energy saving measures. The "benefits" are the monetary savings generated by the utility achieved by reducing peak loads. The "costs" are the incremental costs associated with a measure (such as incentive payments for homeowners under a HPW program). The resulting benefit/cost ratio is also called the Measure Resource Cost Test (MRC). To pass the MRC, the benefit/cost ratio of each measure must be larger than 1. Measures that pass the MRC are analyzed further. Those that fail the MRC are "shelved" until market conditions change.

The results obtained from HOT2000 simulations and from the HPW price survey were used in the Simple Economic Screen. An electronic spreadsheet software program was used in calculating the MRC for a 20 year period (as specified by Manitoba Hydro). Then the MRC was modified to account for the administration costs involved in a potential incentive program. This modification is called the Total Resource Cost Test (TRC). In total, 352 scenarios were evaluated. Sections 2.8 and 3.5 explain the analysis and present the results of utility economic analysis.

1.5.6 Consumer Financial Analysis

The second economic analysis deals with consumers' financial tests of high-performance windows. This analysis focused on consumers' simple payback period (SPP), internal rate of return (IRR), and net present value (NPV) for each window condition. The SPP analysis calculates the number of years required for the net cash flow of an investment to equal zero (Smith 1981). The IRR calculates the opportunity interest rate an investment is expected to yield so that total discounted benefits and costs break-even (Hu 1983). The NPV method calculates the difference between the present value of the benefits and the costs resulting from alternative investments.

The financial analysis used information acquired from the HPW price survey (incremental costs including taxes) and consumer fuel cost savings per year for each window increments from the HOT2000 output. First, consumer financial analysis of each HPW option was executed without any utility incentives. Those scenarios that qualified for incentives (Section 3.6) were then analyzed. The utility savings generated by each measure, over a 20 year period, were transferred to the consumers as monetary compensation and re-analyzed in economic analysis. The calculations were administered for all 352 HPW cases. More technical information and results can be referenced in Sections 2.9 and 3.6.

1.6 ORGANIZATION

This practicum is organized into four chapters. After an introduction of the study in Chapter 1, a review of literature related to HPWs and DSM programs, particularly for Manitoba Hydro, is recorded in the second chapter. In the third chapter, the results of the study are tabulated and analyzed. The last chapter summarizes the results of Chapter 3 and conclusions and recommendations are expressed. The study is enhanced with aides such as organizational tables, bibliographies, definitions of terms, and appendices.

CHAPTER 2

INFORMATION REQUIRED FOR ANALYSIS OF A POTENTIAL MANITOBA HYDRO HIGH-PERFORMANCE WINDOW DEMAND-SIDE MANAGEMENT PROGRAM

2.1 ENERGY CONSERVATION

2.1.1 Introduction

Until recently, many people in North America considered energy to be both inexhaustible and expandable. This is no longer true. The 1973 embargo of the Middle East petroleum cartels instantly increased fossil fuel prices and curbed supply. This radical measure impinged on the prices for other sources of energy as they also dramatically increased as a result of larger demands (Chiogioji and Oura 1982). As well, energy costs today are beginning to reflect more accurately the real costs, since environmental and "external" costs are increasingly borne by the user.

Two major public responses have arisen in the wake of a growing recognition of the energy crisis. The initial response called for the rapid expansion of sources of energy. More recently, energy conservation is being promoted as a measure to reduce unnecessary usage of energy. Conserving energy means reducing the amount of fuel and electricity that a unit uses per given time. Not only does energy conservation save money, it:

- extends the useful life of existing equipment;
- increases reserve capacity for future needs;
- reduces the likelihood of shutdown or curtailment of operations by power shortages;
- reduces pollution and other impacts on the environment (Chiogioji and Oura 1982);
- reduces peak demands for the purpose of delaying major capacity additions; and

* changes the shape of the load curve including peak shaving, valley filling, load shifting, strategic load growth, and strategic conservation (Canadian Electrical Association 1992).

Hydroelectricity in Manitoba is considered a relatively benign source of power compared to other forms, but the equipment and facilities used to generate, transmit, and distribute electricity can have a range of impacts on the environment. Many of the most serious impacts in Manitoba were felt in the last 30 years when the Churchill River Diversion, Lake Winnipeg Regulation, Grand Rapids, and other major projects on the Nelson River were built.

Manitoba Hydro has taken steps to encompass conservation issues into their policies. In April 1991, they unveiled their new conservation effort - "Power Smart". The aim of this Demand-Side Management program is to reduce the demand for electricity, ultimately delaying future Manitoba Hydro capital construction and mitigating environmental degradation associated with these projects. Manitoba Hydro advises consumers on energy conservation and efficiency in residential, commercial, agricultural, and industrial sectors. Manitoba Hydro, through their Power Smart initiatives, offers rebates to those who purchase plug-in timers for car block heaters, recommends installing ceiling fans, insulating attics and basements, and caulking, sealing, and weather stripping doors and windows to conserve energy at home and at the office. With Power Smart, Manitoba Hydro will be in a better position to influence manufacturers and retailers to produce and promote energy-efficient products and to improve the availability of energy-efficient appliances and energy-saving devices. During the next few years, Manitoba Hydro will be announcing several Power Smart programs.

2.1.2 Residential Buildings

Great potential for energy conservation can be achieved in the residential buildings sector as it accounts for about 35 percent of Manitoba Hydro's electricity consumption. With proper energy conservation measures in place, building heating bills can be reduced by 50% or more (EMR, 1983). Retrofitting a house is simply upgrading it to achieve better energy efficiency. This means adding insulation, caulking, weather stripping, adding storm windows or upgrading existing windows, and taking various other common sense energy-saving measures. The three main reasons for retrofitting are:

- conserve energy - reducing costs for consumers and utilities;
- increase comfort - keep out cold winter drafts and reduce condensation problems; and
- investment - improved payback, value, and appearance of home (Manitoba Energy and Mines date unknown).

Opportunities to reduce energy use in existing buildings differ markedly from those in the design of new buildings. These include the building configuration and orientation, its materials and construction, its mechanical systems and controls, and its specific location. Most of these are difficult and expensive to modify, some are impossible.

Building improvements that increase energy efficiencies include:

1. Basement insulation
   Annual reduction in energy conservation: up to 30%
2. Caulking, sealing, and weather stripping
   Annual reduction in energy consumption: up to 20% or more
3. Attic insulation
   Annual reduction in energy consumption: up to 12%
4. Window improvements
   Annual reduction in energy consumption: up to 10%
5. Wall insulation
   Annual reduction in energy consumption: about 2 to 3%

In considering the energy conservation options available, it is important to choose those which will be of real value in a particular circumstance. The initial cost of a conservation action and the savings in operating costs which it may provide must be balanced. Energy conservation experts generally agree that in residential buildings, the greatest energy savings can be attained by reducing air infiltration through windows and doors and by reducing conductive heat transfer through the walls and windows (Hastings 1977). Winds can decrease the exterior film of still air that usually surrounds a building and will increase the thermal vulnerability of roof, wall, and window elements. In the Northern Hemisphere, the north and west sides of a building are said to be exposed to the greatest wind loads - window minimization in these two orientations is necessary (Chiogioji and Oura 1982).

2.2 ENERGY POLICY

2.2.1 Introduction

Energy conservation programs require: strong public support; dynamic, cost-effective, and timely regulations to increase the efficiencies of new equipment and structure; continued government and private R&D to develop and produce improved buildings technologies; and active cooperation among manufacturers and from organizations involved in the design, construction, implementation, and financing of structures.

2.2.2 Jurisdictions

The jurisdictions of energy policy are divided between the federal government and provincial governments. The federal government has exclusive proprietary rights north of 60°, ownership of seabed resources, has regulatory authority affecting provincial affairs, and has power to negotiate international agreements (Mitchell and Sewell 1981). The research capabilities and spending powers of the senior level of government have also enabled it to play an important part in what would otherwise appear to be matters of provincial jurisdiction. The federal government, through its ministries of Energy, Mines and Resources and Environment, may implement policies and programs which can affect energy development and use in Manitoba.

The provinces were granted ownership of all Crown lands and natural resources within their boundaries under the terms of the British North America Act (1931) and were able to exert a strong influence upon energy resource development in Canada. Municipal governments have no jurisdictional powers with respect to energy policy but nonetheless can influence conservation programs (Canadian Resource Policies 1981).

2.2.3 Federal Energy Policies

Two key federal institutions concerning energy are the National Energy Board and the Canadian Department of Energy, Mines and Resources. The statutory functions of the National Energy Board are to advise on energy policy and to regulate the energy industry insofar as it lies within federal jurisdiction. The Department of Energy, Mines and Resources has acquired the responsibility for water resources inventory and planning, administration of offshore seabed minerals, and planning and coordination functions for energy development. The evolution of the Energy Policy in Canada is based largely on petroleum supply/demand crises. Domestic electricity pricing, supply, and demand is encompassed in all energy policies.

The Energy Policy in Canada can be roughly divided into three development periods: 1959-1973, 1973-1980, and 1980 until present (Green 1985). Prior to 1973, since the discovery of oil in Alberta in 1947, the National Energy Policy had been concerned largely with exploiting Canada's energy resources - natural gas, coal and hydro, and oil (Energy Options 1988). The federal government was attempting to spur production and exports to maintain artificially low domestic oil prices. Canada had large energy supplies and no efforts for energy conservation were enforced.

The events of 1973, the Arab oil embargo, followed by the quadrupling of crude oil prices as OPEC exerted its cartel powers, radically changed the world energy picture. The National Energy Policy of the 1960s became largely irrelevant after this event. Many new policies and programs were quickly introduced to address the "energy crisis." The federal government enacted the Energy Supplies Allocation Act which empowered it to control the distribution of petroleum supplies in the event of a crisis. Also, the Office of Energy Conservation was created within the Department of Energy, Mines and Resources. The government's request for the reduction in energy demand would be achieved via higher energy prices and conservation measures. In 1979, the Iranian crisis doubled again the world oil prices. The price of crude oil stood more than six times above its 1973 level. This led to more energy conservation initiatives.

Following the 1979 "energy crisis" the federal government introduced the National Energy Program. This policy established a price designed to protect Canadians against world prices, while slightly decreasing provincial revenues; it established federal dominance over energy policy (Green 1985). This policy sparked much debate between the provincial and federal governments. Having gone head to head over energy policy and resource-revenue sharing, the federal government and the producing provinces sat down to negotiate a compromise. In September 1981, a Memorandum of Agreement was signed by all parties (Green 1989). However, the

Memorandum of Agreement inevitably became irrelevant as a result of steeply declining petroleum prices from 1982 to 1986. The Western Accord in 1985 brought the end of the National Energy Program and returned energy pricing to a market-oriented system.

Due to public driving forces in the 1980s, the environment has entered the higher echelons of policy consideration. In 1987, the World Commission on Environment and Development provided a capsule overview of the interaction between the environment and energy. The new focus stated that environmental concerns must be considered as carefully as social and economic policy objectives when energy programs are evaluated. Recently the Free Trade Agreement, the Green Plan, Meech Lake Accord, and the Charlottetown Accord all have had energy and environmental implications (Lemco 1992).

2.2.4 Provincial and Municipal Energy Policies

In Manitoba, the Department of Energy and Mines administers energy policies, programs, and taxation. The Manitoba Energy Authority has legislative authority to negotiate electrical export sales, promote the development of electrical-intensive industries, and plan for energy emergencies. Manitoba Hydro supplies and exports electrical power (Manitoba Round Table 1991). The Public Utilities Board, the Clean Environment Commission, the Departments of Environment, Finance, and Natural Resources have interests in energy policies.

Energy and Mines Manitoba offers several programs to promote proper energy usage. A comprehensive Energy Act for Manitoba is being planned. A new Act would enshrine the following principles and guidelines as they apply to energy:

- the development and public release of comprehensive energy forecasts and plans;
- energy programs for Manitoba; and
- ongoing monitoring, evaluating, and regular reporting of energy issues inside and outside of the province (Manitoba Round Table 1991).

There is no formal municipal mandate with respect to energy policies. Research done by the Bureau of Municipal Research in Ontario (1978) has concluded that municipalities should not be excluded from energy policy. It has concluded that municipalities can play an important and leading role in promoting the more efficient and less extravagant use of energy and the development of renewable energy supplies.

2.3 DEMAND-SIDE MANAGEMENT

2.3.1 Introduction

The traditional focus of utilities in the past was to meet consumers' energy needs. The Pacific Gas and Electric Company in California (The Economist 1991) and Ontario Hydro (Mitchell and Sewell 1981) emerged at the leading edge of a new philosophy in energy conservation. Today, utilities are not only looking at providing customers with adequate energy, they are concentrating efforts in reducing overall energy usage, peak-energy usage, and all types of generation and consumption inefficiencies. It is often cheaper for a utility to reduce the demand by paying to help make components more energy-efficient than it is to build new power plants. The transition from meeting demand to managing demand is difficult. Effective management of demand requires action at five fronts: economic, behavioral, environmental policy design, legislative, and engineering (Geller et al. 1982).

Demand-Side Management (DSM) is managing demand so that energy may be used more efficiently or more appropriately. A commonly accepted definition of DSM is "the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will promote desired changes in the utility's load shape such as changes in the time pattern and magnitude of a utility's load" (Canadian Electrical Association 1992). Programs of DSM are seen as lower cost alternatives to increased supply (Dyne 1992). From a total resource cost perspective, a utility can offer incentives for a specific DSM measure if the incremental cost of the measure (including administration costs) is less than the utility's avoided cost (Curran 1992).

Utility avoided costs can be defined as, "the incremental cost saving associated with an incremental decrease in load or an incremental increase in supply which would result in changed future Manitoba Hydro system expansion and system operation" (Wojczynski et al. date unknown). The fundamental approach in determining the avoided cost for a program is to evaluate the system expansion and operation costs without the program and then the costs with the program. The savings generated is the avoided cost.

2.3.2 Demand-Side Management Policy

Environmental concerns and utility needs for Demand-Side Management (DSM) have prompted the federal and provincial governments and Canadian electric utilities to administer DSM policies.

Under the auspices of the current Energy Efficiency and Diversity initiative and the Efficiency and Alternative Energy Program outlined in Environment Canada's Green Plan, Energy, Mines and Resources Canada promotes and supports increased energy efficiency. It also supports the development of new energy sources in all sectors of the Canadian economy.

The Canadian Electrical Association is the national association of electrical utilities in Canada. It encourages customer-service initiatives such as DSM. In fact, the Energy Efficient Program promotes DSM in the following areas: residential, industrial building design, commercial, industrial, and agricultural applications (Canadian Electrical Association 1992). The Canadian Electrical Association advises provincial governments and utilities.

Manitoba Energy and Mines supports DSM-type programs and services. Information on energy conservation and efficiency is available to all Manitobans. Also, energy workshops are offered to the general public. Although the Department encourages DSM, it does not legislate DSM policies.

During 1989, Manitoba Hydro established a formal DSM policy for promoting energy conservation and load management. A goal to reduce new supply requirements by 285 MW by the year 2001 is targeted. Presently, some DSM programs are in place for residential, commercial, and agricultural customers.

Examples of the residential programs are: Outdoor Timer Program, Energy Efficient Shower Heads Pilot Program (completed), and Refrigerator and Freezer Buy-back Program (completed). As well, it is developing its major Residential Retrofit Program. Manitoba Hydro is also considering potential DSM programs for the residential sector such as a potential High-Performance Window Incentive Program.

Presently there is no formal policy involving HPWs. The results stemming from this research will aid the utility to formulate a policy in this regard.

2.3.3 Advantages and Disadvantages of DSM Programs

The exploitation of energy is an environmentally intensive enterprise (Melosi 1985). The generation of hydroelectricity is associated with a variety of environmental impacts such as increased air, land, and water pollution. When a new generation station is constructed, there are a number of global environmental impacts caused by the resources used during the design, construction of the facility, and with the generation and transportation of electricity (Platis & McCammond 1992).

DSM programs postpone the need for new energy supply as they are designed to reduce peak demand and electricity usage. Reducing the peak demand is very important since supplementary diesel and thermal generators used only at peak demands are very expensive to operate and costly to build. These supplementary power supplies emit greenhouse gases and are associated with other forms of environmental degradation. During non-peak periods, these expensive supplementary systems are idle. From a pro-environment perspective, less environmental damage would occur if peak loads were lowered (Geller et al. 1982). DSM programs are designed to encourage the efficient consumption of electricity which can in turn reduce supply-side generation requirements. The result is less generation-related environmental impacts due to the decrease of energy generated and possibly delaying the immediate need for additional generation facilities.

There are also a number of negative aspects associated with DSM programs. DSM programs can produce wastes due to the replacement of components before the end of their useful lives. An example of this problem is the replacement of operable incandescent light bulbs with more energy-efficient compact fluorescent light bulbs. The additional waste created is referred to as the by-product waste of the program (Platis & McCammond 1992). There is also the issue of free riders as rebates go to those who would have made the desired DSM investment without a rebate (Curran 1992). These wastes are negative externalities which must be factored into DSM decision-making process. Also, to cover the costs of DSM programs, utilities may increase their energy rates. The consumers who do not take advantage of programs may be faced with the financial burden of compensating users of incentives.

2.3.4 Consumer DSM Driving Forces

Consumers are often not as receptive to DSM programs as utilities would like them to be. Financial incentives alone and information alone have limited ability to bring consumers to act effectively in their economic self-interest. Consumers' motives are not only economic, but can also be usefully described by "attitudinal, social-diffusion, and homeostatic models of behavior" (Stern 1986). Since DSM means influencing consumption patterns that reflect idiosyncrasies of human behavior, different skills are required for promotion - communications, media, behavior analysis, and attitude surveys (Geller et al. 1982).

There is much research being conducted by utilities and academics in the area of consumers' behavioral analysis toward DSM programs. Wood (1991) found that "promotion of the link between residential electricity conservation and the environment has the potential to increase the effectiveness of conservation marketing efforts." Researchers such as Stern (1986), Gaskell & Bates (1986), and Dyne (1992) have concluded that consumers' decisions toward DSM programs are interdisciplinary in nature and place emphasis on quality of environment and life, personal comfort, economic and socio-economic consequences, and personal commitment towards conserving energy. It is concluded that consumers are making rational choices that go beyond a straightforward trade-off between financial costs and benefits.

2.3.5 Marketing DSM Programs

Although there are many driving forces possible to attract customers to DSM programs, rebates have now become the major promotional tool used by utilities. Rebates are designed to accomplish a number of objectives through the promise of a reward for a specific action: they catch the attention of the customer; they promote immediate action; they encourage individuals to try something they may not have tried without a rebate (Curran 1992). Along with a proper promotion package, rebates offered for DSM programs can decrease energy demand and costs to the parties involved. The most compelling argument for saving is economic - the opportunity cost of not saving (Mahon 1983).

2.4 WINDOW ENERGY CONSERVATION

A number of basic design and operational factors are critical for a window's performance. These include: size of the window, the orientation and exterior shading, its thermal resistance, reduction of air leakage, the use of internal and external window coverings, and use of daylight. In the last several years, increasing attention has been devoted to new window products that will add to the flexibility of window use and substantially improve its overall energy efficiencies. The successful implementation of these products and designs should make it possible for windows to lower the overall energy requirements for space conditioning. There is no technology that can be labelled the single "best" approach for all conditions: each differs radically from the other in cost, effectiveness, type of effect, and range of applicability.

When energy conservation is a major goal of a building design, the sun is perhaps the single most important natural element to consider. It affects virtually every portion of a building's design: its site and orientation, structure and glazing, HVAC systems, lighting system, and operating and maintenance policies. In the Northern Hemisphere, for example, the sun factor is most important to the design of the south, east/west, and north sides of a building, in decreasing order (Chiogioji and Oura 1982). Proper design of overhangs are used to admit sunlight in the winter and provide shade in the summer. Deciduous trees ensure summer shade and winter sunshine, and wind breaks temper the effects of winter winds.

If the windows are in reasonable condition, it will be far more cost-effective to repair any defects and upgrade the windows with caulking and weather-stripping than to replace them with new units. If the windows are in very poor condition, and it is not feasible to repair them, then they should be replaced with new units. Even if the existing windows can be repaired, consumers may want to replace them for a variety of reasons: improved appearance, less maintenance, and ease of operation. Presently, consumers usually purchase retrofit and new windows which have three sealed panes of glass with aluminum edge spacers and wood frames. These windows are typically referred to as triple-glazed windows. Recently, consumer and utilities are seeking windows with improved energy performance. Window manufacturers have responded to this request by introducing high-performance windows to the window market.

2.5 HIGH PERFORMANCE WINDOWS

2.5.1 General Characteristics

The window industry responded to consumer demand in the mid-1980s when a host of new technologies became available to improve window thermal performance. These are: heat-reflecting invisible low-emissivity coatings, insulated edge spacers, insulated frames, and low conductance gas between sealed panes. Unfortunately, the energy performance of advanced window systems is difficult to assess compared to other building envelope or mechanical system alternatives. A window's impact upon a house's energy consumption is heavily influenced by three interrelated factors: thermal resistance, solar heat gain, and orientation. This complicates the calculation of performance characteristics of windows.

High-performance windows are available in many sizes and shapes. The two styles that are common are operable and fixed windows. For operable windows, casement or awning-type windows are the most common in Manitoba and provide the best combination of low air leakage, ventilation, and ease of cleaning. As sliding and double-hung windows tend to lose much heat along their sliding tracks, most do not qualify as high-performance. A fixed window is the best choice for a window which is not required for ventilation or as an emergency exit (CANMET 1991). Fixed windows have lower air leakage rates and are less expensive than operable windows.

2.5.2 High-Performance Window Technologies

In recent years, scientific approaches have been used to address overall window heat transfer: radiation, conduction, and convection through the glazing, edge spacer, and frame (see Figure 3). Reduced heat transfer, together with improved solar heat gain characteristics and lessened air infiltration, have resulted in greatly improved windows.

Since two-thirds of the heat loss through a standard sealed glazing unit is radiation loss, a significant reduction in overall heat loss can be achieved by controlling it (Canadian Home Builders' Association 1989). Radiation loss occurs when the inside panel of glass transmits heat from the room and radiates it to the cooler outside panel. This type of heat flow can be reduced with low-emissivity (Low E) coatings and films. Low E metallic coatings slow the rate at which the glass will transmit heat. Short wave radiations (including visible light) pass through while long wave (infrared) radiations are blocked. In addition, low E coatings also partially block ultra-violet light, reducing fading of drapes, carpets, and other furnishings. The coatings are so thin as to be almost invisible. Two generic types of low E coating are in use today. These are usually known as "hard" or "soft" coats, referring to durability characteristics. The hard-coat glass is more durable but has sightly lower performance than soft-coat glass. Low-emissivity films suspended between glazings are also available. "Heat Mirror" is a common trademark name for this type of film.

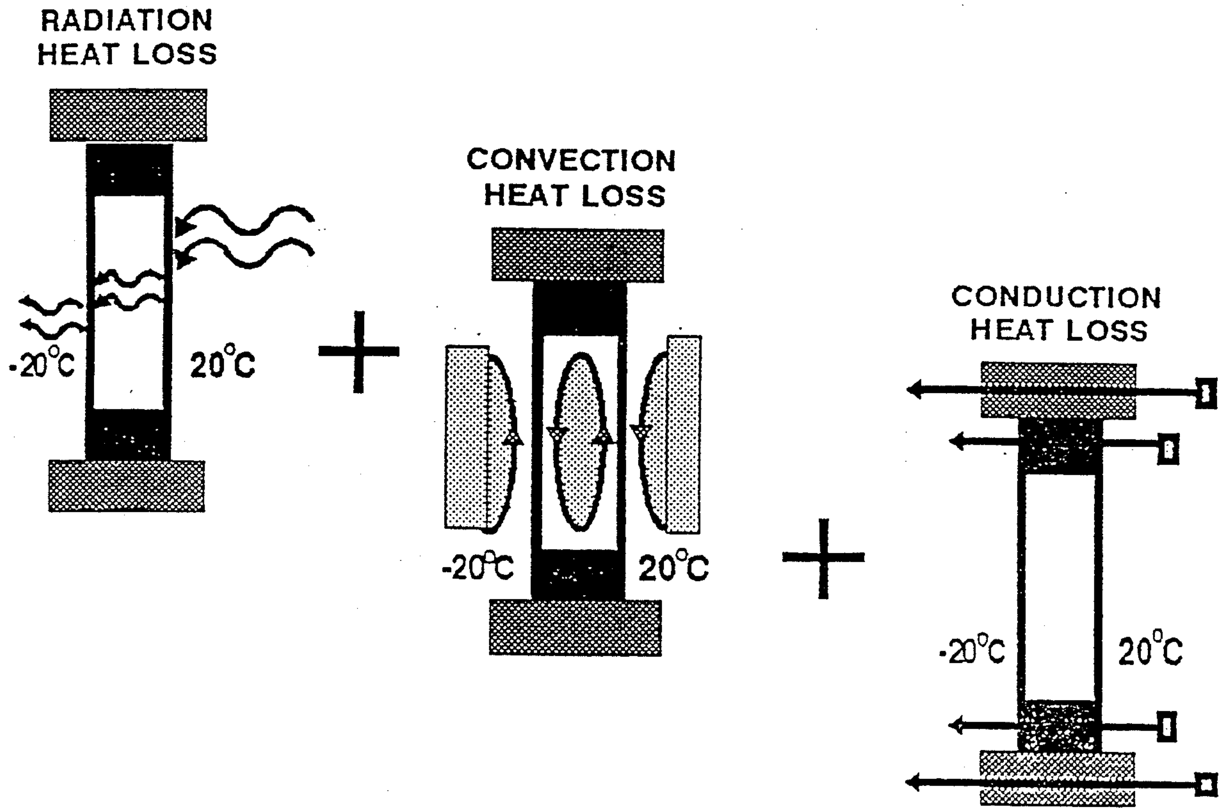


Figure 3. Window Heat Loss Mechanisms (CANMET 1991)

Some window manufacturers fill the space between layers of glazing with heavy gases such as argon and krypton. These gases discourage conduction, thereby reducing heat flow through window layers. However, only a few manufacturers can produce the special seals needed to contain heavy gases. Without these, the long-term performance of the window is suspect. It is also difficult to fill the sealed units with the heavy gas without allowing air to "contaminate" the space. These units are still experimental and warranties against defects are very limited (CANMET, 1991).

If the thermal resistance of the glazing unit has been improved, the "weak link" becomes the spacer at the perimeter. Low conductivity spacers are an important component of a HPW to get the full benefit of low-emissivity coatings and films and gas fills. The spacer bars are filled with a dessicant that absorbs moisture from the air spaces between the glazings. Spacers have traditionally been made of aluminum, but some manufacturers now offer windows incorporating plastic, silicone, or glass fibre spacers. These have lower conductivity and reduce condensation around the edge of the glazing. Insulated spacers also keep the edge of glass warmer, reduce thermal stresses and lessen the likelihood of condensation during cold weather.

Heat loss by air flow through the frame is a major source of window heat loss. Research is now under way to improve frame technology so that in future frames will be thinner and have higher insulation values. In general, a well-designed PVC or fibreglass frame will slightly out-perform a wood frame for insulation qualities, particularly if the hollow channels are filled with insulation.

2.6 ENERGY RATING FOR HEATING CONDITIONS

2.6.1 Generic Energy Rating Number

Superior window energy performance was achieved with the advent of high-performance windows (HPW). Initially, no standard evaluation methods were available for these new technologies. To find a simple approach for consumers as well as design professionals, in 1988, Energy, Mines and Resources Canada commissioned a study to develop a national consensus standard for window performance rating and labelling. The research attempted to establish a standard quantitative approach to evaluate windows for energy performance. This new window evaluation method would account for infiltration heat losses, air leakage losses, and promote the use of passive solar power - a measure of the window's ability to let solar heat inward. This led to an evaluation procedure based on the concept of combining into one number the three main performance characteristics that are measured separately:

Energy Rating = Solar Gains - Transmission Heat Loss -
Infiltration Heat Loss.

A positive value of this window energy rating (ER) would mean that the window is a net heat gainer over a heating season. Windows with high ER numbers are said to have good energy performance characteristics. The ER number is measured in Watts/m^2 (W/m^2).

A standardized method was developed to measure solar gains of windows. The solar heat gain coefficient (SHGC) is defined as the ratio of solar heat gain through a window to the solar radiation incident on it, for a given angle of incidence and for given environmental conditions (indoor temperature, outdoor temperature, wind speed, and solar radiation). Included are directly transmitted solar radiation as well as solar energy absorbed and then reradiated/conducted inwards (CANMET 1991). A piece of standard glass has a SHGC of approximately 0.87 (due to solar ratios, SHGC is dimensionless). Glazing treatments, including glass tint and low-emissivity coatings, can significantly reduce the SHGC.

In order to address transmission heat loss due to conduction, convection, and infrared radiation, the U-value of windows is measured. CANMET, a division of Energy, Mines and Resources Canada defines the U-value as, "the overall heat transmission in unit time through unit area of the complete window product and its boundary air films, induced by unit temperature difference between the environments on each side." The U-value, multiplied by the indoor/outdoor temperature difference and the complete window area, yields the total heat transfer through the window. The units for the U-value are Watts/$m^{2o}C$ (W/$m^{2o}C$). The R-value is the inverse of the U-value. It measures resistance of heat transmission of windows in unit time through a unit area. The units for the R-value are $m^{2o}C$/W.

Windows in Canada are tested for air leakage according to Standard Number CSA A440.1. The standard calls up the ASTM Standard E283 for testing air tightness of windows at room temperature conditions and a specified pressure difference of 75 Pa (Pascals), the pressure applied in the inward direction (infiltration). Results are quoted in terms of (m^3/h) per meter of crack length but these can be converted back to overall window leakage by using appropriate crack length definitions (CANMET 1991).

The ER number for a manufacturer's line is intended to be used only for comparison purposes. Although positive numbers would suggest that the window provides a net energy benefit, the number was determined for hypothetical average conditions. Assumptions were made about the type and location of houses and orientations of windows. The following assumptions were made:

1. solar gains represented by an average of the four cardinal directions;
2. average window air infiltration related to the leakage characteristics of the window, the local wind speed, and the local indoor/outdoor temperature difference; and
3. average Canadian meterological conditions for calculating the ambient temperature over the heating season.

To obtain values for the average meterological condition, a method was used that involved a modified degree-day approach with an estimated building balance point. Weather conditions were averaged over those days that fall below the balance point. The calculation was performed over locations in the 4000 to 6200 degree-day range.

Window performance depends on trade-offs between solar gain and losses due to heat transmission and air leakage. These vary across Canada as a result of a range of climate conditions, for different window orientations in a house, and for different window areas. As an example, a window with a higher SHGC might be better on the south side of a house while a window with a lower U-value might be better on other sides, even though both have the same ER number.

The ER equation in simplified form is (from CANMET 1991):

$$ER = 72.2\ F_w - 21.9\ U_w - 0.54(L_{75}/A_w)$$

where F_w is the solar heat gain coefficient;
U_w is the U-value;
L_{75} is the window air leakage rate; and
A_w is the total window area.

All these window characteristics are evaluated for standard sizes of window types for typical wood-frame houses (Glover 1992).

2.6.2 Specific Energy Rating Number

The ER system also includes a procedure for calculating window performance for more specific cases. This procedure is known as the ERS number. It takes into account such factors as building geographical location, window orientation, house construction type, and window size (Glover 1992). This procedure reflects the window's energy performance more accurately than the ER number.

House type has only a minor effect on ERS. Homes are divided into two categories: (a) average insulation such as building standards have called for since 1975, and (b) R-2000 insulation or better levels. The ERS can be used as an estimate of the impact of windows on building energy conservation. Positive ERS numbers, which can be achieved even for windows on other than south sides, indicate that a window provides a net energy gain over a heating season. Window properties such as SHGC, U-value, and air leakage rates are obtained from manufacturers for calculations. Results of ER and ERS numbers are assembled in Section 3.3.

Several criticisms of the ER and ERS number system exist. One criticism of the ER single-number system is that it only takes into account winter heating loads and that summer cooling loads are overlooked. However, work is under way to include cooling-load considerations in the ER system (Glover 1992). An advantage of the ER system is that a single rating is obtained to represent all sizes of a manufacturer's product line. A further advantage of the energy rating is that when multiplied by the number of hours in the heating season, it provides an estimate of the window's energy impact on a building.

2.7 COMPUTER SIMULATIONS

Computer simulations are used in this research as an aid to achieving cost-effective and accurate results. WINDOW 4.0 and HOT2000 version 6.00 computer programs simulate windows and residential structures, respectively. They were introduced first in Sections 1.5.3 and 1.5.4.

2.7.1 WINDOW 4.0

WINDOW 4.0 was developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory for calculating total window thermal performance properties such as U-values, solar heat gain coefficients, shading coefficients, and visible transmittances (Lawrence Berkeley Laboratory 1992). The program can be used to design and develop new window products, evaluate window performance characteristics, and aid users with quick generic window simulations. WINDOW 4.0 provides libraries of system components which can be combined into a glazing system and/or a complete window system and then analyzed.

The libraries of system components are:

1. Window Library for storing assembled window systems;
2. Glass Library;
3. Gas Library;
4. Glazing System Library for creating, analyzing, and storing glazing systems;
5. Environmental Conditions Library;
6. Frame Library; and
7. Divider Library.

To construct a window, the user needs the appropriate frame elements, glazing systems, divider elements, and environmental conditions stored in their respective libraries. If the necessary components are not in their respective libraries, the user can create new ones. The results of WINDOW 4.0 are found in Section 3.2.

The VISION and FRAME computer software packages could have been used as alternatives to WINDOW 4.0. Unfortunately, FRAME requires specific window frame configurations that were unavailable due to manufacturers' concealments.

2.7.2 HOT2000

HOT2000 is a microcomputer program designed to assist builders, architects, and engineers in the design of low-rise residential buildings. Utilizing current heat loss/gain and system performance models, the program aids in the simulation and design of buildings for thermal effectiveness, passive solar heating, and the operation and performance of heating and cooling systems (Canadian Home Builders' Association 1991). HOT2000 was developed for use by the R-2000 Super Energy Efficient Home Program of Energy, Mines and Resources Canada. Field monitoring of actual

R-2000 houses built under the R-2000 Program in Canada has demonstrated the accuracy of HOT2000 as a design tool.

HOT2000 lets the user input comprehensive data on a proposed building design. It uses a six-digit code to identify types of windows and glazing components for different window orientations. The following window orientations can be analyzed in HOT2000: north, south, east, west, southeast, southwest, northeast, and northwest. The output consists of: air leakage and ventilation rates, a space heating/cooling summary, and an estimated annual fuel consumption summary among others. This quick and efficient package lets the user revise and test altered designs until a satisfactory design is achieved. HOT2000 results are listed in Section 3.4.

2.8 MANITOBA HYDRO DSM GUIDELINES FOR ECONOMIC ANALYSIS

The Guidelines for the Economic Analysis of DSM Programs, first introduced in Section 1.5.5, was developed by DSM consultants Barakat & Chamberlin (1991). It involves three distinct steps. They are as follows:

Step 1) The Qualitative Analysis;
Step 2) The Simple Economic Screen; and
Step 3) The DS Strategist Run.

The Qualitative Analysis establishes whether technologies qualify as potential energy-saving measures based on various qualitative perceptions. If the measures fail the Qualitative Analysis, they are eliminated from future DSM economic analysis. Those measures that pass the Qualitative Analysis are ready for the

Simple Economic Screen (SES). In the SES, measures are eliminated if they do not pass the Measure Resource Cost Test (MRC). The basic equation used in this analysis is:

MRC = Benefits / Costs

where Benefits = Net present value of the utility avoided costs over the life of the measure; and

Costs = Net present value of incremental costs incurred by the customer to use the efficiency measure.

This model calculates the net present value of the stream of avoided-resource costs for each measure and compares this to the incremental costs of the technology. Any measure with a MRC greater or equal to 1.0 is passed on to Step 3 "The DS Strategist Run." Those measures that fail the MRC are shelved. Barakat & Chamberlin (1991) has developed an electronic spreadsheet model to assist DSM planners using the Simple Economic Screen. The analysis figures for the SES are derived from various computer simulations, such as HOT2000, used in DSM planning. Once the SES model is complete, qualifying measures are screened further with the DS Strategist evaluation.

The DS Strategist Run evaluates the total net resource expenditures, Total Resource Cost (TRC), of a DSM program from the point of view of the utility and its ratepayers as a whole. In simple terms, the DS Strategist evaluation includes utility program costs and adjusts for free riders that the SES leaves out. Free riders are the consumers who apply for incentives but would have bought the measures irregardless of whether incentives were offered. A quick rule-of-thumb method was developed by Barakat &

Chamberlin to modify the MRC to simulate the TRC. This method includes a proxy for program costs of 25% of the MRC to establish the TRC. A TRC greater than 1 indicates that the program is at least marginally cost-effective. This is Manitoba Hydro's primary screening criteria for economic cost-effectiveness; all DSM programs must pass this test! The results of the utility economic analysis are tabulated in Section 3.5.

2.9 CONSUMER FINANCIAL ANALYSIS

There are several tools available to calculate the consumers' financial analysis for DSM projects. The techniques were introduced first in Section 1.5.6. The three methods used are: Simple Payback Period (SPP), Internal Rate of Return (IRR), and Net Present Value (NPV).

The SPP analysis calculates the number of years required for the net cash flow of an investment to equal zero (Smith 1981). This payback period is calculated by not considering the interest rate. A more refined method is also available to calculate the payback period including the interest rate of borrowed money. In simple terms, the SPP analysis is calculated to determine the time to repay the investment. It can be used to compare various alternatives, with the energy management alternative having the shorter payback period being the preferred investment.

The IRR analysis calculates the opportunity interest rate an investment is expected to yield so that total discounted benefits and costs break-even (Hu 1983). The criterion for selection among alternatives is to choose the investment with the highest rate of return. The method used to find the interest rate is performed by trial and error when the present worth of the net cash flow is zero (Smith 1981).

The NPV method calculates the difference between the present value of the benefits and the costs resulting from alternative investments. The acceptance criteria of a project, as evaluated with the NPV method, are that: (1) only those investments having positive net benefits will be accepted (unless the project is mandatory); and (2) when selecting among mutually exclusive investments, the one with the highest positive net benefits will be chosen (or the one with the lowest negative net benefits when the project is mandatory and none of the alternatives has positive net benefits) (Hu 1983). A comparison of the aforementioned financial analysis methods is found in Table 1. A more detailed explanation along with results is illustrated in Section 3.6.

Table 1. Comparison of Financial Methods (adapted from Smith 1981, page 379)

Method Name	Advantages	Disadvantages	Recommendations
Simple Payback Period	Easily understood by management	Does not consider variable project lifetimes, future events	Recommended for small projects with lives less than five years
Internal Rate of Return	Similar to present worth; results easily understood by management	Needs iterative calculations and may yield multiple IRRs	Allows the user to weigh against the return of other investments
Net Present Value	Takes into account escalation, cost of money, variable project lives	More calculation effort involved	Recommended as best overall method for all types of projects

2.10 LINKING HIGH-PERFORMANCE WINDOWS TO THE ENVIRONMENT

High-performance window (HPW) technologies such as argon gas fills, low-emissivity coatings, insulated edge spacers, and insulated frames generally improve the energy efficiency of windows. As stated in Barakat & Chamberlin's report (1991), HPWs qualify as potential measures for inclusion in Demand-Side Management (DSM) programs. The intent of DSM programs is to reduce energy consumption and peak loads. These benign measures enable a utility to delay the construction of generation stations which are associated with environmental degradation. Examples of environmental casualties are: flooding, socio-economic problems, and contributions to the ubiquitous greenhouse gases.

HPWs can be part of a holistic environmental movement due to their energy conservation features. In summary, using Demand-Side Management endeavors such as a potential HPW incentive program is good "Natural Resources Management."

2.11 EXISTING UTILITY HPW INCENTIVE PROGRAMS

Some utilities across North America already provide direct purchase incentives for HPWs based on energy performance as part of their Demand-Side Management programs. Two utilities, Bonneville Power and Ontario Hydro, have recently implemented HPW incentive programs. Many others are looking at higher performance fenestration products for inclusion in their DSM programs.

In the United States, as part of their "Super-Good-Sense-Program," Bonneville Power introduced a HPW incentive program in

1986. To qualify for financial incentives, homeowners must purchase windows with minimum heat transmission levels of 0.35 U-value (0.50 R-value).

Ontario Hydro introduced the "Ontario Hydro Window Incentive Program" in the spring of 1992. This three year, $10 million program provides consumers with a $5/sq.ft. ($53.8/m^2) financial incentive for installing improved windows in electrically heated homes, with Energy Ratings greater than +2 for fixed and -13 for operable (Ontario Hydro 1991). Unlike the Bonneville incentive program, Ontario Hydro's incentives are offered to homeowners who purchase windows which meet Energy Rating specifications. The Energy Rating is based on three interrelated characteristics: heat transmission, solar heat gains, and infiltration loss. Now covering over 900 products from about 100 manufactures, the program has paid out over $600,000 in rebates to new construction and to replacement windows (Glover 1992).

2.12 SUMMARY

The events leading to the 1973 oil embargo initiated strategies for energy conservation. The inflation of energy prices resulted in domestic policies which were formulated to protect energy security. These policies affect both the supply of hydroelectricity and energy conservation. Electrical utilities, such as Manitoba Hydro, are taking the initiative to reduce electricity production by managing the demand for power. In 1991, Manitoba Hydro purchased the "Power Smart" program to promote

Demand-Side Management, since the results of energy conservation can have positive impacts on the environment due to delayed capital construction.

Good potential for energy conservation exists through new technologies. Manitoba Hydro has drawn attention to recent developments and improvements of high-performance windows. A study of this new technology has been initiated as a possible Demand-Side Management program. The simulation of energy savings with high-performance windows is possible using computer programs such as WINDOW 4.0 and HOT2000. Using established economic analysis methods, the economic feasibility of high-performance windows can be achieved.

The next chapter evaluates, with computer simulations, whether high-performance windows pass the utility economic and consumer financial screens. This is achieved by simulating various window applications in Winnipeg.

CHAPTER 3

HIGH-PERFORMANCE WINDOW ENERGY PERFORMANCE AND ECONOMIC RESULTS FOR DSM ANALYSIS

3.1 HIGH-PERFORMANCE WINDOW PRICE SURVEY

3.1.1 HPW Questionnaire

A price survey was directed to HPW manufacturers and installers in Winnipeg during the summer of 1992. This price survey established conventional triple-glazed window and HPW options installed prices for windows. A list of window manufacturers contacted for HPW prices is found in Appendix B. The contact people at these manufactures were contacted first by telephone. The researcher introduced himself, explained the study, and made an appointment to visit each manufacture and ask relevant questions for the HPW survey (see questionnaire in Appendix C).

Over the summer of 1992, window installers in Winnipeg were telephoned for HPW installed prices. Due to the initial complacency of installers when faced with a non-sale, as experienced with full identification, the researcher did not identify himself as a university student but as a customer willing to replace an existing broken window. The results generated are believed to be less biased, as installers did not "fluff" window prices in attempt to make an incentive program more viable. The prices quoted are those they would have charged a potential customer. During the course of conversation with contact people, additional comments were noted in regards to HPWs and the Ontario Hydro HPW Incentive Program (these comments are assembled in Section 3.1.3).

3.1.2 HPW Prices

In order to establish statistical validity to the results, a confidence interval (CI) of 2 standard deviations for HPW prices is performed (also known as CI of 95%). The confidence coefficient 0.95 implies that in repeated sampling, 95 percent of the confidence intervals encloses μ, the mean (Mendenhall 1987).

The methodology used to find the confidence interval goes as follows:

1) get the point estimate of the mean, x
2) find the standard deviation, $s = \sqrt{\frac{\sum(x_i - x)^2}{n-1}}$ where n = number of samples
3) find the standard deviation of the curve, $s_x = s/\sqrt{n}$
4) confidence interval = $x \pm t_{\alpha/2} * s_x$, where $t_{\alpha/2}$ is the t value with v=n-1 degrees of freedom, leaving an area of $\alpha/2$ to the right (Walpole & Myers 1985). See Figure 4.

The HPW prices were obtained during the summer of 1992. The researcher required HPW pricing for basic triple-glazed windows and for HPW options and combinations of options. The installed price with and without taxes (PST & GST) is recorded for economic analysis. The statistical analysis of the prices for installed fixed and operable triple-glazed (915 mm x 1220 mm) windows is as follows (prices are on a per window basis):

Fixed Window:
n = 31
x = \$275.65
s = \$91.36
s_x = \$16.41
CI = \$275.65 ± \$33.56 without taxes
CI = \$314.24 ± \$38.26 with 14% taxes

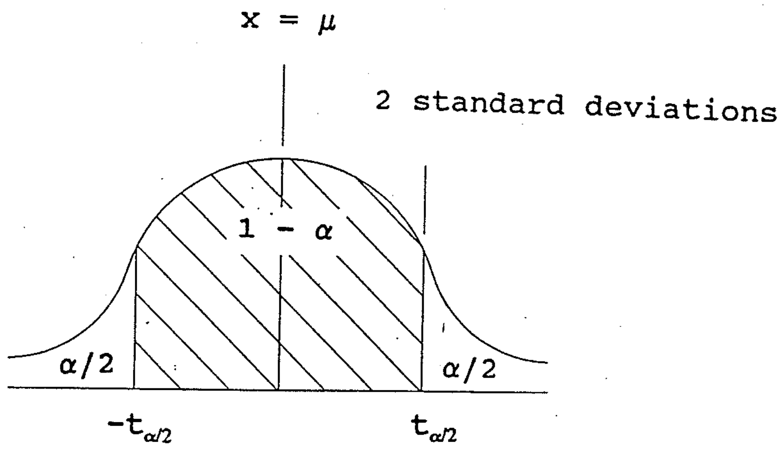


Figure 4. Confidence Interval

Operable Window:
n = 15
x = \$479.67
s = \$91.98
$s_x = \$23.75$
CI = \$479.67 ± \$50.94 without taxes
CI = \$546.82 ± \$58.07 with 14% taxes

The results stemming from this statistical analysis indicate there is a 95% probability that prices of triple-glazed fixed and operable windows will vary by ±12% and ±10% respectively. This relatively narrow price range reflects the high competition of the industry.

For the argon gas filled windows, the confidence interval prices, per window, is as follows:

n = 19
x = \$20.04
s = \$9.84
$s_x = \$2.28$
CI = \$20.04 ± \$4.80 without taxes
CI = \$22.85 ± \$ 5.47 with 14% taxes

The results from the confidence interval for argon gas filled windows indicate a range of ±24%. This wider price range reflects the fact that argon gas filled windows are a relatively new HPW technology and the price has yet been standardized by the window industry.

As there is only one exclusive manufacturer and seller of Heat Mirror in Manitoba, no statistical analysis is possible. The incremental costs of Heat Mirror, per window, are:

$n = 1$
x = \$30.24 without taxes
x = \$34.47 with 14% taxes

For Low E, the confidence interval pricing, per window, is as follows:

$n = 30$
x = \$43.92
s = \$13.20
s_x = \$2.40
CI = \$43.92 ± \$4.92 without taxes
CI = \$50.07 ± \$5.61 with 14% taxes

For the Low E option, the price variation of ±11% is calculated. This relatively low price range reflects its competitiveness.

Most manufacturers and installers suggested that high-performance frame (HPF) prices would add between 16-19% to triple-glazed window prices without HPW options. The HPF prices were therefore calculated at 17.5% above the triple-glazed window prices.

HPF for Fixed Window:
x = \$48.24 without taxes
x = \$54.99 with 14% taxes

HPF for Operable Window:
x = $83.94 without taxes
x = $95.69 with 14% taxes

For insulated edge spacers, the confidence interval pricing, per window, is as follows:

n = 7
x = $9.72
s = $10.68
s_x = $4.08
CI = $9.72 ± $9.96 without taxes
CI = $11.08 ± $11.35 with 14% taxes

A price range of over ±100% for insulated edge spacers reflects a wide variation in pricing of the newest HPW technology.

For double glazed windows with two layers of Heat Mirror, the pricing is (combination incremental costs over and above triple-glazed windows):

Fixed Window: n = 1, only one manufacturer/distributor found
x = $144.35 without taxes
x = $164.56 with 14% taxes

Operable Window: n = 1, only one manufacturer/distributor found
x = $15.33 without taxes
x = $17.48 with 14% taxes

The incremental costs associated with this window type seem very low. These costs may have been lowered by the manufacturer to attract attention from readers of this study.

A HPW hierarchy was developed along with manufacturers' and practicum committee's input to observe the economic and technological impacts of each HPW option for specific conditions. First, each HPW option is studied individually, then the options are combined. The following list describes each measure:

TG: conventional triple-glazed wood-framed window with aluminum/metal spacer bar - no HPW options;

TG, 1-Ar: triple-glazed wood-framed window with aluminum/metal spacer bar and inside window cavity filled with argon gas;

DG, 1-HM: double-glazed wood-framed window with aluminum/metal spacer bar and one film of Heat Mirror between panes;

TG, 1-Low E: triple-glazed wood-framed window with aluminum/metal spacer bar and one layer of Low E;

TG, HPF: triple-glazed window with aluminum/metal spacer bar and high-performance frame constructed of vinyl or fibreglass;

TG, IES: triple-glazed wood-framed window with insulated edge spacer bar;

DG, IES, 1-HM: double-glazed wood-framed window with insulated edge spacer bar and one film of Heat Mirror between panes;

TG, IES, 1-Ar, 1-Low E: triple-glazed wood-framed window with insulated edge spacer bar, one cavity filled with argon, and one layer of Low E;

TG, IES, 2-Ar, 2-Low E: triple-glazed wood-framed window with insulated edge spacer bar, two cavities filled with argon, and two layers of Low E;

TG, HPF, IES, 2-Ar, 2-Low E: triple-glazed high-performance framed window with insulated edge spacer bar, two cavities filled with argon, and two layers of Low E;

DG, HPF, IES, 2-Ar, 1-HM, 1-Low E: double-glazed high-performance framed window with insulated edge spacer bar, two cavities filled with argon, one film of Heat Mirror, and one layer of Low E; and

DG, IES, 2-HM: double-glazed wood-framed window with insulated edge spacer and two layers of Heat Mirror.

The window incremental costs reflecting the HPW option prices calculated above are listed in Table 2. For the HPW combinations, the individual option prices were added. The last window type, "DG, IES, 2-HM", is the only exception.

Table 2. High-Performance Window Prices

Description	Window Incremental Costs			
	Fixed W/O Taxes ($/Window)	Fixed W Taxes ($/Window)	Operable W/O Taxes ($/Window)	Operable W Taxes ($/Window)
TG	-	-	-	-
TG, 1-Ar	20.04	22.85	20.04	22.85
DG, 1-HM	30.24	34.47	30.24	34.47
TG, 1-Low E	43.92	50.07	43.92	50.07
TG, HPF	48.24	54.99	83.94	95.69
TG, IES	9.72	11.08	9.72	11.08
DG, IES, 1-HM	39.96	45.55	39.96	45.55
TG, IES, 1-Ar, 1-Low E	73.68	84.00	73.68	84.00
TG, IES, 2-Ar, 2-Low E	137.64	156.92	137.64	156.92
TG, HPF, IES, 2-Ar, 2-Low E	185.88	211.91	221.58	252.62
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	172.20	196.31	207.90	237.01
DG, IES, 2-HM	144.35	164.56	15.33	17.48

This window type is unique, thus the manufacturer's price quotation was used directly in the calculations. Results recorded in Table 2 indicate that higher-end HPWs are more expensive than those with few options. The HPW option prices are applied in Table 12 on page 79 and Table 16 on page 105.

3.1.3 Additional Survey Comments

The following general comments were made by the contact people at window manufactures/installers in regard to the Energy Rating (ER) system, incentive programs in general, and the Ontario Hydro HPW incentive program specifically.

Many manufacturers and suppliers were in favor of the ER system. They believe that this system can be used as a good marketing tool to sell windows. It was indicated that although the ER number is a good marketing tool, it should not be the sole measure for customers to consider when purchasing windows. Other window properties such as quality, window life, and warranties should be considered equally with the window's ER number. Many manufacturers complained that the ER number was expensive to obtain since the tests had to be performed by qualified laboratories. Also, many believed that the single number system was too simplistic and deceiving to the customers since it combines three distinct properties that some feel should remain separated due to the uniqueness of each parameter.

Both favorable and negative opinions towards incentive programs were given by manufacturers. It seems that the window manufacturers with high ER window values are in favor of the incentive programs and ER numbers while those with lower window ERs are not in favor of any kind of HPW incentive program. One respondent commented that incentive programs may attract "junk dealers who exist solely to exploit utility incentives. Also, past Manitoba Hydro incentive programs offered incentives to consumers irregardless of their heating systems. Some manufacturers believe that by offering incentives only to households with electrical heat discriminates against those with other heating sources.

There were also many negative opinions of the Ontario Hydro incentive program by Manitoba window manufacturers. Manufacturers and consumers complained that the ER cutoff numbers were "picked" by someone prior to any analysis; these numbers are not the end result of any rigor. One manufacturer stated that he believed that the incentive was too low and mostly the free riders were the ones responding to the program. Homeowners who would have purchased HPWs whether an incentive program existed or not are the only ones benefitting from the program. The incentives are perceived as being too low to generate interest from the mass populace. Also, many complaints were expressed about the Ontario Hydro HPW ER cutoff point of -13 for operable windows and +2 for fixed windows. Manufacturers believe these values are too low and the window manufacturers would have to produce lower grades of windows to satisfy the artificial consumer demand generated by the incentive program. Therefore potential energy reductions forecasted are never maximized.

3.2 WINDOW 4.0 ANALYSIS

The HPW thermal performance was evaluated by using WINDOW 4.0, an IBM PC computer program developed at the Lawrence Berkeley Laboratory.

This research required the R-value (1/U-value) and solar heat gain coefficient (SHGC) output from WINDOW 4.0. A sample printout of WINDOW 4.0 is found in Appendix H. Since WINDOW 4.0 does not distinguish between fixed and operable windows, there are only 12 different window specifications. The window performance results are condensed in Table 3:

Table 3. Window 4.0 Output Results

Description	R-val ($m^{2o}C/W$)	SHGC
TG	0.48	0.52
TG, 1-Ar	0.49	0.52
DG, 1-HM	0.57	0.31
TG, 1-Low E	0.52	0.44
TG, HPF	0.52	0.52
TG, IES	0.52	0.52
DG, IES, 1-HM	0.66	0.31
TG, IES, 1-Ar, 1-Low E	0.60	0.45
TG, IES, 2-Ar, 2-Low E	0.73	0.37
TG, HPF, IES, 2-Ar, 2-Low E	0.81	0.37
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	0.88	0.28
DG, IES, 2-HM	1.04	0.33

Referring to Table 3, it seems that HPWs with increasing options have higher R-values and lower SHGCs than the conventional triple-glazed window "TG". It seems that the R-value is inversely proportional to SHGCs with respect to HPWs. In fact, each HPW option has a positive impact on the R-value as each R-value is larger than 0.48 $m^{2o}C/W$ for triple-glazed (TG) windows. Only the Heat Mirror and Low E reduce the SHGC of each window; all other options have no effect on the SHGC. This explains why HPWs have lower SHGCs; they all have either of these low-emissivity technologies. The results from Table 3 are included for further analysis in Table 16 on page 105, under the "Window Energy Performance" column.

3.3 ENERGY RATING CALCULATION

3.3.1 Generic Energy Rating Number

The Energy Rating (ER) calculation for each window is based on the three window properties introduced in Section 2.6. They are: R-values (1/U-value), solar heat gain coefficients (SHGCs), and air leakage rates. Since the R-values and SHGCs were calculated using WINDOW 4.0, only the air leakage rates have yet to be determined. Referring to Appendix D, Clause 8.1 of CSA Standard A440.2 lists both the complete and simplified equations for ER calculations. The ER equation used applies to the heating season only. The heating season is taken as October 1 through April 30 inclusive. The CSA is currently developing an ER system to accommodate both heating and cooling seasons.

The air leakage rates were obtained from actual manufacturer's test results on HPWs. In Table 4, the air leakage rates are listed as follows:

Table 4. Air Leakage Rates

Window Type	Air Leakage Rate ($m^3/h\text{-}m^{-1}$)
wood fixed	0.016
wood operable	0.200
HPF fixed	0.008
HPF operable	0.170
DG, IES, 2-HM	0.060

The simplified equation was used to calculate the windows' Energy Rating (ER) values. The equation is listed as follows (CSA 1991):

$$ER = 72.2\ F_w - 21.9\ U_w - 0.54\ (L_{75} / A_w),\ \text{where}$$

F_w = window solar heat gain coefficient (SHGC), dimensionless
U_w = window U-value (1/R-value), $W/(m^{2\circ}C)$
L_{75} = window air leakage rate at a pressure difference of 75 Pa, m^3/h
A_w = area of window, m^2

A sample ER calculation was performed on the "TG, 1-Ar" HPW for a heating season. Referring to Table 16 on page 105, the values tabulated are as follows (example arbitrarily chosen):

R-val = 0.49 $m^{2\circ}C/W$
SHGC = 0.52
Air Leakage Rate = 0.016 $m^3/h\text{-}m^{-1}$

Rearranging these values into the equation, the values become:

$F_w = 0.52$
$U_w = 1/R\text{-val} = 1/0.49 = 2.04\ W/(m^{2\circ}C)$
$L_{75} = 0.016\ m^3/h\text{-}m^{-1} * 4.27\ m/\text{window} = 0.07\ m^3/h$
$A_w = 1.11\ m^2$

and $ER = -7.2\ W/m^2$

The ER values for each HPW have been recorded in Table 16 on page 105. Observing the ER values for HPWs in Table 16, it seems that in general the ER number increases as more HPW options are added to each window. Also, since high-end HPWs have larger incremental costs, as expressed in Table 2, one can deduce from Figure 6 that the ER is roughly proportional to the window incremental costs.

3.3.2 Specific Energy Rating Number

Clause 8.1 of CSA Standard A440.2 in Appendix D provides a method of calculating the ER value based on average climatic conditions. In order to obtain an energy rating value (ERS) that is specific to the climate of a particular location, to house design, to window orientation and size, the methodology in Part 2 of CSA Standard A440.2 was followed. Again the ERS calculations apply only to the heating season.

A sample ERS calculation was performed on the "TG, 1-AR" HPW for the heating season following the methodology in example 1 and example 2 in Appendix D.

1. House type: Typical Family House (see Appendix E for specifications)
2. Location: Winnipeg
3. Window type: fixed with wood frame and sash; sealed triple-glazing with one argon-filled space. Window properties:
   $F_w = 0.52$
   $U_w = 2.04$
   $L_{75}/A_w = 0.06$
4. Ratio of total window area to house floor area (A_{wt}/A_{fl}): Assume 15%
5. Value of SGI = 0.52*0.15 = 0.078
   Must now interpolate between the top and bottom reference values of SGI in Table 1 (Appendix D) to obtain values for F_s.

6. Values of F_s for orientations of interest:

South	East/West	North
150.0	-69.7	-34.1

7. Values of $qs = F_s * F_w$

South	East/West	North
78.0	36.2	17.7

8. Value of $q_t = U_w(t_i - t_o)$
$q_t = 2.04*28.3 = 57.7$

9. Value of $q_i = F_i(L_{75}/A_w)$
$q_i = 0.57*0.06 = 0.03$

10. Values of $ERS = q_s - q_t - q_i$

South	East/West	North
20.3	-21.5	-40.0

ERS average = -15.7

The ERS values for all HPWs are recorded in Table 16 on page 105. Similar to the ER system, the ERS of each window, in general, increases as windows have more HPW options. The windows on the south orientation have the highest ERS numbers followed by the east/west and north orientations in decreasing order as a result of decreasing solar heat gain. The ERS values for heating and cooling seasons are represented by NA (not applicable) since the method of ERS calculation for these conditions has not yet been developed.

3.4 HOT2000 ANALYSIS

3.4.1 Introduction

HOT2000 is a computer-simulation program designed to provide an accurate way of evaluating building designs. It was introduced in Sections 1.5.4 and 2.7. The evaluation takes into account the thermal effectiveness of the building and its components, the passive solar heating due to the location of the building, and the operation and performance of the building's ventilation, heating, and cooling systems (Canadian Home Builders Association 1991).

The basic functions of HOT2000 are to:

* **Create a house data file.** Building plan blueprint dimensions and thermal resistances of construction materials, six-digit code to identify window and glazing components, heating and cooling system information, and geographical location for a proposed residential structure are entered as data into HOT2000 and stored in a house data file; and

* **Run an analysis.** Using the data in a house data file, HOT2000 performs a heat loss/gain and cooling analysis on the structure, providing detailed information on the causes of heat loss/gain in the existing design. HOT2000 can also include utility fuel costs in its analysis of a structure. This information is presented in concise reports.

3.4.2 HOT2000 Set-up

In order to enter house data into HOT2000 for analysis, statistical house information was required. This information was acquired from Manitoba Energy and Mines and Manitoba Hydro. In the HOT2000 analysis, two house types were evaluated: namely Typical Family House and Energy Efficient Family House. The Typical Family House represents standard insulation levels in houses built after 1975. The Energy Efficient Family House is representative of R-2000 or Power Smart homes built today. See Appendix E for house specifications.

For each house type, heating loads alone and heating and cooling loads are calculated. For each of the above conditions two window types, namely fixed and operable, are being evaluated in HOT2000. Also, windows in north, south, east, and west orientations are studied. In total, there are 32 groups to evaluate. Table 16 on page 105 lists all groups.

For the HOT2000 analysis, all input variables were kept constant except for the windows. First, the energy performance was simulated for houses with standard triple-glazed windows. Then one window at a time in each orientation was upgraded by a high-performance option while keeping all other windows as triple-glazed. This analysis simulated all high-performance window options for different conditions keeping all other variables constant.

For each group, the window conditions are evaluated. The WINDOW 4.0 window thermal performance results are added into the "User Defined Parameter" option in HOT2000. HOT2000 uses a six-digit code to identify these user-defined windows. The windows listed in Table 5 were used in the HOT2000 analysis (refer to Section 3.1.2 for window specifications):

Table 5. HOT2000 User-Defined Window Codes

HOT2000 Code	Window Description
000001/100001	TG
000002/100002	TG, 1-Ar
000003/100003	DG, 1-HM
000004/100004	TG, 1-Low E
000005/100005	TG, HPF
000006/100006	TG, IES
000007/100007	DG, IES, 1-HM
000008/100008	TG, IES, 1-Ar, 1-Low E
000009/100009	TG, IES, 2-Ar, 2-Low E
000010/100010	TG, HPF, IES, 2-Ar, 2-Low E
000011/100011	DG, HPF, IES, 2-Ar, 1-HM, 1-Low E
000012/100012	DG, IES, 2-HM

The HOT2000 codes with a "0" as the first digit indicates that the window is fixed; those with a "1" are operable windows. WINDOW 4.0 and HOT2000 window performances (R-val and SHGC) are the same for both operable and fixed windows.

HOT2000 can include fuel costs in its analysis of a house in its "Fuel Costs Editor". This library maintains utility rates data for various fuels (electricity, natural gas, oil, and wood). These libraries are accessed by HOT2000 whenever the user wishes to include energy cost calculations in the analysis of the building.

Manitoba Hydro's electricity billing schedule was added into the HOT2000 "Fuel Costs Editor" which calculates the consumer energy bills on a monthly or yearly basis. Manitoba Hydro has what is known as a front end block rate structure whereby all residential customers in Winnipeg (Zone 1) pay 5.7 cents per Kilowatt-hour (KWh.) for the first 175 KWh. of electricity consumed per month with the balance of consumption costing the customer 4.6 cents per KWh. (September 1992 rates). Residential customers also pay a Manitoba Hydro loan payment and applicable taxes on their electricity bills. A simplified version of the front end block rate structure is shown in Figure 5:

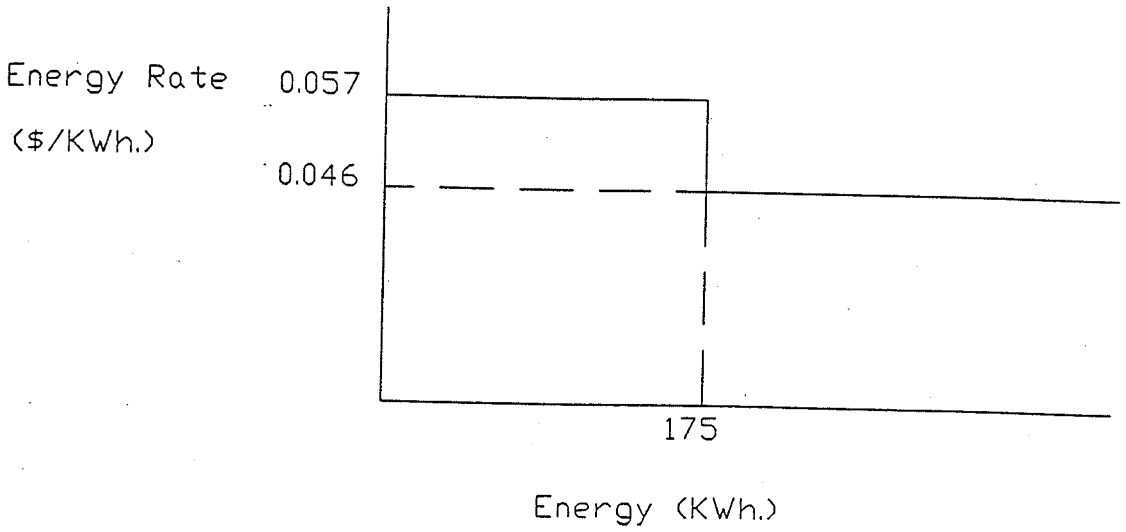


Figure 5. Manitoba Hydro Billing Schedule for Winnipeg

3.4.3 HOT2000 Results

The HOT2000 analysis was performed for 192 scenarios. The energy use for the Typical Family House and Energy Efficient Family House is consistent with the statistical figure of 27,470 KWh. per year shown in Appendix E. A sample HOT2000 computer printout can be consulted in Appendix G.

The HOT2000 annual energy use for each HPW scenario has been assembled in Table 6:

Table 6. HOT2000 Annual Energy Results

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed/Operable

		KWh./yr	
Window Description	South	East/West	North
TG	28788.5	28788.5	28788.5
TG, 1-Ar	28778.1	28778.1	28778.1
DG, 1-HM	28954.2	28841.5	28774.7
TG, 1-Low E	28843.2	28800.4	28775.0
TG, HPF	28754.3	28754.3	28754.3
TG, IES	28754.3	28754.3	28754.3
DG, IES, 1-HM	28905.7	28793.0	28726.2
TG, IES, 1-Ar, 1-Low E	28780.2	28742.6	28720.5
TG, IES, 2-Ar, 2-Low E	28809.2	28728.7	28681.2
TG, HPF, IES, 2-Ar, 2-Low E	28781.7	28701.3	28653.8
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	28862.4	28733.6	28657.3
DG, IES, 2-HM	28771.1	28669.1	28608.9

House Type: Energy Efficient Family House
Air Conditioning: No
Window Type: Fixed/Operable

		KWh./yr	
Window Description	South	East/West	North
TG	23483.7	23483.7	23483.7
TG, 1-Ar	23475.3	23475.3	23475.3
DG, 1-HM	23639.2	23527.8	23467.6
TG, 1-Low E	23535.7	23493.4	23470.7
TG, HPF	23452.1	23452.1	23452.1
TG, IES	23452.1	23452.1	23452.1
DG, IES, 1-HM	23591.9	23480.5	23420.5
TG, IES, 1-Ar, 1-Low E	23474.7	23437.7	23417.8
TG, IES, 2-Ar, 2-Low E	23500.0	23420.6	23377.9
TG, HPF, IES, 2-Ar, 2-Low E	23473.3	23393.9	23351.3
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	23548.7	23421.4	23352.8
DG, IES, 2-HM	23461.5	23360.9	23306.8

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
	KWh./yr		
TG	29669.8	29669.8	29669.8
TG, 1-Ar	29659.4	29659.4	29659.4
DG, 1-HM	29805.9	29691.0	29643.1
TG, 1-Low E	29713.6	29670.7	29651.4
TG, HPF	29635.6	29635.6	29635.6
TG, IES	29635.6	29635.6	29635.6
DG, IES, 1-HM	29757.4	29642.6	29594.7
TG, IES, 1-Ar, 1-Low E	29652.0	29614.4	29597.6
TG, IES, 2-Ar, 2-Low E	29670.1	29586.6	29553.3
TG, HPF, IES, 2-Ar, 2-Low E	29642.7	29559.2	29526.0
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	29710.2	29579.1	29524.0
DG, IES, 2-HM	29625.5	29521.6	29478.7

House Type: Energy Efficient Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
	KWh./yr		
TG	24488.8	24488.8	24488.8
TG, 1-Ar	24480.4	24480.4	24480.4
DG, 1-HM	24606.8	24495.5	24453.4
TG, 1-Low E	24522.8	24480.8	24470.4
TG, HPF	24457.2	24457.2	24457.2
TG, IES	24457.2	24457.2	24457.2
DG, IES, 1-HM	24559.9	24448.6	24406.3
TG, IES, 1-Ar, 1-Low E	24463.8	24427.0	24418.7
TG, IES, 2-Ar, 2-Low E	24477.1	24398.2	24368.1
TG, HPF, IES, 2-Ar, 2-Low E	24450.3	24371.8	24341.7
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	24512.5	24385.4	24337.1
DG, IES, 2-HM	24433.5	24332.9	24294.8

The annual energy savings for each HPW option are then calculated by taking the difference of energy results between high-performance windows and respective base triple-glazed windows (TG) in Table 6. The results of these calculations are found in Table 7.

Table 7. Annual Energy Savings for HPW Options

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed/Operable

Window Description	South (KWh./yr)	East/West (KWh./yr)	North (KWh./yr)
TG	-	-	-
TG → TG, 1-Ar	10.4	10.4	10.4
TG → DG, 1-HM	-165.7	-53.0	13.8
TG → TG, 1-Low E	-54.7	-11.9	13.5
TG → TG, HPF	34.2	34.2	34.2
TG → TG, IES	34.2	34.2	34.2
TG → DG, IES, 1-HM	-117.2	-4.5	62.3
TG → TG, IES, 1-Ar, 1-Low E	8.3	45.9	68.0
TG → TG, IES, 2-Ar, 2-Low E	-20.7	59.8	107.3
TG → TG, HPF, IES, 2-Ar, 2-Low E	6.8	87.2	134.7
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-73.9	54.9	131.2
TG → DG, IES, 2-HM	17.4	119.4	179.6

House Type: Energy Efficient Family House
Air Conditioning: No
Window Type: Fixed/Operable

Window Description	South (KWh./yr)	East/West (KWh./yr)	North (KWh./yr)
TG	-	-	-
TG → TG, 1-Ar	8.4	8.4	8.4
TG → DG, 1-HM	-155.5	-44.1	16.1
TG → TG, 1-Low E	-52.0	-9.7	13.0
TG → TG, HPF	31.6	31.6	31.6
TG → TG, IES	31.6	31.6	31.6
TG → DG, IES, 1-HM	-108.2	3.2	63.2
TG → TG, IES, 1-Ar, 1-Low E	9.0	46.0	65.9
TG → TG, IES, 2-Ar, 2-Low E	-16.3	63.1	105.8
TG → TG, HPF, IES, 2-Ar, 2-Low E	10.4	89.8	132.4
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-65.0	62.3	130.9
TG → DG, IES, 2-HM	22.2	122.8	176.9

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
		KWh./yr	
TG	-	-	-
TG → TG, 1-Ar	10.4	10.4	10.4
TG → DG, 1-HM	-136.1	-21.2	26.7
TG → TG, 1-Low E	-43.8	-0.9	18.4
TG → TG, HPF	34.2	34.2	34.2
TG → TG, IES	34.2	34.2	34.2
TG → DG, IES, 1-HM	-87.6	27.2	75.1
TG → TG, IES, 1-Ar, 1-Low E	17.8	55.4	72.2
TG → TG, IES, 2-Ar, 2-Low E	-0.3	83.2	116.5
TG → TG, HPF, IES, 2-Ar, 2-Low E	27.1	110.6	143.8
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-40.4	90.7	145.8
TG → DG, IES, 2-HM	44.3	148.2	191.1

House Type: Energy Efficient Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
		KWh./yr	
TG	-	-	-
TG → TG, 1-Ar	8.4	8.4	8.4
TG → DG, 1-HM	-118.0	-6.7	35.4
TG → TG, 1-Low E	-34.0	8.0	18.4
TG → TG, HPF	31.6	31.6	31.6
TG → TG, IES	31.6	31.6	31.6
TG → DG, IES, 1-HM	-71.1	40.2	82.5
TG → TG, IES, 1-Ar, 1-Low E	25.0	61.8	70.1
TG → TG, IES, 2-Ar, 2-Low E	11.7	90.6	120.7
TG → TG, HPF, IES, 2-Ar, 2-Low E	38.5	117.0	147.1
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-23.7	103.4	151.7
TG → DG, IES, 2-HM	55.3	155.9	194.0

General observations can be made about Table 7 with reference to energy savings. It seems that as HPWs have more options, the energy savings increase. Also, the greatest energy savings occur in the north, east/west, and south orientations in decreasing order. These results will be later used to calculate the utility avoided costs in the Simple Economic Screen (see Table 12 on page 79). The energy savings are directly transferred into the Simple Economic Screen and used in the utility economic analysis.

The annual consumer fuel costs were calculated by using the "Fuel Costs Editor" in HOT2000. These results are tabulated in Table 8.

Table 8. Annual Fuel Costs

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed/Operable

Window Description	South	East/West	North
	$/yr		
TG	1413.85	1413.85	1413.85
TG, 1-Ar	1413.37	1413.37	1413.37
DG, 1-HM	1421.48	1416.29	1413.22
TG, 1-Low E	1416.37	1414.40	1413.23
TG, HPF	1412.28	1412.28	1412.28
TG, IES	1412.28	1412.28	1412.28
DG, IES, 1-HM	1419.24	1414.06	1410.99
TG, IES, 1-Ar, 1-Low E	1413.47	1411.74	1410.72
TG, IES, 2-Ar, 2-Low E	1414.80	1411.10	1408.92
TG, HPF, IES, 2-Ar, 2-Low E	1413.54	1409.84	1407.66
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	1417.25	1411.33	1407.82
DG, IES, 2-HM	1413.05	1408.36	1405.59

House Type: Energy Efficient Family House
Air Conditioning: No
Window Type: Fixed/Operable

	$/yr		
Window Description	South	East/West	North
TG	1169.83	1169.83	1169.83
TG, 1-Ar	1169.45	1169.45	1169.45
DG, 1-HM	1176.98	1171.86	1169.09
TG, 1-Low E	1172.23	1170.28	1169.23
TG, HPF	1168.38	1168.38	1168.38
TG, IES	1168.38	1168.38	1168.38
DG, IES, 1-HM	1174.81	1169.69	1166.92
TG, IES, 1-Ar, 1-Low E	1169.42	1167.72	1166.80
TG, IES, 2-Ar, 2-Low E	1170.58	1166.93	1164.97
TG, HPF, IES, 2-Ar, 2-Low E	1169.35	1165.70	1163.74
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	1172.82	1166.97	1163.81
DG, IES, 2-HM	1168.81	1164.18	1161.69

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

	$/yr		
Window Description	South	East/West	North
TG	1454.39	1454.39	1454.39
TG, 1-Ar	1453.91	1453.91	1453.91
DG, 1-HM	1460.65	1455.37	1453.16
TG, 1-Low E	1456.41	1454.43	1453.55
TG, HPF	1452.82	1452.82	1452.82
TG, IES	1452.82	1452.82	1452.82
DG, IES, 1-HM	1458.42	1453.14	1450.94
TG, IES, 1-Ar, 1-Low E	1453.57	1451.84	1451.07
TG, IES, 2-Ar, 2-Low E	1454.41	1450.56	1449.04
TG, HPF, IES, 2-Ar, 2-Low E	1453.15	1449.30	1447.78
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	1456.25	1450.22	1447.68
DG, IES, 2-HM	1452.35	1447.57	1445.60

House Type: Energy Efficient Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	$/yr South	 East/West	 North
TG	1216.07	1216.07	1216.07
TG, 1-Ar	1215.68	1215.68	1215.68
DG, 1-HM	1221.50	1216.37	1214.44
TG, 1-Low E	1217.63	1215.70	1215.22
TG, HPF	1214.63	1214.63	1214.63
TG, IES	1214.63	1214.63	1214.63
DG, IES, 1-HM	1219.34	1214.22	1212.27
TG, IES, 1-Ar, 1-Low E	1214.91	1213.23	1212.84
TG, IES, 2-Ar, 2-Low E	1215.53	1211.90	1210.52
TG, HPF, IES, 2-Ar, 2-Low E	1214.29	1210.68	1209.30
TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	1217.16	1211.31	1209.09
DG, IES, 2-HM	1213.52	1208.89	1207.14

The annual consumer savings were calculated by subtracting the annual fuel costs of each high-performance window from the annual fuel costs of the triple-glazed window (TG) in each grouping. The results are tabulated below in Table 9:

Table 9. Annual Consumer Savings

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed/Operable

Window Description	South	East/West	North
	$/yr		
TG	-	-	-
TG → TG, 1-Ar	0.48	0.48	0.48
TG → DG, 1-HM	-7.63	-2.44	0.63
TG → TG, 1-Low E	-2.52	-0.55	0.62
TG → TG, HPF	1.57	1.57	1.57
TG → TG, IES	1.57	1.57	1.57
TG → DG, IES, 1-HM	-5.39	-0.21	2.86
TG → TG, IES, 1-Ar, 1-Low E	0.38	2.11	3.13
TG → TG, IES, 2-Ar, 2-Low E	-0.95	2.75	4.93
TG → TG, HPF, IES, 2-Ar, 2-Low E	0.31	4.01	6.19
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-3.40	2.52	6.03
TG → DG, IES, 2-HM	0.80	5.49	8.26

House Type: Energy Efficient Family House
Air Conditioning: No
Window Type: Fixed/Operable

Window Description	South	East/West	North
	$/yr		
TG	-	-	-
TG → TG, 1-Ar	0.38	0.38	0.38
TG → DG, 1-HM	-7.15	-2.03	0.74
TG → TG, 1-Low E	-2.40	-0.45	0.60
TG → TG, HPF	1.45	1.45	1.45
TG → TG, IES	1.45	1.45	1.45
TG → DG, IES, 1-HM	-4.98	0.14	2.91
TG → TG, IES, 1-Ar, 1-Low E	0.41	2.11	3.03
TG → TG, IES, 2-Ar, 2-Low E	-0.75	2.90	4.86
TG → TG, HPF, IES, 2-Ar, 2-Low E	0.48	4.13	6.09
TG → HPF, IES, 2-Ar, 1-HM, 1-Low E	-2.99	2.86	6.02
TG → DG, IES, 2-HM	1.02	5.65	8.14

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
	$/yr		
TG	-	-	-
TG → TG, 1-Ar	0.48	0.48	0.48
TG → DG, 1-HM	-6.26	-0.98	1.23
TG → TG, 1-Low E	-2.02	-0.04	0.84
TG → TG, HPF	1.57	1.57	1.57
TG → TG, IES	1.57	1.57	1.57
TG → DG, IES, 1-HM	-4.03	1.25	3.45
TG → TG, IES, 1-Ar, 1-Low E	0.82	2.55	3.32
TG → TG, IES, 2-Ar, 2-Low E	-0.02	3.83	5.35
TG → TG, HPF, IES, 2-Ar, 2-Low E	1.24	5.09	6.61
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-1.86	4.17	6.71
TG → DG, IES, 2-HM	2.04	6.82	8.79

House Type: Energy Efficient Family House
Air Conditioning: Yes
Window Type: Fixed/Operable

Window Description	South	East/West	North
	$/yr		
TG	-	-	-
TG → TG, 1-Ar	0.39	0.39	0.39
TG → DG, 1-HM	-5.43	-0.30	1.63
TG → TG, 1-Low E	-1.56	0.37	0.85
TG → TG, HPF	1.44	1.44	1.44
TG → TG, IES	1.44	1.44	1.44
TG → DG, IES, 1-HM	-3.27	1.85	3.80
TG → TG, IES, 1-Ar, 1-Low E	1.16	2.84	3.23
TG → TG, IES, 2-Ar, 2-Low E	0.54	4.17	5.55
TG → TG, HPF, IES, 2-Ar, 2-Low E	1.78	5.39	6.77
TG → TG, HPF, IES, 2-Ar, 1-HM, 1-Low E	-1.09	4.76	6.98
TG → DG, IES, 2-HM	2.55	7.18	8.93

The results from Table 9, similar to those of Table 7, indicate that as HPWs have more options, the annual consumer fuel cost savings are larger as well. The greatest savings are generated in the north, east/west, and south orientations in decreasing order. Negative savings were experienced where HPW options blocked passive solar energy and decreased the overall energy performance compared to standard triple-glazed windows. These results are also tabulated in the "overall analysis" (Table 16 on page 105) under the "Consumers Savings" column. These results are used to calculate the consumer economic analysis.

3.5 UTILITY ECONOMIC ANALYSIS

All energy-saving measures follow the guidelines for the economic analysis of DSM programs as discussed in Sections 1.5.5 and 2.8. Since windows have passed the Qualitative Analysis test in Barakat & Chamberlin (1991), they are passed on to the second step, the Simple Economic Screen. The Simple Economic Screen (SES) is an economic analysis developed to eliminate technologies and measures that do not pass the Measure Resource Cost Test (MRC). The basic equation for the MRC is:

MRC = Benefits/Costs, where

Benefits = net present value of the utility avoided costs over the life of the measure; and

Costs = Net present value of incremental costs incurred by the customer to use the efficiency measure.

Measures with a MRC greater than or equal to 1.0 are assessed in the DS Strategist Run to calculate the Total Resource Cost Test (TRC). Following recommendations of Dave Huminicki at Manitoba Hydro and using Barakat & Chamberlin (1991) guidelines, a modified version of the MRC test is used to simulate the TRC test. A proxy of 25% for program costs to represent program costs is added to the MRC to simulate the TRC. A TRC greater than 1 indicates that the program is cost-effective from the total resource cost perspective. This is Manitoba Hydro's primary screening criteria for economic cost effectiveness.

The Simple Economic Screen was developed by Manitoba Hydro and DSM consultants Barakat & Chamberlin. The detailed avoided costs for Manitoba Hydro DSM programs (Barakat & Chamberlin 1991) are found in Appendix F in Tables F1 and F2. These values are incorporated into Table F3. Then the present values of figures in Table F3 are calculated in Table F4. These values are then added together for their respective years in Table F5. These values are entered into an electronic spreadsheet program to calculate the Simple Economic Screen. The user inputs: the life of the measure, the incremental cost of the measure, summer demand, winter A.M. and P.M. demand savings, and annual energy savings. The SES calculates the avoided cost benefits and MRC of each measure.

The incremental costs of each measure are obtained from the HPW price survey. The calculations for the SES are exempt of all taxes as the utility shadow prices technologies and does not offer rebates to cover any form of taxes. Therefore the HPW prices without taxes added are used in the SES calculations. The energy savings are obtained directly from the HOT2000 results. Note in Table 12 that zeroes replace negative energy savings commonly found in Table 9. These window applications are not cost-effective since they do not perform as well as triple-glazed windows. Therefore extensive economic analyses were not performed for these scenarios since they are energy "losers." The summer and winter peak demands are calculated from the energy savings following the methodology in Barakat & Chamberlin (1991). The calculations are performed as follows:

Summer Demand Savings, KW: 0 for houses without summer cooling
: 1/2203 of cooling energy savings for houses with summer cooling

Winter A.M. Demand Savings, KW: 1/2840.9 of annual energy savings for all house types

Winter P.M. Demand Savings, KW: 1/3876.0 of annual energy savings for all house types

The calculations for the SES are made using the following equations derived from Table F5 in Appendix F for a 20 year life. The avoided cost formula is:

$$\begin{aligned}\text{Avoided cost} &= \text{summer demand savings (KW)} * \$68.93\\ &+ \text{winter A.M. demand savings (KW)} * \$321.72\\ &+ \text{winter P.M. demand savings (KW)} * \$321.72\\ &+ \text{annual energy savings (KWh.)} * 0.324\end{aligned}$$

where

68.93 → value of summer on peak demand (KW) levelized for a 20 year window life;

321.72 → value of winter A.M. or P.M. on peak demand (KW) levelized for a 20 year window life; and

0.324 → value of total annual energy (KWh.) levelized for a 20 year window life.

The SES calculates the avoided costs based in 1990$. For the purposes of this research, the avoided costs have to be elevated to 1992$. The following inflation values were obtained from Dave Huminicki at Manitoba Hydro:

1990\$ → 1991\$ inflate * 1.039
1991\$ → 1992\$ inflate * 1.019
therefore 1990\$ → 1992\$ inflate * 1.059

where

1.039 → inflation from 1990 to 1991, set at 3.9%;

1.019 → inflation from 1991 to 1992, set at 1.9%; and

1.059 → multiplication of above rates to calculate inflation from 1990 to 1992.

The MRC for each measure is obtained with the following formula:

MRC = avoided cost benefits (1992\$) / incremental costs (1992\$)

These values are recorded in Table 12 on page 79. The avoided cost (1992\$) and MRC values are also reflected in Table 16 on page 105.

The Total Resource Cost (TRC) is calculated for each scenario using the following equation:

TRC = MRC / 1.25

where a proxy of 25% accounts for DSM program set-up and operating costs but does not account for free riders (see Table 16 for TRC values). Free riders are the consumers who would purchase measures irregardless of incentives. The free riders are accounted for in the DS Strategist but not in the modified version to calculate TRC used in this study.

The results from the Simple Economic Screen Test (SES) are tabulated in Table 12. Most measures failed the Measure Resource Cost Test (MRC) as results generally indicate benefit/cost ratios below 1.0. Low MRC values indicate that high-performance windows

(HPW) incremental costs are higher than discounted utility avoided costs for 20 years. All HPWs with insulated edge spacers (TG, IES) consistently passed the MRC test with benefit/cost ratios near 2. All north-facing HPWs with Heat Mirror (DG, IES, 1-HM) also consistently passed MRC tests with benefit/cost ratios near 1. Operable double-glazed HPWs with insulated edge spacers and two layers of Heat Mirror (DG, IES, 2-HM) passed MRC tests with benefit/cost ratios near 7. Unfortunately, the incremental costs for this window may have been biased as mentioned in Section 3.1.2. The economic results for this window type are treated with caution. The best MRC test results from Table 12 on page 79 are condensed in Table 10.

Table 10. Best Measure Resource Cost Test Results

Window Description	MRC (approximately)
TG, IES (all orientations)	2.0
DG, IES, 1-HM (north orientation)	1.0

No economic analysis was performed for scenarios with negative energy savings as zeroes filled the rows of those measures. Observations from Table 12 indicate that the largest potential energy savings from HPWs exist in the north, east/west, and south orientations in decreasing order. Also, the economic analysis results do not vary much for similar house conditions.

The Total Resource Cost Test (TRC) results are expressed in Table 16 on page 105. The 25% proxy (for program set-up costs) brought down TRC levels to approximately 1.6 for TG, IES windows and approximately 0.8 for DG, IES, 1-HM windows. Table 11 shows these values.

Table 11. Best Total Resource Cost Test Results

Window Description	TRC (approximately)
TG, IES (all orientations)	1.6
DG, IES, 1-HM (north orientation)	0.8

Table 12. Simple Economic Screen Results

Notes pertaining to each component in Table 12 are listed as follows:

Incremental Cost (1992$) : the incremental cost of the options listed in 1992$

Summer Demand Savings, KW : 0 for houses with summer cooling 1/2203 of cooling energy savings with summer cooling

Winter A.M. Demand Savings, KW : 1/2840.9 of annual energy savings for houses with/without summer cooling

Winter P.M. Demand Savings, KW : 1/3876.0 of annual energy savings for houses with/without summer cooling

Annual Energy Savings, KWh. : Difference of annual energy savings obtained between TG and TG with HPW options obtained from HOT2000

Avoided Cost Benefits (1990$) : Avoided costs calculated by SES given energy and demand savings at avoided cost rates

Avoided Cost Benefits (1992$) : Avoided costs (1990$) inflated to 1992$

MRC Benefit/Cost : Avoided Cost Benefits / Incremental Costs.

Heating Load Only

End Use	Measure	Life (yrs)	Incremental Cost (1992$)	SAVINGS				Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/Cost Ratio
				Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh			
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0029	0.0021	8.3	$4.69	$4.97	0.07
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0024	0.0018	6.8	$3.88	$4.11	0.02
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$144.35	0.0000	0.0061	0.0045	17.4	$9.88	$10.46	0.07
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0118	45.9	$26.07	$27.61	0.37
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0210	0.0154	59.8	$33.94	$35.94	0.26
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0307	0.0225	87.2	$49.53	$52.45	0.28
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0193	0.0142	54.9	$31.18	$32.02	0.19
	TG -> DG, IES, 2-HM	20	$144.35	0.0000	0.0420	0.0308	119.4	$67.80	$71.80	0.50
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0049	0.0036	13.8	$7.86	$8.33	0.28
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0048	0.0035	13.5	$7.69	$8.14	0.19
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.94
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0239	0.0175	68.0	$38.60	$40.87	0.55
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0378	0.0277	107.3	$60.96	$64.55	0.47
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0474	0.0348	134.7	$76.52	$81.03	0.44
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0462	0.0338	131.2	$74.51	$78.90	0.46
	TG -> DG, IES, 2-HM	20	$144.35	0.0000	0.0632	0.0463	179.6	$101.99	$108.01	0.75
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0118	45.9	$26.07	$27.61	0.37
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0210	0.0154	59.8	$33.94	$35.94	0.26
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0307	0.0225	87.2	$49.53	$52.45	0.28
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0193	0.0142	54.9	$31.18	$33.02	0.19

				SAVINGS						
End Use	Measure	Life (yrs)	Incremental Cost (1992$)	Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0029	0.0021	8.3	$4.69	$4.97	0.07
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0024	0.0018	6.8	$3.88	$4.11	0.02
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0061	0.0045	17.4	$9.88	$10.46	0.68
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0118	45.9	$26.07	$27.61	0.37
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0210	0.0154	59.8	$33.94	$35.94	0.26
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0307	0.0225	87.2	$49.53	$52.45	0.24
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0193	0.0142	54.9	$31.18	$33.02	0.16
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0420	0.0308	119.4	$67.80	$71.80	4.68
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0049	0.0036	13.8	$7.86	$8.33	0.28
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0048	0.0035	13.5	$7.69	$8.14	0.19
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.94
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0239	0.0175	68.0	$38.60	$40.87	0.55
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0378	0.0277	107.3	$60.96	$64.55	0.47
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0474	0.0348	134.7	$76.52	$81.03	0.37
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0462	0.0338	131.2	$74.51	$78.90	0.38
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0632	0.0463	179.6	$101.99	$108.01	7.05
House Type: Typical Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0118	45.9	$26.07	$27.61	0.37
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0210	0.0154	59.8	$33.94	$35.94	0.26
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0307	0.0225	87.2	$49.53	$52.45	0.24
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0193	0.0142	54.9	$31.18	$33.02	0.16
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0420	0.0308	119.4	$67.80	$71.80	4.68

				SAVINGS						
End Use	Measure	Life (yrs)	Incremental Cost (1992$)	Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0032	0.0023	9.0	$5.11	$5.42	0.07
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0037	0.0027	10.4	$5.92	$6.27	0.03
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$141.35	0.0000	0.0078	0.0057	22.2	$12.60	$13.34	0.09
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0011	0.0008	3.2	$1.80	$1.91	0.05
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0119	46.0	$26.14	$27.68	0.38
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0222	0.0163	63.1	$35.84	$37.96	0.28
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0316	0.0232	89.8	$51.01	$54.02	0.29
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.22
	TG -> DG, IES, 2-HM	20	$144.35	0.0000	0.0432	0.0317	122.8	$69.74	$73.86	0.51
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0057	0.0042	16.1	$9.17	$9.71	0.32
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0046	0.0034	13.0	$7.41	$7.84	0.18
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0222	0.0163	63.2	$35.88	$38.00	0.95
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0232	0.0170	65.9	$37.43	$39.64	0.54
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0372	0.0273	105.8	$60.08	$63.62	0.46
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0466	0.0342	132.4	$75.21	$79.65	0.43
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0461	0.0338	130.9	$74.36	$78.75	0.46
	TG -> DG, IES, 2-HM	20	$144.35	0.0000	0.0623	0.0456	176.9	$100.47	$106.40	0.74
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0011	0.0008	3.2	$1.80	$1.91	0.05
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0119	46.0	$26.14	$27.68	0.38
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0222	0.0163	63.1	$35.84	$37.96	0.28
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0000	0.0316	0.0232	89.8	$51.01	$54.02	0.29
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.22

End Use	Measure	Life (yrs)	Incremental Cost (1992$)	SAVINGS						
				Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0032	0.0023	9.0	$5.11	$5.42	0.07
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0037	0.0027	10.4	$5.92	$6.27	0.03
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0078	0.0057	22.2	$12.60	$13.34	0.87
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0011	0.0008	3.2	$1.80	$1.91	0.05
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0119	46.0	$26.14	$27.68	0.38
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0222	0.0163	63.1	$35.84	$37.96	0.28
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0316	0.0232	89.8	$51.01	$54.02	0.24
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.18
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0432	0.0317	122.8	$69.74	$73.86	4.82
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0057	0.0042	16.1	$9.17	$9.71	0.32
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0046	0.0034	13.0	$7.41	$7.84	0.18
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0222	0.0163	63.2	$35.88	$38.00	0.95
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0232	0.0170	65.9	$37.43	$39.64	0.54
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0372	0.0273	105.8	$60.09	$63.62	0.46
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0466	0.0342	132.4	$75.21	$79.65	0.36
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0461	0.0338	130.9	$74.36	$78.75	0.38
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0623	0.0456	176.9	$100.47	$105.40	6.94
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: No	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0011	0.0008	3.2	$1.80	$1.91	0.05
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0000	0.0162	0.0119	46.0	$26.14	$27.68	0.38
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0222	0.0163	63.1	$35.84	$37.96	0.28
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0000	0.0316	0.0232	89.8	$51.01	$54.02	0.24
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0219	0.0161	62.3	$35.38	$37.47	0.18
	TG -> DG, IES, 2-HM	20	$15.33	0.0000	0.0432	0.0317	122.8	$69.74	$73.86	4.82

Heating/Cooling Load

				SAVINGS						
End Use	Measure	Life (yrs)	Incremental Cost (1992$)	Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: South	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0029	0.0021	17.8	$8.52	$9.02	0.12
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0092	0.0024	0.0018	27.1	$12.06	$12.77	0.07
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$144.35	0.0122	0.0061	0.0045	44.3	$20.72	$21.94	0.15
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: East	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0123	0.0000	0.0000	27.2	$10.96	$11.61	0.29
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0162	0.0118	55.4	$29.90	$31.66	0.43
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0106	0.0210	0.0154	83.2	$43.37	$45.93	0.33
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0106	0.0307	0.0225	110.6	$58.96	$62.44	0.34
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0163	0.0193	0.0142	90.7	$45.62	$48.31	0.28
	TG -> DG, IES, 2-HM	20	$144.35	0.0131	0.0420	0.0308	148.2	$79.41	$84.10	0.58
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: North	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0059	0.0049	0.0036	26.7	$13.07	$13.84	0.46
	TG -> TG, 1-Low E	20	$43.92	0.0022	0.0048	0.0035	18.4	$9.66	$10.23	0.23
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0058	0.0219	0.0161	75.1	$40.54	$42.93	1.07
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0019	0.0239	0.0175	72.2	$40.29	$42.66	0.58
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0042	0.0378	0.0277	116.5	$64.67	$68.48	0.50
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0041	0.0474	0.0348	143.8	$80.18	$84.91	0.46
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0066	0.0462	0.0338	145.8	$80.39	$85.13	0.49
	TG -> DG, IES, 2-HM	20	$144.35	0.0052	0.0632	0.0463	191.1	$106.62	$112.91	0.78
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: West	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.43
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0123	0.0000	0.0000	27.2	$10.96	$11.61	0.29
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0162	0.0118	55.4	$29.90	$31.66	0.43
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0106	0.0210	0.0154	83.2	$43.37	$45.93	0.33
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0106	0.0307	0.0225	110.6	$58.96	$62.44	0.34
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0163	0.0193	0.0142	90.7	$45.62	$48.31	0.28
	TG -> DG, IES, 2-HM	20	$144.35	0.0131	0.0420	0.0308	148.2	$79.41	$84.10	0.58

				SAVINGS						
End Use	Measure	Life (yrs)	Incremental Cost (1992$)	Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Typical Family House Air Conditioning: Yes Window Type: Operable Orientation: South	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0029	0.0021	17.8	$8.52	$9.02	0.12
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0092	0.0024	0.0018	27.1	$12.06	$12.77	0.06
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$15.33	0.0122	0.0061	0.0045	44.3	$20.72	$21.94	1.43
House Type: Typical Family House Air Conditioning: Yes Window Type: Operable Orientation: East	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0123	0.0000	0.0000	27.2	$10.96	$11.61	0.29
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0162	0.0118	55.4	$29.90	$31.66	0.43
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0106	0.0210	0.0154	83.2	$43.37	$45.93	0.33
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0106	0.0307	0.0225	110.6	$58.96	$62.44	0.28
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0163	0.0193	0.0142	90.7	$45.62	$48.31	0.23
	TG -> DG, IES, 2-HM	20	$15.33	0.0131	0.0420	0.0308	148.2	$79.41	$84.10	5.49
House Type: Typical Family House Air Conditioning: Yes Window Type: Operable Orientation: North	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0059	0.0049	0.0036	26.7	$13.07	$13.84	0.46
	TG -> TG, 1-Low E	20	$43.92	0.0022	0.0048	0.0035	18.4	$9.66	$10.23	0.23
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0058	0.0219	0.0161	75.1	$40.54	$42.93	1.07
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0019	0.0239	0.0175	72.2	$40.29	$42.66	0.58
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0042	0.0378	0.0277	116.5	$64.67	$68.48	0.50
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0041	0.0474	0.0348	143.8	$80.18	$84.91	0.38
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0066	0.0462	0.0338	145.8	$80.39	$85.13	0.41
	TG -> DG, IES, 2-HM	20	$15.33	0.0052	0.0632	0.0463	131.1	$106.62	$112.91	7.37
House Type: Typical Family House Air Conditioning: Yes Window Type: Operable Orientation: West	Window Replacment - Incremental costs only									
	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0037	0.0027	10.4	$4.99	$5.28	0.26
	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	0.24
	TG -> TG, IES	20	$9.72	0.0000	0.0120	0.0088	34.2	$19.40	$20.55	2.11
	TG -> DG, IES, 1-HM	20	$39.96	0.0123	0.0000	0.0000	27.2	$10.96	$11.61	0.29
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0043	0.0162	0.0118	55.4	$29.90	$31.66	0.43
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0106	0.0210	0.0154	83.2	$43.37	$45.93	0.33
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0106	0.0307	0.0225	110.6	$58.96	$62.44	0.28
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0163	0.0193	0.0142	90.7	$45.62	$48.31	0.23
	TG -> DG, IES, 2-HM	20	$15.33	0.0131	0.0420	0.0308	148.2	$79.41	$84.10	5.49

				SAVINGS						
End Use	Measure	Life (yrs)	Incremental Cost (1992$)	Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	MRC Benefit/ Cost Ratio
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: Yes	TS -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0073	0.0032	0.0023	25.0	$11.57	$12.25	0.17
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0053	0.0000	0.0000	11.7	$4.71	$4.99	0.04
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0128	0.0037	0.0027	38.5	$17.25	$18.27	0.10
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$144.35	0.0150	0.0078	0.0057	55.3	$25.93	$27.46	0.19
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0036	0.0000	0.0000	6.0	$3.22	$3.41	0.08
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0168	0.0011	0.0008	40.2	$16.71	$17.70	0.44
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0072	0.0162	0.0119	61.8	$32.51	$34.43	0.47
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0125	0.0222	0.0163	90.6	$46.93	$49.69	0.36
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0123	0.0316	0.0232	117.0	$61.97	$65.62	0.35
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0187	0.0219	0.0161	103.4	$51.95	$55.01	0.32
	TG -> DG, IES, 2-HM	20	$144.35	0.0150	0.0432	0.0317	155.9	$83.08	$87.98	0.61
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0088	0.0057	0.0042	35.4	$16.95	$17.95	0.59
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0025	0.0046	0.0034	18.4	$9.59	$10.15	0.23
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0088	0.0222	0.0163	82.5	$43.66	$46.24	1.16
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0019	0.0232	0.0170	70.1	$39.12	$41.43	0.56
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0068	0.0372	0.0273	120.7	$66.09	$69.98	0.51
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0067	0.0466	0.0342	147.1	$81.14	$85.92	0.46
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0094	0.0461	0.0338	151.7	$82.74	$87.62	0.51
	TG -> DG, IES, 2-HM	20	$144.35	0.0078	0.0623	0.0456	194.0	$107.36	$113.70	0.79
House Type: Energy Efficient Family House	Window Replacement - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Fixed	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0036	0.0000	0.0000	8.0	$3.22	$3.41	0.08
	TG -> TG, HPF	20	$48.24	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.39
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0168	0.0011	0.0008	40.2	$16.71	$17.70	0.44
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0072	0.0162	0.0119	61.8	$32.51	$34.43	0.47
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0125	0.0222	0.0163	90.6	$46.93	$49.69	0.36
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$185.88	0.0123	0.0316	0.0232	117.0	$61.97	$65.62	0.35
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$172.20	0.0187	0.0219	0.0161	103.4	$51.95	$55.01	0.32
	TG -> DG, IES, 2-HM	20	$144.35	0.0150	0.0432	0.0317	155.9	$83.08	$87.98	0.61

End Use	Measure	Life (yrs)	Incremental Cost (1992$)	SAVINGS Summer Demand kW	Winter A.M. Demand kW	Winter P.M. Demand kW	Annual Energy kWh	Avoided Cost Benefits (1990$)	Avoided Cost Benefits (1992$)	NRC Benefit/ Cost Ratio
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: South	TG -> TG, 1-Low E	20	$43.92	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0073	0.0032	0.0023	25.0	$11.57	$12.25	0.17
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0053	0.0000	0.0000	11.7	$4.71	$4.99	0.04
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.59	0.0128	0.0037	0.0027	38.5	$17.25	$18.27	0.08
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
	TG -> DG, IES, 2-HM	20	$15.33	0.0150	0.0078	0.0057	55.3	$25.93	$27.46	1.79
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: East	TG -> TG, 1-Low E	20	$43.92	0.0036	0.0000	0.0000	8.0	$3.22	$3.41	0.08
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0168	0.0011	0.0008	40.2	$16.71	$17.70	0.44
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0072	0.0162	0.0119	61.8	$32.51	$34.43	0.47
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0125	0.0222	0.0163	90.6	$46.93	$49.69	0.36
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0123	0.0316	0.0232	117.0	$61.97	$65.62	0.30
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0187	0.0219	0.0161	103.4	$51.95	$55.01	0.26
	TG -> DG, IES, 2-HM	20	$15.33	0.0150	0.0432	0.0317	155.9	$83.08	$87.98	5.74
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0088	0.0057	0.0042	35.4	$16.95	$17.95	0.59
Orientation: North	TG -> TG, 1-Low E	20	$43.92	0.0025	0.0046	0.0034	18.4	$9.59	$10.15	0.23
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0088	0.0222	0.0163	82.5	$43.66	$46.24	1.16
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0019	0.0232	0.0170	70.1	$39.12	$41.43	0.56
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0068	0.0372	0.0273	120.7	$66.09	$69.98	0.51
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0067	0.0466	0.0342	147.1	$81.14	$85.92	0.39
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0094	0.0461	0.0338	151.7	$82.74	$87.62	0.42
	TG -> DG, IES, 2-HM	20	$15.33	0.0078	0.0623	0.0456	194.0	$107.36	$113.70	7.42
House Type: Energy Efficient Family House	Window Replacment - Incremental costs only									
Air Conditioning: Yes	TG -> TG, 1-Ar	20	$20.04	0.0000	0.0030	0.0022	8.4	$4.04	$4.28	0.21
Window Type: Operable	TG -> DG, 1-HM	20	$30.24	0.0000	0.0000	0.0000	0.0	$0.00	$0.00	0.00
Orientation: West	TG -> TG, 1-Low E	20	$43.92	0.0036	0.0000	0.0000	8.0	$3.22	$3.41	0.08
	TG -> TG, HPF	20	$83.94	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	0.23
	TG -> TG, IES	20	$9.72	0.0000	0.0111	0.0082	31.6	$17.96	$19.01	1.96
	TG -> DG, IES, 1-HM	20	$39.96	0.0168	0.0011	0.0009	40.2	$16.71	$17.70	0.44
	TG -> TG, IES, 1-Ar, 1-Low E	20	$73.68	0.0072	0.0162	0.0119	61.8	$32.51	$34.43	0.47
	TG -> TG, IES, 2-Ar, 2-Low E	20	$137.64	0.0125	0.0222	0.0163	90.6	$46.93	$49.69	0.36
	TG -> TG, HPF, IES, 2-Ar, 2-Low E	20	$221.58	0.0123	0.0316	0.0232	117.0	$61.97	$65.62	0.30
	TG -> DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	20	$207.90	0.0187	0.0219	0.0161	103.4	$51.95	$55.01	0.26
	TG -> DG, IES, 2-HM	20	$15.33	0.0150	0.0432	0.0317	155.9	$83.08	$87.98	5.74

3.6 CONSUMER FINANCIAL ANALYSIS

3.6.1 Financial Analysis without Incentives

The simple payback period (SPP), internal rate of return (IRR), and net present value (NPV) were calculated for each HPW scenario. The methods for calculating economic analysis were introduced in Sections 1.5.6 and 2.9. The incremental HPW option costs from the HPW price survey and the fuel cost savings from HOT2000 analyses were required for these evaluations. The HPW option costs with 14% taxes (PST and GST) were used in the consumers' economic analysis as consumers are not exempt from taxes.

In brief, the SPP determines the time required to repay the investment without including the interest rate. The NPV calculates the present value of a series of present and future disbursements or receipts (Smith 1981). The IRR calculates the opportunity interest rate an investment is expected to yield, the discount rate that equates the present value of benefits and costs (Hu 1983). An electronic spreadsheet was used to calculate the IRR and NPV to expedite the calculations. The results of the consumer economic analysis are tabulated in Table 16 on page 105. The values with "NA" represent scenarios with negative annual fuel cost savings as a result of HPWs having lower performance than standard triple-glazed windows. No economic calculations were pursued for these cases.

Most measures failed the consumer economic indicators due to low consumer savings for very expensive high-performance window

(HPW) options. In Table 16, most simple payback periods are very high (up to 600 years), internal rates of return are very low, and net present values are usually negative. The three aforementioned economic tests are closely related and so it is not surprising that the results are similar.

The best window options are again the HPWs with insulated edge spacers (TG, IES) and double-glazed windows with insulated edge spacers with Heat Mirror (DG, IES, 1-HM). Also, triple-glazed windows with insulated edge spacers, one argon gas fill, and one Low E coated glazing (TG, IES, 1-Ar, 1-Low E) performed marginally well in economic analysis. Table 13 illustrates the best consumer economic analysis results without incentives.

Economic results are similar in common window groupings. Similar to the utility economic analysis, greatest energy saving potential (shown by highest SPP, IRR, AND NPV levels) occurs on the north, east/west, and south orientations in decreasing order.

Table 13. Best Consumer Economic Analysis Test Results without Incentives

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed
Orientation: North

Measure	SPP (years)	IRR	NPV ($)
TG → TG, IES	7.1	0.129	7.68
TG → DG, IES, 1-HM	13.2	0.043	-4.32
TG → TG, IES, 1-Ar, 1-Low E	25.3	-0.021	-44.32

A sensitivity analysis of the NPV results was calculated for different interest rates, in order to establish whether changing the interest rates had a large impact on the NPVs of each measure. A small impact on the NPVs would indicate low sensitivity to interest rates. The sensitivity analysis for the following measures was performed in Table 14 for the following arbitrarily chosen scenario:

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed
Orientation: South

The results from Table 14 indicate that the NPVs do not vary significantly. The scenarios with negative NPVs remain negative and varying the interest rates has limited economic impact on consumer acceptance of the individual measures.

Table 14. Sensitivity Analysis for Net Present Value Results

House Type: Typical Family House
Air Conditioning: No
Window Type: Fixed
Orientation: South

Window Code	NPV @ 2%	NPV @ 5.5%	NPV @ 10%	NPV @ 15%
TG → TG, 1-Ar	-15.00	-17.11	-18.76	-19.84
TG → DG, 1-HM	NA	NA	NA	NA
TG → TG, 1-Low E	NA	NA	NA	NA
TG → TG, HPF	-29.32	-36.23	-41.62	-45.16
TG → TG, IES	14.59	7.68	2.29	-1.25
TG → DG, IES, 1-HM	NA	NA	NA	NA
TG → TG, IES, 1-Ar, 1-Low E	-77.79	-79.46	-80.76	-81.62
TG → TG, IES, 2-Ar, 2-Low E	NA	NA	NA	NA
TG → TG, HPF, IES, 2-Ar, 2-Low E	-206.84	-208.21	-209.27	-209.97
TG → DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	NA	NA	NA	NA
TG → DG, IES, 2-HM	-151.48	-155.00	-157.75	-159.55

3.6.2 Financial Analysis with Incentives

The utility offers financial incentives to consumers through DSM incentive programs if they purchase measures that generate overall savings for the utility. Each scenario was analyzed to establish whether incentives were applicable for the following structure for a 20 year window life:

If NPV of incremental cost of HPW option (including taxes)
- NPV of annual fuel costs

is positive, then no need to offer utility incentives since these options already have good payback

is negative, then utility may offer incentives if the absolute value of the result is smaller than the NPV of utility avoided cost benefits - otherwise, no incentive is offered

Once the incentives are offered to qualifying measures, the net present value of 0 for a 20 year life stream results. Maximum potential incentive levels are limited by the utility avoided costs calculated in the Simple Economic Screen Test for each respective scenario.

In Table 16 on page 105, economic analysis results with utility incentives are listed. Most scenarios do not qualify for incentives (shown by NA) because either the HPW options are self-sustaining and do not need incentives (NPV > 0 but found in very few cases) or the HPW options costs are higher than the avoided costs for each respective scenario (where SPP > 20 years). Measures qualified for incentives only when the net present value of the avoided costs for a 20 year period were larger than the incremental costs of each respective HPW option. Therefore the utility covers the additional costs associated with HPW options.

The best consumer economic analysis results including incentives is found in Table 15 for the best economic conditions (the same conditions used in Table 13).

For those measures receiving the incentives, the SPP is 12 years (the payback would have been 20 years using a 5.5% discount rate), the IRR is 5.5% (the interest rate used in calculations) and the NPV is zero.

Table 15. Best Consumer Economic Analysis Test Results with Incentives

House Type: Typical Family House
Air Conditioning: Yes
Window Type: Fixed
Orientation: North

Measure	SPP (years)	IRR	NPV ($)
TG → TG, IES	NA	NA	NA
TG → DG, IES, 1-HM	12.0	0.055	0.00
TG → TG, IES, 1-Ar, 1-Low E	12.0	0.055	0.00

3.7 ENERGY RATING PLOTS

Although a window incentive program is not economically feasible, an attempt to find a correlation between Energy Rating numbers and energy performance is executed. Results tabulated in Table 16 are plotted to find any relationships. Ontario Hydro is currently using the ER system as cutoffs for qualification towards their window incentive program.

Figure 6 shows a plot of ER vs annual consumer energy savings. The regression analysis indicates that as ER numbers for HPWs increase, so do annual consumer energy savings. However the R-square is very low (R-square = 0.2830) indicating a scatter of points and low certainty of results. An R-square of 1.0 indicates a perfect regression analysis. Therefore, due to the scattering of points expressed by a low R-square, the ER relation is poor. A poor correlation is observed between ER numbers and annual consumer energy savings.

In Figure 7, the ER is plotted against the utility avoided costs discounted for a 20 year period. The results indicate that as ER numbers increase, so do utility avoided costs at a slope of 3.8096. The R-square for this relationship is also low as expressed by an R-square value of 0.2839. Therefore comparing the ER number to the utility avoided costs does not define a clear relationship.

In Figure 8, the ER is plotted against the utility Total Resource Cost (TRC). The results indicate that as the ER value increases, so does the TRC at a very low rate shown by the slope of

0.0751. This regression analysis is again very low, the R-square value is 0.0949. Therefore, plotting the ER values verses the utility TRC does not identify a well-defined relationship.

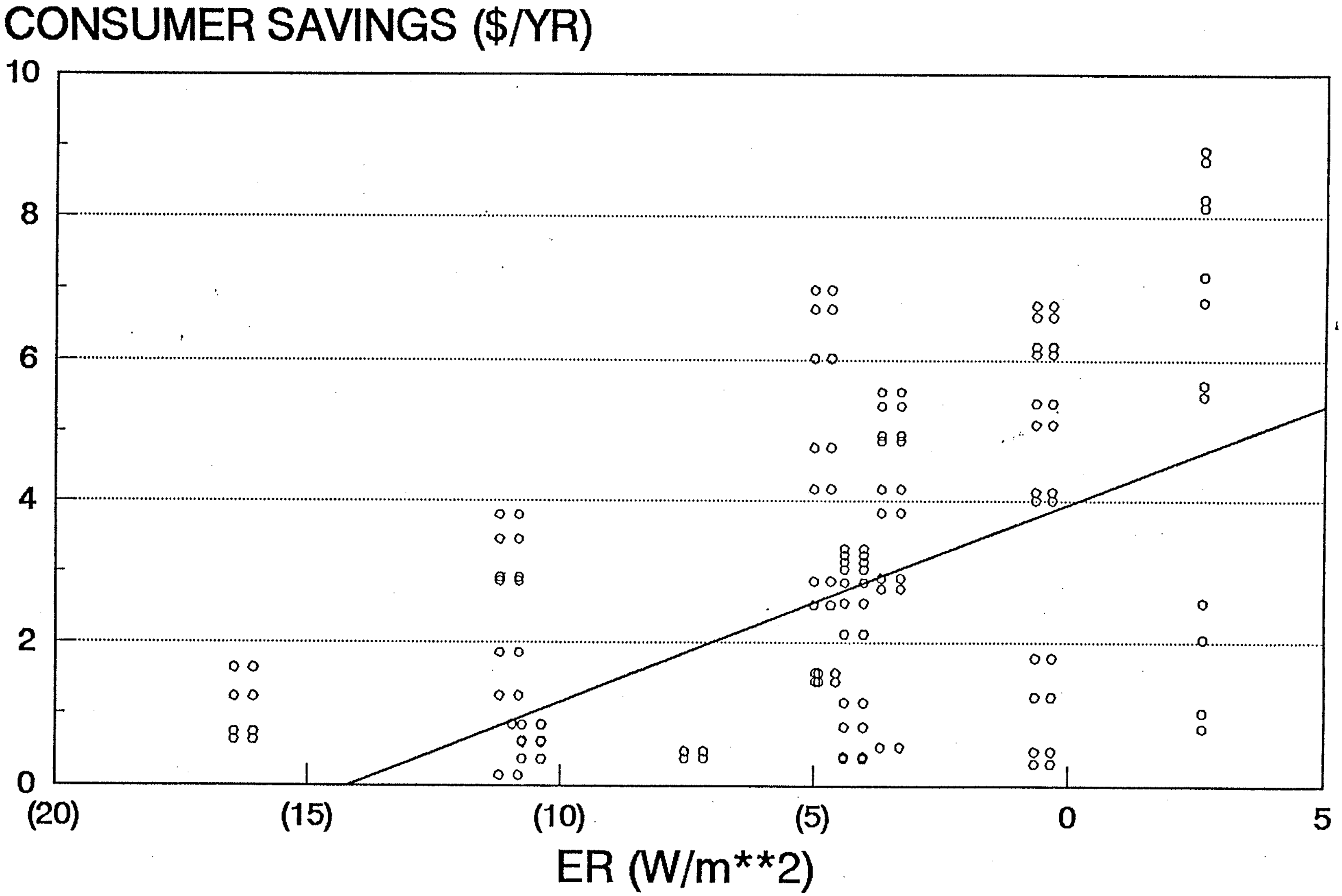
The results in Figure 9 show the relation between ER and window incremental costs. Although the window incremental costs increase as the ER values increase, this relationship is also very poor as the R-square value is 0.1920 due to the wide scatter of window prices. As a result of these poor values, a poor correlation is observed.

Even though a high-performance window incentive program is not feasible at this time, a potential link between Energy Rating numbers and window economic performance was attempted. Due to the scatter of points in the figures, poor regression analysis results were obtained. Therefore no clearly identifiable relationship could be identified.

3.8 SUMMARY

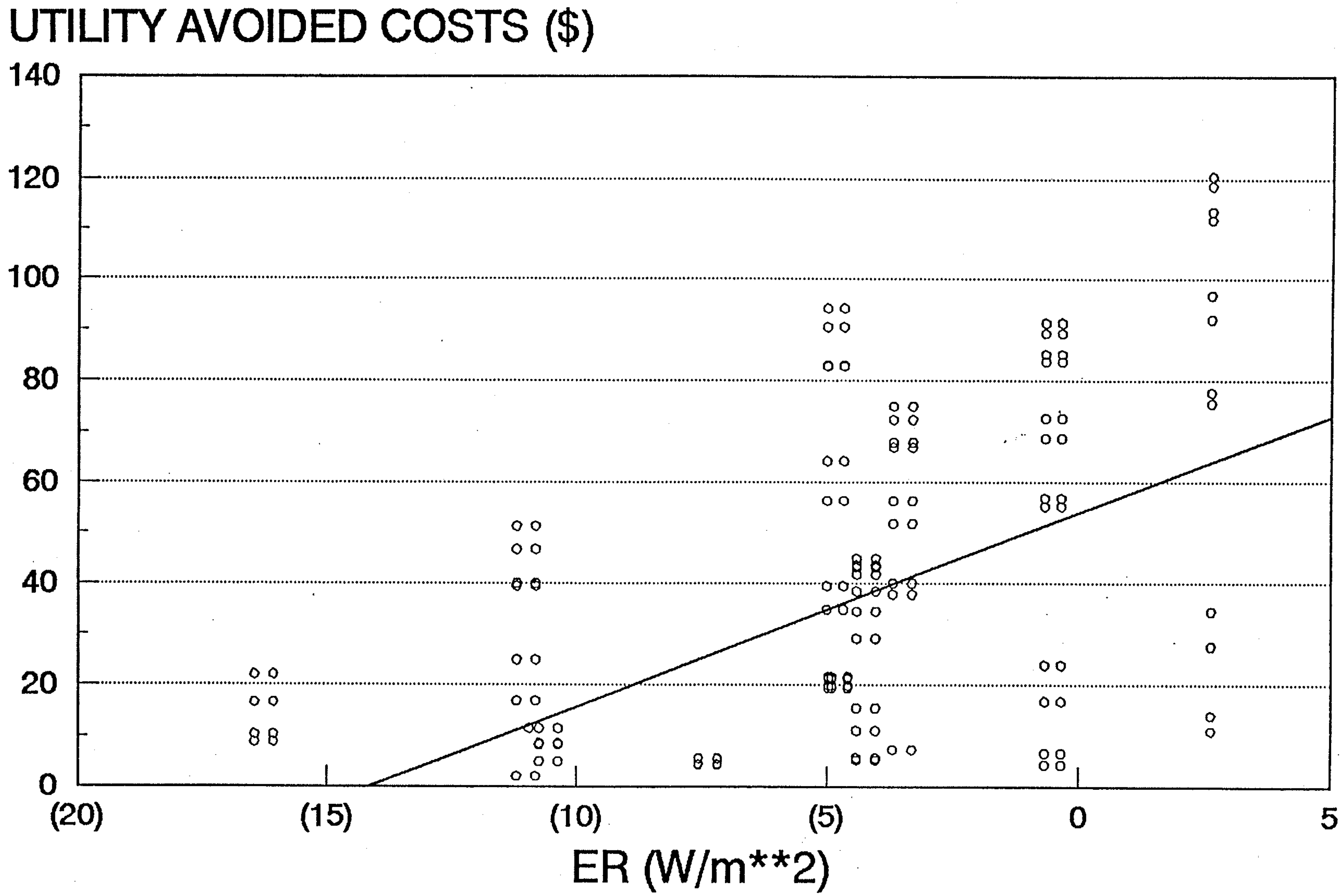
In this chapter, a study of the economic feasibility of high-performance windows for a possible Demand-Side Management program was carried out. The results indicate that the costs of high-performance window options are high compared to the energy savings introduced by this energy conserving measure. Also, the utility economic analyses and consumer financial analyses calculations indicate that few high-performance options pass the economic screens.

Although most windows fail the economic screens, two window types are the exception. Triple-glazed windows with improved edge spacers consistently passed all economic screens. Also, double-glazed windows with improved edge spacers and one layer of Heat Mirror also passed the economic criteria on the north orientation. Energy conservation gains of high-performance windows were generally experienced in the north, east/west, and south orientations in decreasing order. Passive solar power intake is reduced with high-performance window options with low-emissivity coatings and films which affects the performance features of windows in the south, east/west, and north orientations in decreasing order.



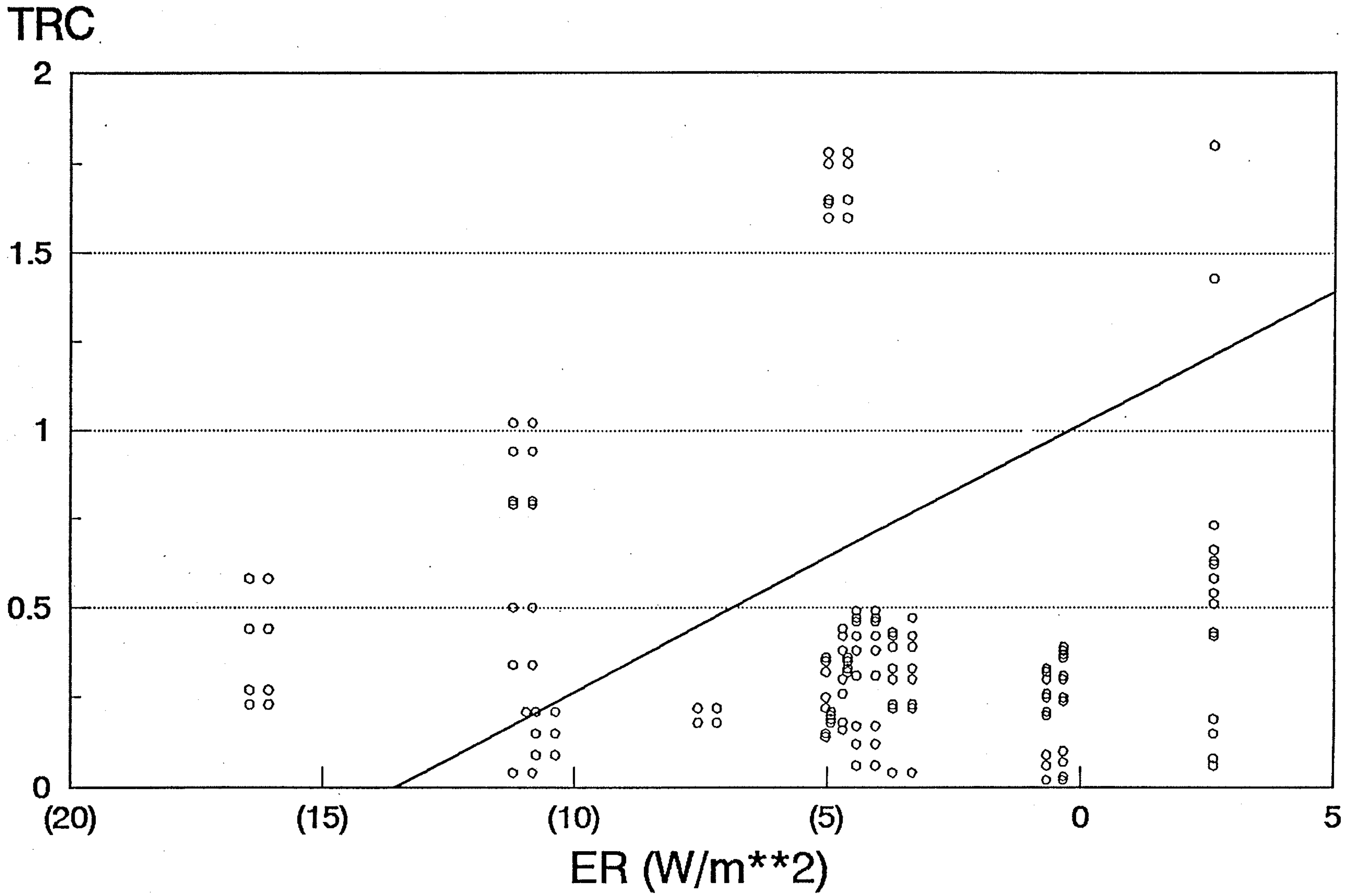
R-square = 0.2830
b = 0.2790
a = 3.9684

Figure 6. ER vs Annual Consumer Energy Savings



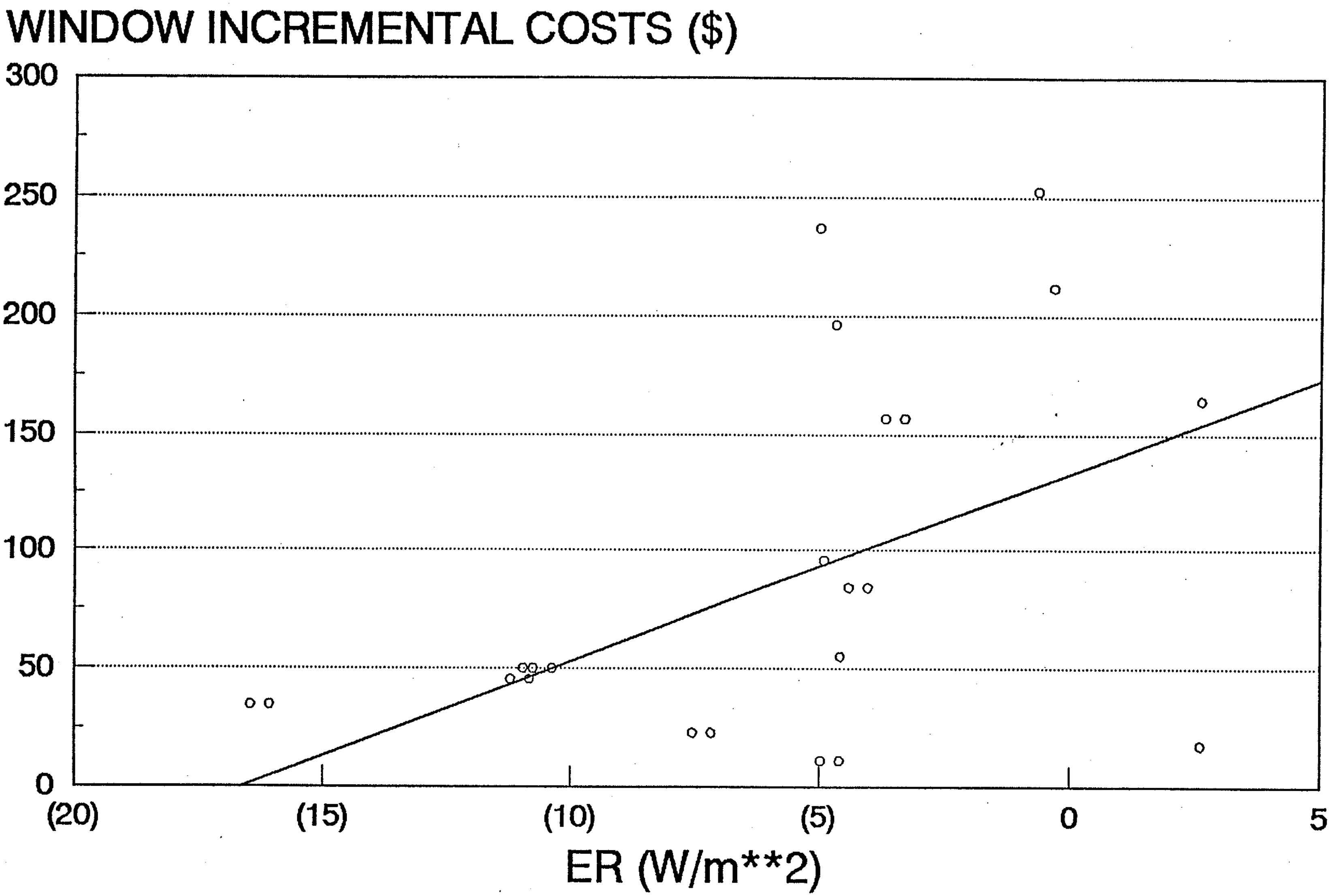
R-square = 0.2839
b = 3.8096
a = 53.9562

Figure 7. ER vs Utility Avoided Costs



R-square = 0.0949
b = 0.0751
a = 1.0184

Figure 8. ER vs TRC



R-square = 0.1920
b = 8.0153
a = 133.4115

Figure 9. ER vs Window Incremental Costs

Table 16. Overall Results

Notes pertaining to each component of the table are listed as follows:

End Use Window Identification	:	Introduces window and house conditions
Measure	:	Gives basis of comparison for TG windows with HPW options to TG windows
HOT2000 Window Code	:	6-digit user-defined window codes schedule for HOT2000 analysis
Life (yrs)	:	Useful lifetime of windows
R-val (Rsi)	:	Overall R-value of HPW
SHGC	:	Solar heat gain coefficient of HPW
Air Leakage Rate (m^3/h-m^{-1})	:	Air leakage rate of HPW derived from manufacturer's specifications
ER (W/m^2)	:	Energy rating of HPW based on average climatic conditions
ERS (W/m^2)	:	Energy rating value that is specific to the climate of a particular location, to window orientation, and size
Window Incremental Costs w/o Taxes ($/window)	:	The difference in cost of the HPW to a TG window of same size and style without taxes
Window Incremental Costs with Taxes ($/window)	:	Same as above with 14% taxes added to calculations
Avoided Costs ($)	:	Energy and Demand savings for the lifetime of measure. Derived from SES
MRC	:	Measure resource cost derived in SES

TRC : Total resource cost = MRC/1.25

Consumer Savings ($/yr) : Consumer's fuel cost savings established in HOT2000 analysis

Consumer Economic Analysis without Incentives:

SPP (yrs) : Simple payback period

IRR : Internal rate of return

NPV ($) : Net Present Value

Consumer Economic Analysis with Incentives:

SPP (yrs) : Simple payback period for qualifying HPWs

IRR : Internal rate of return for qualifying HPWs

NPV ($) : Net Present Value for qualifying HPWs

NA : Not applicable

Heating Load Only

End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	Window Energy Performance SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	Window Incremental Costs W/O Taxes ($/window)	W Taxes ($/window)	Utility Economic Analysis Avoided Costs ($)	MRC	TRC	Consumer Economic Analysis w/o Incentives Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	Consumer Economic Analys with Incentives SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	20.3	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-2.7	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	11.9	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	23.7	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
Orientation: South	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	23.7	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	35.6	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	20.4	73.68	84.00	4.97	0.07	0.06	0.38	221.1	-0.166	-79.46	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	17.0	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	21.0	185.88	211.91	4.11	0.02	0.02	0.31	683.6	-0.222	-208.21	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	10.1	172.20	196.31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	22.6	144.35	164.56	10.46	0.07	0.06	0.80	205.7	-0.162	-155.00	NA	NA	NA
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-21.5	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-27.7	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-23.6	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-18.1	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
Orientation: East	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-18.1	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-6.4	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-15.8	73.68	84.00	27.61	0.37	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-12.8	137.64	156.92	35.34	0.26	0.21	2.75	57.1	-0.084	-124.06	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-8.8	185.88	211.91	52.45	0.28	0.22	4.01	52.8	-0.079	-163.99	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	-12.5	172.20	196.31	33.02	0.19	0.15	2.52	77.9	-0.105	-166.20	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-4.1	144.35	164.56	71.80	0.50	0.40	5.49	30.0	-0.036	-98.95	NA	NA	NA
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-40.0	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-38.9	30.24	34.47	8.33	0.28	0.22	0.63	54.7	-0.081	-26.94	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-39.3	43.92	50.07	8.14	0.19	0.15	0.62	80.8	-0.107	-42.66	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-36.7	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
Orientation: North	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-36.7	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-25.2	39.96	45.55	37.47	0.94	0.75	2.86	15.9	0.023	-11.37	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-31.9	73.68	84.00	40.87	0.55	0.44	3.13	26.8	-0.027	-46.60	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-26.1	137.64	156.92	64.55	0.47	0.38	4.93	31.8	-0.041	-98.00	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-22.2	185.88	211.91	81.03	0.44	0.35	6.19	34.2	-0.047	-137.94	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	-22.6	172.20	196.31	78.90	0.46	0.37	6.03	32.6	-0.043	-124.25	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-16.0	144.35	164.56	108.01	0.75	0.60	8.26	19.9	0.000	-65.85	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-21.5	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-27.7	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-23.6	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-18.1	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
Orientation: West	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-18.1	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-6.4	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-15.8	73.68	84.00	27.61	0.37	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-12.8	137.64	156.92	35.34	0.26	0.21	2.75	57.1	-0.084	-124.06	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-8.8	185.88	211.91	52.45	0.28	0.22	4.01	52.8	-0.079	-163.99	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	-12.5	172.20	196.31	33.02	0.19	0.15	2.52	77.9	-0.105	-166.20	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-4.1	144.35	164.55	71.80	0.50	0.40	5.49	30.0	-0.036	-98.95	NA	NA	NA

						Window Energy Performance			Window Incremental Costs		Utility Economic Analysis				Consumer Economic Analysis w/o Incentives			Consumer Economic Analysis with Incentives		
End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	MRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	19.8	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-3.1	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	11.4	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	23.3	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: South	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	23.2	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	35.2	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	20.0	73.68	84.00	4.97	0.07	0.06	0.38	221.1	-0.166	-79.46	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-lov E	100009	20	0.73	0.37	0.200	-3.7	16.6	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	20.6	221.58	252.61	4.11	0.02	0.02	0.31	814.9	-0.231	-248.91	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	9.8	207.90	237.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	22.6	15.33	17.48	10.46	0.68	0.54	0.80	21.9	-0.008	-7.92	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-21.9	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-28.1	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-24.0	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-18.5	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: East	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-18.5	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-6.8	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-16.2	73.68	84.00	27.61	0.37	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-13.2	137.64	156.92	35.94	0.26	0.21	2.75	57.1	-0.084	-124.06	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-lov E	100010	20	0.81	0.37	0.170	-0.7	-9.2	221.58	252.61	52.45	0.24	0.19	4.01	63.0	-0.091	-204.69	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-12.9	207.90	237.01	33.02	0.16	0.13	2.52	94.1	-0.117	-206.90	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-4.1	15.33	17.48	71.80	4.68	3.74	5.49	3.2	0.313	48.13	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-40.4	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-39.3	30.24	34.47	8.33	0.28	0.22	0.63	54.7	-0.081	-26.94	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-39.7	43.92	50.07	8.14	0.19	0.15	0.62	80.8	-0.107	-42.66	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-37.0	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: North	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-37.1	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.123	7.63	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-25.6	39.96	45.55	37.47	0.94	0.75	2.86	15.9	0.023	-11.37	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-32.3	73.68	84.00	40.87	0.55	0.44	3.13	26.8	-0.027	-46.60	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-26.5	137.64	156.92	64.55	0.47	0.38	4.93	31.8	-0.041	-98.00	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	-22.5	221.58	252.61	81.03	0.37	0.30	6.19	40.8	-0.060	-178.64	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-23.0	207.90	237.01	78.90	0.38	0.30	6.03	39.3	-0.057	-164.95	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-16.0	15.33	17.48	109.01	7.05	5.64	8.26	2.1	0.472	81.23	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-21.9	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-28.1	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-24.0	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-18.5	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: West	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-18.5	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-6.8	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-16.2	73.68	84.00	27.61	0.37	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-13.2	137.64	156.92	35.94	0.26	0.21	2.75	57.1	-0.084	-124.06	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	-9.2	221.58	252.61	52.45	0.24	0.19	4.01	63.0	-0.091	-204.69	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-12.9	207.90	237.01	33.02	0.16	0.13	2.52	94.1	-0.117	-206.90	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-4.1	15.33	17.48	71.80	4.68	3.74	5.49	3.2	0.313	48.13	NA	NA	NA

End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	Window Energy Performance				Window Incremental Costs		Utility Economic Analysis			Consumer Economic Analysis w/o Incentives				Consumer Economic Analys with Incentives		
					SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	NRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	19.0	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-3.0	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	11.0	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	22.4	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: South	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	22.4	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	3.5	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	19.4	73.68	84.00	5.42	0.07	0.06	0.41	204.9	-0.162	-79.10	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	16.4	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	20.4	185.88	211.91	6.27	0.03	0.02	0.48	441.5	-0.201	-206.17	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	9.8	172.20	196.31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	22.1	144.35	164.56	13.34	0.09	0.07	1.02	161.3	-0.149	-152.37	NA	NA	NA
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-22.2	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-27.9	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-24.0	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-18.8	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: East	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-18.8	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-21.4	39.96	45.55	1.91	0.05	0.04	0.14	325.4	-0.186	-43.88	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-16.3	73.68	84.00	27.68	0.38	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-13.1	137.64	156.92	37.96	0.28	0.22	2.90	54.1	-0.080	-122.26	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-9.1	185.88	211.91	54.02	0.29	0.23	4.13	51.3	-0.077	-162.56	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	-12.7	172.20	196.31	37.47	0.22	0.18	2.86	68.6	-0.097	-162.13	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-4.3	144.35	164.56	73.86	0.51	0.41	5.65	29.1	-0.033	-97.04	NA	NA	NA
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-40.3	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-38.9	30.24	34.47	9.71	0.32	0.26	0.74	46.6	-0.070	-25.63	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-39.5	43.92	50.07	7.84	0.18	0.14	0.60	83.4	-0.109	-42.85	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-36.9	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: North	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-36.9	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-32.4	39.96	45.55	38.00	0.95	0.76	2.91	15.6	0.025	-10.77	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-32.2	73.68	84.00	39.64	0.54	0.43	3.03	27.7	-0.029	-47.79	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-26.3	137.64	156.92	63.62	0.46	0.37	4.86	32.3	-0.042	-98.84	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-22.3	185.88	211.91	79.65	0.43	0.34	6.09	34.8	-0.048	-139.13	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	-4.7	-22.7	172.20	196.31	78.75	0.46	0.37	6.02	32.6	-0.043	-124.37	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-16.1	144.35	164.56	106.40	0.74	0.59	8.14	20.2	-0.001	-67.28	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	-7.2	-22.2	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	-16.1	-27.9	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	-10.4	-24.0	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	-4.6	-18.8	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: West	TG > TG, IES	000006	20	0.52	0.52	0.016	-4.6	-18.8	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	-10.8	-21.4	39.96	45.55	1.91	0.05	0.04	0.14	325.4	-0.186	-43.88	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	-4.0	-16.3	73.68	84.00	27.68	0.38	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	-3.3	-13.1	137.64	156.92	37.36	0.28	0.22	2.90	54.1	-0.080	-122.26	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	-0.3	-9.1	185.88	211.91	54.02	0.29	0.23	4.13	51.3	-0.077	-162.56	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.89	0.28	0.008	-4.7	-12.7	172.20	196.31	37.47	0.22	0.18	2.86	68.6	-0.097	-162.13	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	2.6	-4.3	144.35	164.56	73.86	0.51	0.41	5.65	29.1	-0.033	-97.04	NA	NA	NA

					Window Energy Performance				Window Incremental Costs		Utility Economic Analysis			Consumer Economic Analysis w/o Incentives				Consumer Economic Analys with Incentives		
End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	MRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	18.6	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-3.4	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	10.6	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	22.0	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: South	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	22.0	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	3.1	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	19.4	73.68	84.00	5.42	0.07	0.06	0.41	204.3	-0.162	-79.10	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	16.0	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	20.0	221.58	252.61	6.27	0.03	0.02	0.48	526.3	-0.210	-246.87	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	9.4	207.90	237.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	22.1	15.33	17.48	13.34	0.87	0.70	1.02	17.1	0.015	-5.29	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-22.6	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-28.3	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-24.4	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-19.2	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: East	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-19.2	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-21.8	39.96	45.55	1.91	0.05	0.04	0.14	325.4	-0.186	-43.88	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-16.3	73.68	84.00	27.68	0.38	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-13.5	137.64	156.92	37.96	0.28	0.22	2.90	54.1	-0.080	-122.26	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	-9.5	221.58	252.61	54.02	0.24	0.19	4.13	61.2	-0.089	-203.26	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-13.1	207.90	237.01	37.47	0.18	0.14	2.86	82.9	-0.109	-202.83	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-4.3	15.33	17.48	73.86	4.82	3.86	5.65	3.1	0.322	50.04	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-40.7	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-39.3	30.24	34.47	9.71	0.32	0.26	0.74	46.6	-0.070	-25.63	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-33.9	43.92	50.07	7.84	0.18	0.14	0.60	83.7	-0.109	-42.85	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-37.3	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: North	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-37.3	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-32.8	39.96	45.55	38.00	0.95	0.76	2.91	15.6	0.025	-10.77	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-32.2	73.68	84.00	33.64	0.54	0.43	3.03	27.7	-0.029	-47.79	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-26.7	137.64	156.92	63.62	0.46	0.37	4.86	32.3	-0.042	-98.84	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	-22.7	221.58	252.61	79.65	0.36	0.29	6.09	41.5	-0.061	-179.83	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-23.1	207.90	237.01	78.75	0.38	0.30	6.02	39.4	-0.057	-165.07	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-16.1	15.33	17.48	106.40	6.34	5.55	8.14	2.1	0.465	79.80	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	-7.6	-22.6	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	-16.5	-28.3	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: No	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	-10.8	-24.4	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	-4.9	-19.2	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: West	TG > TG, IES	100006	20	0.52	0.52	0.200	-5.0	-19.2	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	-11.2	-21.8	39.96	45.55	1.91	0.05	0.04	0.14	325.4	-0.186	-43.88	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	-4.4	-16.3	73.68	84.00	27.68	0.38	0.30	2.11	39.8	-0.058	-58.78	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	-3.7	-13.5	137.64	156.92	37.96	0.28	0.22	2.90	54.1	-0.080	-122.26	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	-0.7	-9.5	221.58	252.61	54.02	0.24	0.19	4.13	61.2	-0.089	-203.26	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	-5.0	-13.1	207.90	237.01	37.47	0.18	0.14	2.86	82.9	-0.109	-202.83	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	2.6	-4.3	15.33	17.48	73.86	4.82	3.86	5.65	3.1	0.322	50.04	NA	NA	NA

Heating/Cooling Load

				Window Energy Performance					Window Incremental Costs		Utility Economic Analysis				Consumer Economic Analysis w/o Incentives			Consumer Economic Analys with Incentives		
End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	NRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: South	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	9.02	0.12	0.10	0.82	102.4	-0.122	-74.20	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	12.77	0.07	0.06	1.24	170.9	-0.152	-197.09	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	21.94	0.15	0.12	2.04	80.7	-0.107	-140.18	NA	NA	NA
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: East	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	11.61	0.29	0.23	1.25	36.4	-0.051	-30.61	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	31.66	0.43	0.34	2.55	32.9	-0.043	-53.53	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	45.93	0.33	0.26	3.83	41.0	-0.060	-111.15	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	62.44	0.34	0.27	5.09	41.6	-0.062	-151.08	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	48.31	0.28	0.22	4.17	47.1	-0.071	-146.48	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	84.10	0.58	0.46	6.82	24.1	-0.017	-83.06	12.0	0.055	0.00
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: North	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	13.84	0.46	0.37	1.23	28.0	-0.030	-19.77	NA	NA	NA
	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	10.23	0.23	0.18	0.84	59.6	-0.087	-40.03	NA	NA	NA
	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	42.93	1.07	0.86	3.45	13.2	0.043	-4.32	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	42.66	0.58	0.46	3.32	25.3	-0.021	-44.32	12.0	0.055	0.00
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	68.48	0.50	0.40	5.35	29.3	-0.034	-92.99	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	84.91	0.46	0.37	6.61	32.1	-0.041	-132.92	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	85.13	0.49	0.39	6.71	29.3	-0.034	-116.12	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	112.91	0.78	0.62	8.79	18.7	0.006	-59.52	NA	NA	NA
House Type: Typical Family House Air Conditioning: Yes Window Type: Fixed Orientation: West	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	20.55	0.43	0.34	1.57	35.0	-0.048	-36.23	NA	NA	NA
	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	11.61	0.29	0.23	1.25	36.4	-0.051	-30.61	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	31.66	0.43	0.34	2.55	32.9	-0.043	-53.53	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	45.93	0.33	0.26	3.83	41.0	-0.060	-111.15	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	62.44	0.34	0.27	5.09	41.6	-0.062	-151.08	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	48.31	0.28	0.22	4.17	47.1	-0.071	-146.48	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	84.10	0.58	0.46	6.82	24.1	-0.017	-83.06	12.0	0.055	0.00

				Window Energy Performance					Window Incremental Costs		Utility Economic Analysis				Consumer Economic Analysis w/o Incentives			Consumer Economic Analys with Incentives		
End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	MRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: South	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	9.02	0.12	0.10	0.82	102.4	-0.122	-74.20	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	12.77	0.06	0.05	1.24	203.7	-0.162	-237.79	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	21.94	1.43	1.14	2.04	8.6	0.093	6.90	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: East	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	11.61	0.29	0.23	1.25	36.4	-0.051	-30.61	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	31.66	0.43	0.34	2.55	32.9	-0.043	-53.53	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	45.93	0.33	0.26	3.83	41.0	-0.060	-111.15	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	62.44	0.28	0.22	5.09	49.6	-0.074	-191.78	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	48.31	0.23	0.18	4.17	56.8	-0.084	-187.18	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	84.10	5.49	4.39	6.82	2.6	0.390	64.02	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	13.84	0.46	0.37	1.23	28.0	-0.030	-19.77	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	10.23	0.23	0.18	0.84	59.6	-0.097	-40.03	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: North	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	42.93	1.07	0.86	3.45	13.2	0.043	-4.32	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	42.66	0.58	0.46	3.32	25.3	-0.021	-44.32	12.0	0.055	0.00
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	68.48	0.50	0.40	5.35	29.3	-0.034	-92.99	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	84.91	0.38	0.30	6.61	38.2	-0.055	-173.62	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	85.13	0.41	0.33	6.71	35.3	-0.049	-156.82	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	112.91	7.37	5.90	8.79	2.0	0.503	87.56	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	5.28	0.26	0.21	0.48	47.6	-0.071	-17.11	NA	NA	NA
Typical Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	20.55	0.24	0.19	1.57	60.9	-0.089	-76.93	NA	NA	NA
Orientation: West	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	20.55	2.11	1.69	1.57	7.1	0.129	7.68	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	11.61	0.29	0.23	1.25	36.4	-0.051	-30.61	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	31.66	0.43	0.34	2.55	32.9	-0.043	-53.53	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	45.93	0.33	0.26	3.83	41.0	-0.060	-111.15	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	62.44	0.28	0.22	5.09	49.6	-0.074	-191.78	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	48.31	0.23	0.18	4.17	56.8	-0.084	-187.18	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	84.10	5.49	4.39	6.82	2.6	0.390	64.02	NA	NA	NA

				Window Energy Performance					Window Incremental Costs		Utility Economic Analysis			Consumer Economic Analysis w/o Incentives				Consumer Economic Analys with Incentives		
End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	W/O Taxes ($/window)	W Taxes ($/window)	Avoided Costs ($)	MRC	TRC	Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	19.01	0.39	0.31	1.45	38.2	-0.054	-37.66	NA	NA	NA
Orientation: South	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	12.25	0.17	0.14	1.16	72.4	-0.100	-70.10	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	4.99	0.04	0.03	0.54	290.6	-0.180	-150.47	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	18.27	0.10	0.08	1.78	119.1	-0.131	-190.64	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	27.46	0.19	0.15	2.55	64.5	-0.093	-134.09	NA	NA	NA
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	3.41	0.08	0.06	0.37	135.3	-0.139	-45.65	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: East	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	17.70	0.44	0.35	1.85	24.6	-0.019	-23.44	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	34.43	0.47	0.38	2.84	29.6	-0.085	-50.06	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	49.69	0.36	0.29	4.17	37.6	-0.054	-107.09	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	65.62	0.35	0.28	5.39	39.3	-0.057	-147.50	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	55.01	0.32	0.26	4.76	41.2	-0.061	-139.43	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	87.98	0.61	0.49	7.18	22.9	-0.013	-78.76	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM.	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	17.95	0.59	0.47	1.63	21.1	-0.005	-14.99	12.0	0.055	0.00
Air Conditioning: Yes	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	10.15	0.23	0.18	0.85	58.9	-0.086	-39.91	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: North	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	46.24	1.16	0.93	3.80	12.0	0.054	-0.14	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	41.43	0.56	0.45	3.23	26.0	-0.024	-45.40	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	69.98	0.51	0.41	5.55	28.3	-0.031	-90.60	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	85.92	0.46	0.37	6.77	31.3	-0.034	-131.01	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	87.62	0.51	0.41	6.98	28.1	-0.030	-112.90	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	113.70	0.79	0.63	8.93	18.4	0.008	-57.84	12.0	0.055	0.00
House Type:	TG > TG, 1-Ar	000002	20	0.49	0.52	0.016	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	000003	20	0.57	0.31	0.016	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	000004	20	0.52	0.44	0.016	NA	NA	43.92	50.07	3.41	0.08	0.06	0.37	135.3	-0.139	-45.65	NA	NA	NA
Window Type: Fixed	TG > TG, HPF	000005	20	0.52	0.52	0.008	NA	NA	48.24	54.99	19.01	0.39	0.31	1.45	37.9	-0.054	-37.66	NA	NA	NA
Orientation: West	TG > TG, IES	000006	20	0.52	0.52	0.016	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	000007	20	0.66	0.31	0.016	NA	NA	39.96	45.55	17.70	0.44	0.35	1.85	24.6	-0.019	-23.44	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	000008	20	0.60	0.45	0.016	NA	NA	73.68	84.00	34.43	0.47	0.38	2.84	29.6	-0.085	-50.06	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	000009	20	0.73	0.37	0.016	NA	NA	137.64	156.92	49.69	0.36	0.29	4.17	37.6	-0.051	-107.09	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	000010	20	0.81	0.37	0.008	NA	NA	185.88	211.91	65.62	0.35	0.28	5.39	39.3	-0.057	-147.50	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	000011	20	0.88	0.28	0.008	NA	NA	172.20	196.31	55.01	0.32	0.26	4.76	41.2	-0.061	-139.43	NA	NA	NA
	TG > DG, IES, 2-HM	000012	20	1.04	0.33	0.060	NA	NA	144.35	164.56	87.98	0.61	0.49	7.18	22.9	-0.013	-78.76	12.0	0.055	0.00

End Use	Measure	HOT 2000 Window Code	LIFE (Yrs)	R-val (Rsi)	SHGC	Window Energy Performance Air Leakage Rate m**3/(h-m)	ER (W/m**2)	ERS (W/m**2)	Window Incremental Costs W/O Taxes ($/window)	W Taxes ($/window)	Utility Economic Analysis Avoided Costs ($)	MRC	TRC	Consumer Economic Analysis w/o Incentives Consumer Savings ($/yr)	SPP (yrs)	IRR	NPV ($)	Consumer Economic Analys with Incentives SPP (yrs)	IRR	NPV ($)
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	19.01	0.23	0.10	1.45	66.5	-0.094	-78.36	NA	NA	NA
Orientation: South	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	81.00	12.25	0.17	0.14	1.16	72.4	-0.100	-70.10	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	4.99	0.04	0.03	0.54	290.6	-0.180	-150.47	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	18.27	0.08	0.06	1.78	141.9	-0.141	-231.34	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	27.46	1.79	1.43	2.55	6.9	0.134	12.99	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	3.41	0.08	0.06	0.37	135.3	-0.139	-45.65	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: East	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	17.70	0.44	0.35	1.85	24.6	-0.019	-23.44	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	34.43	0.47	0.38	2.84	29.6	-0.035	-50.06	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	49.69	0.36	0.29	4.17	37.6	-0.054	-107.09	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	65.62	0.30	0.24	5.39	46.9	-0.070	-188.20	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	55.01	0.26	0.21	4.76	49.8	-0.075	-180.13	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	87.98	5.74	4.59	7.18	2.4	0.410	68.32	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	17.95	0.59	0.47	1.63	21.1	-0.005	-14.99	12.0	0.055	0.00
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	10.15	0.23	0.18	0.85	58.9	-0.086	-39.91	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: North	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	46.24	1.16	0.93	3.80	12.0	0.054	-0.14	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.69	84.00	41.43	0.56	0.45	3.23	26.0	-0.024	-45.40	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	69.98	0.51	0.41	5.55	28.3	-0.031	-90.60	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.59	252.61	95.92	0.39	0.31	6.77	37.3	-0.053	-171.71	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	87.62	0.42	0.34	6.98	34.0	-0.046	-153.60	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	113.70	7.42	5.94	8.93	2.0	0.511	89.24	NA	NA	NA
House Type:	TG > TG, 1-Ar	100002	20	0.49	0.52	0.200	NA	NA	20.04	22.85	4.28	0.21	0.17	0.38	60.1	-0.088	-18.31	NA	NA	NA
Energy Efficient Family House	TG > DG, 1-HM	100003	20	0.57	0.31	0.200	NA	NA	30.24	34.47	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Air Conditioning: Yes	TG > TG, 1-Low E	100004	20	0.52	0.44	0.200	NA	NA	43.92	50.07	3.41	0.08	0.06	0.37	135.3	-0.139	-45.65	NA	NA	NA
Window Type: Operable	TG > TG, HPF	100005	20	0.52	0.52	0.170	NA	NA	83.94	95.69	19.01	0.23	0.18	1.45	66.0	-0.094	-78.36	NA	NA	NA
Orientation: West	TG > TG, IES	100006	20	0.52	0.52	0.200	NA	NA	9.72	11.08	19.01	1.96	1.57	1.45	7.6	0.116	6.25	NA	NA	NA
	TG > DG, IES, 1-HM	100007	20	0.66	0.31	0.200	NA	NA	39.96	45.55	17.70	0.44	0.35	1.85	24.6	-0.019	-23.44	12.0	0.055	0.00
	TG > TG, IES, 1-Ar, 1-Low E	100008	20	0.60	0.45	0.200	NA	NA	73.68	84.00	34.43	0.47	0.38	2.84	29.6	-0.035	-50.06	NA	NA	NA
	TG > TG, IES, 2-Ar, 2-Low E	100009	20	0.73	0.37	0.200	NA	NA	137.64	156.92	49.69	0.36	0.29	4.17	37.6	-0.054	-107.09	NA	NA	NA
	TG > TG, HPF, IES, 2-Ar, 2-Low E	100010	20	0.81	0.37	0.170	NA	NA	221.58	252.61	65.62	0.30	0.24	5.39	46.9	-0.070	-188.20	NA	NA	NA
	TG > DG, HPF, IES, 2-Ar, 1-HM, 1-Low E	100011	20	0.88	0.28	0.170	NA	NA	207.90	237.01	55.01	0.26	0.21	4.76	49.8	-0.075	-180.13	NA	NA	NA
	TG > DG, IES, 2-HM	100012	20	1.04	0.33	0.060	NA	NA	15.33	17.48	87.98	5.74	4.59	7.18	2.4	0.410	68.32	NA	NA	NA

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

As HPWs' performance increases, based on WINDOW 4.0 analysis, the R-values also increase while the solar heat gain coefficients (SHGC) decrease. It was found that all high-performance window (HPW) options increased the overall window's R-values but low-emissivity coatings and films such as Low E and Heat Mirror (HM) decreased the SHGCs. In order to attain the highest Energy Rating (ER) values, windows must have high R-values, high SHGCs, and low air leakage rates. It seems that concessions in SHGC performance must be made to reach the highest R-values for HPWs.

In order to optimize HPW selections for each orientation, the proper combinations of R-value/SHGC characteristics must be chosen. On the south-face of houses, the highest combination of R-value and SHGC should be obtained while keeping the air leakage rates low to achieve the best energy performance results. Based on economic results, Low E and HM should not be used on south-facing walls of houses. They decrease SHGCs and reduce "free" passive solar energy intake. All other HPW options, that increase R-values, should be promoted on the south-facing side of houses.

Based on HOT2000 analysis, window performance results on the east and west orientations of a house are the same since the simulation program does not calculate any predominant Manitoba winds. Since solar power is not as pronounced for these orientations, the SHGC can be sacrificed to obtain higher window R-values to achieve greatest energy performance (keeping air leakage rates low). HPW options such as Low E and HM are more beneficial for these orientations. Based on economic analysis, HPW options are most suitable for north-facing windows. The greatest energy savings were recorded for this orientation. Therefore, HPWs with many options with the largest R-values, lower SHGCs, and low air leakage rates, are fairly acceptable on the north-facing window orientation. Based on results, HPWs are most efficient on the north, east/west, and south facing sides of houses in decreasing order.

The results derived from Table 16 and Figures 6 to 9, relating the ER number system to cost parameters, did not provide conclusive results. The regression analysis of scattered points illustrated in the figures resulted in low R-square values. The windows which demonstrated superior economic performance are not necessarily the ones with the highest ER values. Conversely, low-performing windows did not necessarily produce the lowest ER values. This evaluation system is too general for site specific applications of windows.

The problems associated with the ER system are still apparent as it is still in the development stage. For example, a window with a specific ER value can achieve wide-ranging energy savings dependent on its orientation. The solar heat gain coefficients, R-values, and air leakage rates compiled together in the ER numbering system no longer reflect accurately the performance characteristics of a window. The application of windows are site specific and orientation specific. The ER system fails when it tries to generalize these conditions.

Based on computer simulations and economic analyses, most HPW options were not favorable for consumers and Manitoba Hydro. Most HPWs did not pass the utility's economic analysis TRC test, nor did most pass the consumers' financial analysis SPP, IRR, and NPV tests.

Although most HPW options did not perform well in economic analysis, two options were the exception to the rule. Insulated edge spacers passed all TRC test for all scenarios. Also, Heat Mirror options passed the consumer and utility economic analyses, but for north-facing windows only.

4.2 RECOMMENDATIONS

Manitoba Hydro, in the near future, will be evaluating new technologies in their pursuit of introducing Demand-Side Management programs. Based on the results of this study, it is suggested that the following recommendations be implemented.

1) **Manitoba Hydro should not offer incentives to consumers, with electrically-heated homes, who upgrade to high-performance windows.**

A Manitoba Hydro HPW incentive program at present appears to be unsuitable based on economic results. Further research in this area should be carried as the following rough approximations independently make HPW options economically viable for the utility: (a) avoided costs increase by a factor of 8; (b) high-performance window incremental costs decrease by a factor of 8; and (c) the electricity rates increase by a factor of 6. The rough calculations used to establish these criteria were based upon varying either of the aforementioned costs independently while keeping all other costs static. In actual market economies, this would not occur as all costs would be interrelated.

2) **The evaluation of household cooling loads may be omitted in future studies.**

The cooling load has a small effect on the energy bills in relation to the heating bills due to a short cooling season in Manitoba. Also, summer electricity capacity is large due to high reservoir levels as a result of increased seasonal precipitation. The peak energy requirements are never threatened in summer.

3) **Only one house type may be analyzed for future studies.**

Many similarities were observed in the results of the two house types analyzed in this study. Only one house type may be analyzed in future studies to decrease repetitiveness. It is suggested that only Energy Efficient Houses (also known as Power Smart or R-2000) be analyzed as many new homes fulfil the specifications of this house type.

4) **Manitoba Hydro should monitor further research of the technological performance of improved edge spacers.**

The improved edge spacers, such as butyl-metal or insulated spacers, performed very well economically both for Manitoba Hydro's economic analyses and consumers' financial analyses. If the research demonstrates positive technological results, Manitoba

Hydro should promote improved edge spacers in their Power Smart publications, but without subsidy or incentive payments. Manitoba Hydro is already involved in discussions with manufacturers with regard to HPWs. Perhaps a program to help the manufacturers set up production of improved edge spacer technologies would be more appropriate at this time than a general HPW incentive program.

5) A study focusing on the economic and financial analyses associated with retrofitting existing sealed glazings with metal spacers to sealed glazings with improved edge spacers is recommended.

This study could focus on changing the sealed glazings without changing other components of the window. In analysis, the total retrofit costs could be compared to the energy savings of the new technology.

6) Manitoba Hydro should promote window practices suitable to Manitoba conditions in their Power Smart publications.

Insulating shades, awnings, and venetian blinds are window components that help reduce energy loss in winter, at night, and reduce solar heat gain on hot summer days. Manitoba Hydro should recommend the proper installation and use of these components to their customers. Also publications should emphasize the qualities of HPWs such as low condensation, low maintenance, comfort, and ease of operation.

7) **Manitoba Hydro should conduct a residential survey of existing window types, forecast of window purchases, and general perspectives on windows.**

The questionnaire could be included in the "Manitoba Hydro Residential Energy Use Survey" conducted by Manitoba Hydro every two to three years. The results could be useful for future reference in the event that changes occur in markets affecting high-performance windows initiating further window studies.

8) **Manitoba Hydro should stay informed of new developments related to HPWs.**

The "Ontario Hydro Window Incentive Program" and the ER system are two developments affecting Manitoba's window manufacturers as their sales have penetrated the Ontario window market. Certain pressures from manufacturers will be experienced further by the utility to offer incentives to the Manitoba window market due to Ontario Hydro's incentive program. Manitoba Hydro at this stage should use caution when rating windows with the ER system.

9) **Further research should analyze the economic benefits (or losses) associated when replacing older windows (such as dual-pane storm windows) with high-performance windows.**

The methodology of this study analyzed the economic data of HPWs by taking the difference in energy savings with basic triple-glazed windows. Since there are numerous "old" windows in Manitoba, a study to evaluate the energy savings introduced with high-performance windows is warranted. The energy savings may be large. Costs involved would be the total installed costs for HPWs rather than only the incremental costs for each option.

10) The continued use of the incremental cost approach for new technologies in Demand-Side Management planning is recommended.

The incremental cost approach is very useful and applicable to this study. This method can be used in calculating economic feasibility of future window studies, future Power Smart feasibility studies, and general Demand-Side Management studies. The incremental cost approach offers a valid method of establishing the economic feasibility studies of new technologies.

11) The electricity avoided costs should shadow price environmental costs such as flooding, recreation loss, and socio-economic implications of those affected.

The economics of this study dealt with the avoided cost savings associated with reduced peak loads. In this method, the costs associated with peak capacity energy and demand were shadow priced by Manitoba Hydro. There are broader issues, however, involved in energy conservation. The externalities introduced with the construction of each generation station have to be accounted for in decision making. Energy conservation may also decrease many forms of environmental degradation. Examples of externalities associated with power generation are flooding, mercury leaching, and loss of traditional flora and fauna habitats. Human socio-economic impacts such as loss of subsistence fishing (due to contaminated fish), displacement due to flooding and depression often leading to alcoholism and suicide also have to be accounted. Once these performance and economical characteristics are shadow priced more accurately, Manitoba Hydro can follow the research methodology outlined here in analysis and compare results with this 1992 baseline study.

It is hoped that the recommendations will aid Manitoba Hydro with the high-performance window study and future Demand-Side Management studies. It is important that Manitoba Hydro continue energy conservation studies on Demand-Side Management. Continued effort and amelioration of methods in evaluating programs will benefit the utility. The decisions stemming from Demand-Side Management planning are very important as they may have an effect on domestic energy security and will produce positive impacts on the environment.

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Tait, P., Sales Agent, Polar Window of Canada Ltd., Winnipeg, Manitoba.

Toker, R., Manufacturer's Agent, Collins-Toker Agencies Ltd., Winnipeg, Manitoba.

Warkentin, D., Project Sales, Loewen Windows, Steinbach, Manitoba.

Wyndels, T., Residential Technical Advisor, Department of Energy and Mines, Winnipeg, Manitoba.

Yeo, D., General Manager, Dorwin Industries, Winnipeg, Manitoba.

Yewchyn, B., Sales Manager, Duraco Windows, Winnipeg, Manitoba.

APPENDICES

APPENDIX A.

DEFINITION OF TERMS

Air Infiltration - air leakage due to holes, gaps, and cracks

Air Leakage Rate - the volume of air flowing per unit of time through leakage paths in the closed window product under specified temperature and pressure conditions on both sides of the window

Argon Gas Fill - most typical HPW gas fill between window panes; higher molecular weight than air reduces conductive heat losses

Avoided Cost - utility savings created by the reduction in energy and demand of electricity

Baseline - the basic standard of value against which comparisons or measures are made

Conduction - transfer of heat through matter by communication of kinetic energy from particle to particle

Convection - transfer of heat by circulating currents

Demand-Side Management - managing energy at the demand stage

Energy Conservation - wise utilization of energy resulting in the conservation of natural resources

Energy Efficiency - capacity to produce desired results with a minimum expenditure of energy, time, money, or materials

Energy Rating Number - window evaluation system used by window industry based on the combination of the main performance characteristics of windows

Edge Spacer - spacers at the perimeter of windows along the buffer zone to the frames

Fixed Windows - sealed windows which provide no ventilation

Frame - the associated head, jamb, sill, and where applicable, mullion and muntin that, when assembled, house the sash or fixed glazing

Free Riders - consumers who would purchase measures irregardless of whether incentives were offered

Glazing - a piece of glass; glass pane

Heat Mirror - clear low-emissivity film suspended between two glazings

High-Performance Frame - polyvinyl chloride or fibreglass frame

High-Performance Windows - triple-pane windows with options such as low-E, gas fills, insulated edge spacers, and insulated frames

HOT2000 - computer simulation program designed to simulate energy requirements for residential dwellings

HVAC Systems - Heating, Ventilation, and Air Conditioning Systems

Infiltration Heat Loss - Heat loss due to air leakages through holes and gaps

Insulated Edge Spacers - butyl-metal or silicone edge spacers

Low-Emissivity (Low E) - coatings, only a few atoms thick, usually of metallic or semiconductor material, applied to glazing surfaces to reflect radiation

Operable Windows - windows which can open to provide ventilation; types include casement, slider, projecting, and tilt/turn

Radiation - energy radiated in the form of waves or particles

R-value - measure of heat transmission resistance, inverse of U-value

Shading Coefficient - standard measure used in evaluating the contribution of shading

Solar Heat Gain Coefficient - the ratio of solar heat gain through a window component to the solar radiation incident on it, for a given angle of incidence and for given environmental conditions

Thermal Break - an insulating material incorporated in a metal window frame to reduce thermal conduction

Thermal Performance - generic combination of energy characteristics to determine energy evaluation of a system

Transmission Heat Loss - heat loss due to radiation, convection, and conduction

Utility - public-oriented electricity-generating company

U-Value - overall heat transmission in unit time through a unit area, inverse of R-value

Weatherstripping - material around operating lights designed to reduce air leakage and/or water penetration

APPENDIX B.

HIGH-PERFORMANCE WINDOW MANUFACTURERS

The following high-performance window manufacturers were contacted for the HPW incremental cost price survey:

1. **All Weather Windows**, 45 Higgins Avenue, Winnipeg, Manitoba.
   Contact Person: Bill Loewen, Sales Consultant.

2. **Dominion Window & Door Ltd.**, 1924 Main St., Winnipeg, Manitoba.
   Contact Person: Ken Anderson, Sales/Marketing.

3. **Dorwin Industries**, 666 Nairn Ave., Winnipeg, Manitoba.
   Contact Person: David L. Yeo, General Manager.

4. **Duraco Windows**, 159 DeBaets Street, Winnipeg, Manitoba.
   Contact Person: Brian D. Yewchyn, Sales Manager.

5. **Hi-Therm Corporation**, 11 Higgins Avenue, Winnipeg, Manitoba.
   Contact Person: Harv Klassen, General Manager.

6. **Loewen Windows**, Box 2260, Steinbach, Manitoba.
   Contact Person: Clyde Loewen, Product Development Manager.

7. **Paramount Windows Inc.**, 105 Panet Road, Winnipeg, Manitoba.
   Contact Person: Tim Dudeck, Sales Consultant.

8. **Pella Hunt Corporation**, 375-550 Century Street, Winnipeg, Manitoba.
   Contact Person: Mike Garlinski, Branch Manager.

9. **Polar Window of Canada Ltd.**, 672 Kimberly Ave., Winnipeg, Manitoba.
   Contact Person: Phil Tait, Sales Agent.

10. **Storm-Tite Inc.**, 404 Egesz Street, Winnipeg, Manitoba.
    Contact Person: Kurt Koberstein, Production Manager.

11. **Visionwall Technologies, Inc.**, 110, 14904-123 Avenue, Edmonton, Alberta.
    Contact Person: Vern Gudmundson, President, V.B.G. Distributors, Ltd.

12. **Willmar Windows**, 485 Watt Street, Winnipeg, Manitoba.
    Contact Person: Al Dueck, Vice-President, Marketing.

APPENDIX C.

HIGH-PERFORMANCE WINDOW PRICE QUESTIONNAIRE

The questionnaire was presented in the following format after introduction and once the contact person was enlightened about the purpose of the study.

- I need a price quotation for an installed (fixed and/or operable) replacement triple-glazed window complete with framing with 3' x 4' overall dimensions;
- What kind of edge spacer does this window have?
- What is the additional price for an insulated edge spacer for this window?
- What is the additional price for each layer of Low E or Heat Mirror?
- What is the additional price for filling the cavity with argon gas?
- What kind of frame does this window have?
- What is the additional cost for a vinyl or fibreglass frame?
- Please comment on the current energy rating system and its usefulness, particularly with respect to the Ontario Hydro HPW incentive program.

APPENDIX D.

CSA STANDARD A440.2

CSA Preliminary Standard
A440.2-M1991

Energy Performance Evaluation of Windows and Sliding Glass Doors

CSA Special Publication
A440.3-M1991

User Guide to CSA Preliminary Standard A440.2-M1991, Energy Performance Evaluation of Windows and Sliding Glass Doors

ISSN 0317-5669
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Canada
M9W 1R3

8. Energy Rating of Residential Windows and Sliding Glass Doors

8.1 Energy Rating for Heating Conditions

The energy rating, for heating conditions, of windows used in self-contained low-rise dwelling units shall be computed from the following equation:

$$ER = [F_w F_\theta H_t] - [(t_{bi} - t_{bo})\, U_w] - [(t_{bi} - t_{bo})(0.138PF\, L_{75}/A_w)(\rho C_p/3.6)]$$

where

ER = window energy rating for heating conditions, W/m^2

F_w = window solar heat gain coefficient for the reference size in Table 1, established in accordance with Clause 6, dimensionless

F_θ = off-normal incidence angle factor for solar radiation, dimensionless

H_t = average solar radiation incident on vertical windows facing the four cardinal directions during hours of the year when solar heat gains influence heating load, W/m^2

t_{bi} = average indoor temperature during hours of the year when daily average outdoor temperature is below 12°C (assumed to be 20.0°C)

t_{bo} = average outdoor temperature during hours of the year when daily average outdoor temperature is below 12°C (assumed to be −1.9°C)

U_w = window U-value for the reference size in Table 1, established in accordance with Clause 5, $W/(m^{2}{}^\circ C)$

L_{75} = window air leakage rate at a pressure difference of 75 Pa for the reference size in Table 1, established in accordance with Clause 7, expressed in m^3/h

$0.138PFL_{75}/A_w$ = air leakage rate per unit area for installed window of reference size, under average weather conditions during hours of the year when daily average outdoor temperature is below 12°C, expressed in m^3/h per m^2

$\rho\, C_p$ = thermal capacitance of air, 1.2 $kJ/m^{3}{}^\circ C$

3.6 = kJ/h per watt

A_w = area of window based on the reference size in Table 1, m^2

8.2 Simplified Equation for ER

The values of weather factors used to establish an average energy rating for all climates and all cardinal compass directions shall be as follows:

$F_\theta H_t = 72.2$
$t_{bi} - t_{bo} = 21.9$
$PF = 0.54$

Then the ER equation becomes,

$$ER = 72.2\, F_w - 21.9\, U_w - 0.54\, (L_{75}/A_w)$$

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CSA Special Publication A440.3-M1991 ***User Guide to CSA Preliminary Standard A440.2-M1991, Energy Performance Evaluation of Windows and Sliding Glass Doors***

Part 1 — Explanation of Clauses

Note: *Clause numbers in this part of the User Guide correspond to those in the body of CSA Standard A440.2. Commentary is not provided for all Clauses in the Standard.*

1. Scope

1.1

The angle from horizontal at which windows are installed has some effect on thermal properties. The Standard specifies the determination of reference values for vertical installation, as most windows are installed at this angle. These values of F and U are generally appropriate for comparing the performance of windows installed at other angles. The ER value, however, is based on solar radiation incident on vertical surfaces and therefore does not apply directly to windows installed at other angles.

1.3

The energy rating in the Standard is not currently relevant for energy use required for mechanical cooling of residences. The effect of windows on energy requirements for cooling of a residence can be calculated, but a simple comparative rating procedure has not yet been standardized. Similarly, the energy rating is not directly applicable to heating or cooling applications in multistorey apartments or commercial building applications, where the relationship of heating and cooling loads to weather conditions is more complex.

In developing the energy rating, each of the weather factors in 13 Canadian cities with more than 4000 heating degree-days were averaged, including solar radiation incident on windows facing the four cardinal compass directions, to produce a single set of average weather conditions. Rating values based on these average conditions therefore do not apply to any specific location. The ranking of the windows, however, is the same, for the most part, as that which would be obtained using local weather conditions.

The ranking of windows would, however, likely be affected if an ER value were computed for a specific orientation. A method for obtaining ERS values for a specific location and orientation is provided in Part 2 of this User Guide, for those who may wish to select or market windows on this basis. The ERS values so obtained can be used to make a comparative estimate of the effect on annual heating energy requirements of alternate window installations, and the User Guide provides a method for making such estimates.

See Clause 8 of this User Guide regarding the effect of window size on ER values.

1.5

Thermal properties of windows may change with time. For example, there may be some uncertainty about the long-term service life of some sealed glazing systems. Similarly, air leakage rates for some air-sealing systems change more rapidly than others. Standard methods for establishing the ability of windows to retain certain thermal properties have not been established.

2. Definitions

It will be noted that the frame area (A_f) as defined may not be the same as the projected surface area of the frame as seen from the indoors or outdoors, as the frame components could overlap the installation clearances on either the inside or outside (see Figures 1 and 2 of this Standard). The frame area includes the area of any sash members.

Solar heat gain coefficient (F) and shading coefficient (SC) for glazing materials are normally taken to be related as follows:

$SC = 1.15\ F$

In this Standard, the value for these coefficients is that for incident solar radiation normal to the glazing. Angle of incidence affects the values of the coefficients, but the effect is small for windows without shading devices when off-normal incidence angles are less than 45°. In Canada most of the solar radiation received by vertical surfaces over the heating season occurs at off-normal incidence angles less than 45°.

The temperatures of the indoor and outdoor surfaces of the window are not uniform. For purposes of defining the thermal conductance of the window specimen, the temperature of each of these surfaces is a derived average.

4. Selection of Specimen Windows

4.2 Specimen Size — ER Determination

The reference window sizes in Table 1 of the Standard are those proposed for Type A windows in the draft ASTM Standard, *Practice for Determining the Steady State Thermal Transmittance of Fenestration Systems,* January 1990, and for Model Size AA in the Interim Procedure for Determining Fenestration Product Thermal Properties, March 15, 1991, NFRC Technical Committee. The sizes are consistent with those generally used in residential construction. Reference sizes are used so that comparison of the energy-use characteristics can be made on an equitable basis. Larger windows have a larger ratio of centre-of-glass area to edge-of-glass and frame areas. Thus, for example, for glazing arrangements in which the centre-of-glass U-value is less than the frame U-value, the overall U-value will decrease with increasing window size, and vice versa. The effect increases as the difference between centre-of-glass U-value and frame U-value increases. Similarly, the air leakage rate per unit area of window for a specific model is likely to vary with window size.

The solar heat gain coefficient is affected by window size because the ratios of the total glazing area and the frame area to the complete window area are affected. The value of solar heat gain coefficient for the frame (F_f) is usually very small relative to the solar heat gain coefficient for the glazing. Thus as the size of the window increases, and the relative area of the glazing increases, the solar heat gain coefficient for the complete window product (F_w) increases.

Where values of the thermal properties are obtained for window sizes other than the reference sizes in Table 1, Appendix B of CSA Preliminary Standard A440.2, when applicable, can be used to extrapolate these values to those for the reference size.

4.3 Air Leakage Rate

With operable windows, most of the air leakage occurs through the joints between the sash and the frame, and between meeting rails of the sliding sash. The ratio of the length of this crack to the window area decreases with increasing window size. Thus, with other factors equal, the air leakage per unit area of window will tend to decrease with increasing window size. The relative pressure exerted on the weatherstripping by operating and locking hardware will also be a factor determining the leakage per unit of crack length. Ideally, therefore, the air leakage rate should be determined using window test specimens with sizes according to Table 1. In CSA Standard CAN/CSA-A440, reference sizes are chosen for structural performance considerations, and are therefore larger than those in Table 1 of A440.2. In order to avoid the need for a second air leakage test, the results from tests in accordance with CSA Standard A440 can be used, if they are adjusted for size in accordance with Appendix B of CSA Preliminary Standard A440.2.

The size of the sliding door specimen required in CGSB Standard CAN/CGSB-82.1 is within the tolerances for the reference size in Table 1. Where these tolerances are exceeded, measured air leakage rates can be adjusted to the reference size in accordance with Appendix B of the Standard.

5. U-Value

5.2 Determination of U-Value by Measurement

A standard method of test and a standard practice for determining the U-value of windows by measurement are being developed by ASTM, based on BRN234. They will be considered for reference in Clause 5.2.1 when available.

Air pressure differences across the test specimen during heat transmission measurement may vary between one specimen and another and between test apparatus.

Thus it is important to minimize air leakage during testing as specified in Clause 5.2.2 of the Standard. The effect of air leakage on the energy required for heating is dealt with separately in the ER calculation. Appendix C provides guidance on measures for minimizing air leakage.

The indoor and outdoor temperatures specified in Clause 5.2.3 are those used in calculating the U-values in the 1989 ASHRAE Handbook, *Fundamentals.*

It is essential that the method of test provide uniform, controlled surface conductances, within the limits stated in Clause 5.2.4, that can be accurately determined. Because surface conductances affect overall U-values, reference values are specified (Clause 5.2.5), and window U-values are established for these reference values.

Outdoor surface conductances vary significantly with wind speed and shielding. The reference value specified in Clause 5.2.5 corresponds to that for a wind speed of 6.7 m/s (15 mph). This reference value for the outdoor surface conductance is proposed in the draft ASTM standard practice referred to above and approximates that used in computing the window U-values given in the 1989 ASHRAE Handbook, *Fundamentals.* It is a value normally used for establishing heat losses for sizing of heating equipment. For annual energy use, a somewhat lower value would be appropriate for most locations. The effect of outdoor surface conductance on U-value decreases as thermal resistance increases.

The reference value for the indoor surface conductance is for natural convection conditions and is proposed in the draft ASTM standard practice.

5.3 Determination of U-Value by Calculation (Simulation)

The reference surface conductances specified in Clause 5.3.4 are consistent with those specified in Clause 5.2.5. The equation form of the indoor surface conductance is convenient for computer use. It assumes that the indoor surface of the fenestration is exposed to natural convection and to black body conditions at indoor air temperature. It gives a value of 8.3 W/(m^2°C), for a glazing emissivity of 0.90, an indoor air temperature of 20°C, and an indoor surface temperature for the fenestration of 2.5°C. The effect on U-value of any differences in the reference values of indoor surface conductance between measurement and calculation procedures will be small.

6.2 Determination of Solar Heat Gain Coefficient by Measurement

There is currently no published standard method for measuring solar heat gain coefficients. The method referenced in this Standard is based on the National Solar Test Facility, in Kingston, Ontario. ASHRAE is considering the development of a Standard. One of the principal technical issues is how to deal with the dependence of transmitted solar radiation on angle of incidence. As noted, this Standard uses values for normal incidence.

Because of the variable effect of shading devices on solar heat gain, removable shading devices are removed for the determination of solar heat gain coefficients. While it would be desirable to obtain shading coefficients for a number of positions of non-removable, adjustable shading devices, a test at only one reference condition (Clause 6.1.2) is specified for purposes of energy rating.

6.3.4 Solar Heat Gain Coefficient (SHGC) of Frame and Dividers

The equation for F_f and F_d comes from *Development of a Procedure for Calculating Total Window U-value and SHGC*, November 1990, Energy, Mines and Resources Canada ($F_f = a_f U_f$, where a_f is the solar absorptance of the frame). The value of a_f is taken as 0.3.

7. Air Leakage Rate

See comments on Clause 4.3. Both CSA Standard CAN/CSA-A440 and CGSB Standard CAN/CGSB-82.1 refer to the ASTM E283 air leakage test method. Both express air leakage in (m^3/h) per metre of crack length, whereas CSA Standard A440.2 expresses it in (m^3/h) for the appropriate reference size. Values obtained in accordance with A440 will have to be converted to an air leakage rate for the reference size by the method given in Clause B3 of Appendix B. The same method can be applied to sliding glass doors when the specimen size is not in accordance with Table 1.

The ASTM E283 test method uses room temperature conditions on both sides. Studies have shown that air leakage rates for some windows may be affected when windows are subjected to a temperature difference such as occurs in practice.

8. Energy Rating for Heating Conditions

See comments in Clause 1.3.

The ER equation incorporates three terms for: solar heat gain, heat transmission loss and heat loss associated with window air leakage. Values of the weather factors (Clause 8.2) were obtained by averaging the relevant weather data for 12 locations in Canada and 2 locations in the USA with °C-days between 4000–6200. For H_t, the incident solar radiation on vertical surfaces facing the four compass cardinal directions was averaged for all locations. It was assumed that internal heat gains were sufficient to provide all heating requirements when outdoor temperatures were above 12°C, based on computer calculations for a typical house. Weather data were therefore averaged for those hours throughout the year when the outdoor temperature was 12°C or lower in each of the 14 cities.

The off-normal incidence angle factor for solar radiation accounts for the variation in solar heat gain coefficient with off-normal incident angles of solar radiation (direct, diffuse and reflected) received by the window:

$F_\theta = F_a/F_n$

where

F_a = the value of the solar heat gain coefficient for any off-normal angle of incidence

F_n = the value of the solar heat gain coefficient for normal incidence

The term for the heat loss associated with window air leakage is based on a model for estimating average house air leakage developed by Sherman and Grimsrud, and described in Chapter 23 of the 1989 ASHRAE Handbook, *Fundamentals*. The underlying relationship is as follows:

$L = ELA_4\,[A(t_i-t_o) + Bv^2]^{1/2}$

where

L = average house air leakage rate for the period, m^3/s

ELA_4 = total equivalent leakage area of the house envelope referenced to a pressure difference of 4 Pa, cm^2

A = a stack coefficient, depending on the house height and the distribution of the equivalent leakage area

t_i-t_o = the average indoor-outdoor temperature difference for the time period, °C

B = a wind coefficient, depending upon terrain and local shielding conditions, and upon the house height and the distribution of the equivalent leakage area

v = average wind velocity for the period, m/s

The PF term in Clause 8.1 is then

$PF = [A(t_i-t_o) + Bv^2]^{1/2}$

The PF component accounts for the average pressure difference driving air leakage, resulting from buoyancy and wind forces; it has units of $m^3/(s\bullet cm^2)$. In selecting coefficients for the PF term, a two-storey house was assumed with moderate local shielding. House leakage area was assumed to be half in the walls, with the remainder divided equally between lower floor and ceiling. This corresponds to values of 0.00376 for A and 0.00299 for B. In applying the house air leakage relationship to windows, window leakage area was regarded simply as a component of overall house leakage area. In order to express window leakage characteristics in terms of L_{75}, instead of the equivalent leakage area at 4 Pa, and to express the average leakage rate for the period in terms of m^3/h, instead of m^3/s, the conversion factor, 0.138, was incorporated.

The values of F_w, U_w, and L_{75} used to compute the ER values are those for the reference window sizes in Table 1. This provides a uniform basis for comparing the ER values of different products. The values of these energy-related window properties can vary with size (see comments on Clauses 4.2 and 4.3). The nature of this variation depends upon the design of the product. Thus the comparison of window performance based on the reference ER values is, strictly speaking, valid only for the reference sizes. ER values can, of course, be calculated for any window size if the corresponding window properties are known.

Part 2 — Computing ERS Values for Specific Location, Orientation, and Size

Clause 8.1 of CSA Standard A440.2 provides a method for computing an energy rating based on average climatic conditions. This section of the User's Guide provides a method for obtaining an energy rating value (ERS) that is specific to the climate of a particular location, to window orientation, and to window size. The concept of the ERS is similar to that for the average ER in Clause 8.1. A different method, however, was employed for its derivation (see Appendix A, Bibliography — 1). The ERS is defined as

$$ERS = [F_w F_\theta H_s N_s] - [(t_i - t_o) U_w] - [(t_i - t_o)(0.138\ PF\ L_{75}/A_w)(\rho C_p/3.6)]$$

where

ERS = window energy rating for the heating season, for specific location and orientation, W/m^2

F_w = window solar heat gain coefficient established in accordance with this Standard, dimensionless

F_θ = off-normal incidence angle factor for solar radiation, dimensionless, taken as 0.93

H_s = average rate of solar radiation incident on a window for a specific location and orientation condition during the heating season, W/m^2

N_s = utilization factor for solar heat gain, dimensionless

t_i = average indoor air temperature during the heating season, °C

t_o = average outdoor air temperature during the heating season for the specific location, °C

U_w = window U-value established in accordance with this Standard, $W/(m^2 {}^\circ C)$

L_{75} = window air leakage rate at a pressure difference of 75 Pa, established in accordance with the Standard, m^3/h

$0.138PFL_{75}/A_w$ = air leakage rate per unit area for installed window under average weather conditions for the heating season, m^3/h per m^2

PF = a factor which is dependent on the wind and stack pressures causing air leakage and therefore varies with location, m^3/s per cm^2 of leakage area

ρC_p = thermal capacitance of air, 1.2 $kJ/(m^3 {}^\circ C)$

Note: *The heating season is taken as October 1 through April 30, inclusive.*

To calculate the ERS for a particular window size, the values of F_w, U_w, and L_{75}/A_w for the actual size, instead of for the reference size, must be used in the calculations. The values must be determined following the methods given in CSA Standard A440.2, using the reference indoor and outdoor conductances.

It will be noted that the ERS equation contains three terms:

(a) the first represents the average rate of useable solar heat gain through unit area of the window during the heating season, (q_s);

(b) the second represents the average rate of heat loss through the window by transmission, (q_t); and

(c) the third represents the average rate of heat loss through the window by infiltration, (q_i).

The ERS number then represents the average rate of net heat loss or net heat gain through unit area of the window during the heating season.

For convenience, the equation has been rearranged as follows:

$ERS = F_s F_w - U_w (t_i - t_o) - F_i L_{75}/A_w$

where
$F_s = F_\theta H_s N_s$

and

$F_i = (t_i - t_o)(0.138\ PF)(\rho C_p/3.6)$

The value of the solar utilization factor, N_s, and therefore F_s, depends on the total solar heat gain relative to the house heat loss. To take this into account, a parameter, the solar heat gain index, was defined as

$SGI = F_w A_{wt}/A_{fl}$

where
F_w = solar heat gain coefficient for window, dimensionless
A_{wt} = total area of windows above grade in house, m^2
A_{fl} = total above grade floor area in house, m^2

Values of F_s were computed, using the HOT 2000 computer program (see Appendix A, Bibliography — 2), for two values of SGI bracketing the range generally encountered. Since these values depend also on the heat loss characteristics of the house, they were generated for two levels of thermal efficiency:
(a) houses typical of post-1975 construction; and
(b) houses meeting R-2000 energy performance requirements.

Values of F_s for 13 Canadian cities are given in Tables 1 and 2 of the User Guide. Tables 1 and 2 also include values of $(t_i - t_o)$ and F_i. Table 1 can also be used to compute ERS values for windows used in pre-1975 houses with little error. Because these houses will tend to have higher overall heat loss characteristics, the F_s values, and therefore the computed ERS values, will tend to be lower than the correct values.

Using Tables 1 and 2

The ERS can be obtained using the factors in Tables 1 and 2, if the following values are known:
(a) window solar heat gain coefficient (F_w);
(b) overall heat transmission coefficient (U_w) and air leakage rate per unit area at 75 Pa (L_{75}/A_w) determined by the methods given in Standard A440.2; and
(c) values of the average rate of net heat loss or heat gain for the heating season per unit area of window for specific locations, orientations and window sizes.

The ERS values are intended primarily as a uniform basis for comparing windows in relation to their effect on seasonal energy requirements for heating. ERS values for many window arrangements, orientations and sizes will be negative, indicating that they add to the energy requirements for heating; the greater the negative number, the more the net heat loss attributed to the window. Some window arrangements and orientations will have ERS values that are positive, indicating that over the heating season there is a net gain in energy (and net reduction in heating requirements) attributed to the window.

The procedure for using Tables 1 and 2 is as follows:

(a) determine which of the two house types best represents the thermal characteristics of the house (ie, post-1975 or R2000);

(b) identify the city in Table 1 nearest, or which best models, the location for which ERS values are required;

(c) determine values of F_w, U_w, and L_{75}/A_w for the window, based on the methods given in CSA Standard A440.2;

(d) determine the approximate ratio of total window area to house floor area for above-grade floors. Where F_s values are required for general use, rather than for a specific installation, it is suggested that a value of 15% be used for A_{wt}/A_{fl};

(e) determine the value of F_wA_{wt}/A_{fl} (the SGI);

(f) choose the orientations that best represent those of interest and determine the value of F_s for these orientations, interpolating linearly between the values of F_s given for the two values of SGI in Table 1;

(g) multiply these values of F_s by the value of F_w for the window, to obtain q_s for each orientation of interest;

(h) where an average ERS value is required for the same windows used on more than one orientation, an appropriate average value of q_s is obtained by area weighting:

q_s average = $(A_1q_{s1} + A_2q_{s2} + ...+A_nq_{sn})/(A_1 + A_2 + ...+A_n)$

where
$A_1, A_2, ...A_n$ = window areas for each orientation
$q_{s1}, q_{s2}, ...q_{sn}$ = average seasonal rate of solar heat gain for each orientation.

Where there are approximately equal areas in each direction, area weighting is not required and simple averaging will lead to the correct average of q_s.

(i) determine the value of (t_i-t_o) for the location of interest and multiply this by the value of U_w for the window to obtain q_t;

(j) determine the value of F_i for the location of interest and multiply this by the value of L_{75}/A_w for the window to obtain q_i; and

(k) the value of ERS for the window arrangement of interest is:

$ERS = q_s - q_t - q_i$

If windows with different values of F_w are to be used in a particular case, for example, if different windows are being considered for south and north walls, or if replacement windows are being considered for one orientation, Table 1 can still be used to obtain an appropriate value of q_s and hence ERS. As a first approximation, values of SGI can be calculated for each window type (for each F_w), using the area of all windows for A_{wt}, and these values used to obtain values of F_s from Table 1. This will give a value of q_s and ERS for each window that will be adequate for most purposes.

If the window being rated has a lower value of F_w than the other windows, the value of F_s will be somewhat higher than it should be, since Table 1 is based on a model house with the same F_w in all orientations. Thus the value of F_w used in computing SGI should be an appropriate average of the F_w values of all the windows. This average should reflect the appropriate total solar heat gain. This can be approximated by weighting the different values of F_w by the multiple of the actual area of each window type and its value of q_s obtained in the first approximation above:

F_w average = $(F_{w1} A_1q_{s1} + F_{w2} A_2 q_{s2} + ...+F_{wn}A_nq_{sn})/(A_1q_{s1} + A_2q_{s2} + ...+A_nq_{sn})$

where
$F_{w1}, F_{w2}, ...F_{wn}$ = values of F_w for windows in different orientations
$A_1, A_2, ...A_n$ = actual areas of windows with different F_w values in different orientations
$q_{s1}, q_{s2}, ...q_{sn}$ = first approximation of q_s values for windows with different F_s values in different orientations

New values of F_s for windows in each orientation can then be obtained from the tables, using the new value of SGI, and new values of q_s computed for each combination of F_w and orientation.

An approximation of the total heat loss or heat gain through windows in a particular application can be obtained by multiplying the ERS values for each orientation by the total window area for that orientation, and by the number of hours in the heating season.

$$Q_w = 5088\,(ERS_1A_1 + ERS_2A_2 + ERS_3A_3 + ERS_4A_4)$$

where

Q_w = total increase or decrease in seasonal energy use for heating due to windows, W•h

ERS_1, ERS_2, ...ERS_n = ERS values for windows in the different orientations, W/m^2

A_1, A_2, ...A_n = area of windows in the different orientations, m^2

5088 = hours in the heating season (October 1 to April 30 inclusive).

If an estimate of the total seasonal energy required for heating is wanted for a specific house, a computer program such as HOT 2000 can be used.

Example 1

1. House type: R-2000
2. Location: Winnipeg
3. Window type: Casement with wood frame and sash; clear sealed-double glazing with air space and metal spacer. Window properties (from CSA Standard A440.2):

F_w = 0.53
U_w = 2.82
L_{75}/A_w = 2.73

4. Ratio of total window area to house floor area (A_{wt}/A_{fl}):
Assume 20%
5. Value of SGI: $0.53 \times 0.2 = 0.106$
This is approximately mid-way between the two reference values in Tables 1 and 2
6. Values of F_s for orientations of interest

south	east/west	north
147.3	68.2	33.4

7. Values of $q_s = F_sF_w$

south	east/west	north
78.1	36.1	17.7

8. Average value of q_s:

Assume equal window areas in each orientation. q_s average = 42

9. Value of $q_t = U_w(t_i - t_o)$

$q_t = 2.82\ (28.3) = 79.8$

10. Value of $q_i = F_i(L_{75}/A_w)$

$q_i = 0.57\ (2.73) = 1.6$

11. Values of $ERS = q_s - q_t - q_i$

south	east/west	north
–3.3	–45.3	–63.7

ERS average = –39.4

Example 2

1. House type: Post–1975

2. Location: Toronto

3. Window type: casement with wood frame and sash; sealed double-glazing with low-E coating and argon-filled space with insulating spacer. Window properties:

$F_w = 0.51$
$U_w = 1.99$
$L_{75}/A_w = 2.73$

4. Ratio of total window area to house floor area (A_{wt}/A_{fl}):
Assume 15%

5. Value of $SGI = 0.51 \times 0.15 = 0.077$
This is 25% of the numerical distance between the top and bottom reference values of SGI in Tables 1 and 2.

6. Values of F_s for orientations of interest:

south	east/west	north
110.4	59.0	31.0

7. Values of $q_s = F_s F_w$

south	east/west	north
56.3	30.1	15.8

8. Average value of q_s:
Assume equal window areas in each orientation.

q_s average = 33.1

9. Value of $q_t = U_w(t_i - t_o)$

$q_t = 1.99\,(20.7) = 41.2$

10. Value of $q_i = F_i(L_{75}/A_w)$

$q_i = 0.361\,(2.73) = 0.99$

11. Values of $ERS = q_s - q_t - q_i$

south	east/west	north
14.11	–12.1	–26.4

ERS average = –9.1

Table 1
Computing ERS Values for Post–1975 Houses

EDMONTON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	145.2	116.9	65.7	37.3	32.5
0.174	140.0	112.5	62.8	35.6	31.2
	$F_i = 0.479$			$t_i - t_o = 27.3$	

FREDERICTON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	128.0	104.9	64.1	38.4	33.9
0.174	123.4	101.0	61.4	36.7	32.5
	$F_i = 0.379$			$t_i - t_o = 22.6$	

HALIFAX

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	104.5	89.3	62.4	44.0	40.3
0.174	100.1	85.5	59.6	42.1	38.7
	$F_i = 0.397$			$t_i - t_o = 21.2$	

MONTREAL

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	117.0	97.8	63.3	40.1	35.4
0.174	112.2	93.6	60.3	38.2	33.8
	$F_i = 0.407$			$t_i - t_o = 22.7$	

OTTAWA

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	128.1	106.1	66.3	39.8	34.6
0.174	122.7	101.2	62.8	37.7	33.0
	$F_i = 0.406$			$t_i - t_o = 23.2$	

QUEBEC

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	129.9	107.1	66.4	40.6	35.8
0.174	125.8	103.5	63.8	39.0	34.5
	$F_i = 0.455$			$t_i - t_o = 24.6$	

ST JOHN'S

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	90.7	76.9	52.3	37.1	34.4
0.174	88.8	75.2	51.0	36.1	33.6
	$F_i = 0.474$			$t_i - t_o = 21.2$	

SASKATOON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	160.7	128.6	70.9	38.0	32.6
0.174	154.9	123.7	67.7	36.2	31.2
	$F_i = 0.553$			$t_i - t_o = 28.6$	

TORONTO

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	111.6	93.1	59.8	36.4	31.3
0.174	106.7	88.8	56.7	34.5	29.9
	$F_i = 0.361$			$t_i - t_o = 20.7$	

VANCOUVER

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	87.0	71.6	43.7	25.7	22.1
0.174	81.3	66.6	40.1	23.5	20.4
	$F_i = 0.212$			$t_i - t_o = 15.1$	

WHITEHORSE

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	114.2	91.7	50.0	28.4	24.2
0.174	110.8	88.7	47.9	27.0	23.4
	$F_i = 0.564$			$t_i - t_o = 30.3$	

WINDSOR

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	121.9	102.2	67.1	42.0	36.6
0.174	112.0	93.7	61.1	38.4	33.8
	$F_i = 0.344$			$t_i - t_o = 19.0$	

WINNIPEG

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	151.3	122.4	70.5	39.8	34.4
0.174	146.5	118.2	67.6	38.1	33.1
	$F_i = 0.570$			$t_i – t_o = 28.3$	

Table 2
Computing ERS Values for R-2000 Houses

EDMONTON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	145.1	116.8	65.7	37.2	32.5
0.174	136.9	109.8	61.1	34.5	30.4
	$F_i = 0.479$			$t_i - t_o = 27.3$	

FREDERICTON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	127.9	104.8	64.0	38.3	33.9
0.174	120.3	98.4	59.6	35.7	31.6
	$F_i = 0.379$			$t_i - t_o = 22.6$	

HALIFAX

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	104.4	89.2	62.3	43.9	40.3
0.174	97.2	83.0	57.8	40.9	37.6
	$F_i = 0.397$			$t_i - t_o = 21.2$	

MONTREAL

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	116.8	97.6	63.1	40.0	35.3
0.174	109.0	90.8	58.3	37.0	32.9
	$F_i = 0.407$			$t_i - t_o = 22.7$	

OTTAWA

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	128.1	105.8	66.3	39.7	34.5
0.174	119.2	98.2	61.0	36.5	32.0
		$F_i = 0.406$		$t_i - t_o = 23.2$	

QUEBEC

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	129.8	107.1	66.3	40.6	35.8
0.174	123.0	101.1	62.2	38.0	33.7
	$F_i = 0.455$			$t_i - t_o = 24.6$	

ST JOHN'S

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	90.7	76.9	52.3	37.1	34.4
0.174	87.4	73.9	50.0	35.4	32.9
	$F_i = 0.474$			$t_i - t_o = 21.2$	

SASKATOON

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	160.6	128.5	70.8	38.0	32.5
0.174	151.9	121.2	66.0	35.3	30.5
	$F_i = 0.553$			$t_i - t_o = 28.6$	

TORONTO

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	111.4	92.9	59.6	36.3	31.2
0.174	103.4	86.0	54.7	33.3	29.0
	$F_i = 0.361$			$t_i - t_o = 20.7$	

VANCOUVER

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	86.6	71.2	43.4	25.5	22.0
0.174	77.6	63.4	37.9	22.1	19.2
	$F_i = 0.212$			$t_i - t_o = 15.1$	

WHITEHORSE

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	114.1	91.6	49.9	28.4	24.5
0.174	108.7	86.9	46.6	26.2	22.8
	$F_i = 0.564$			$t_i - t_o = 30.3$	

WINDSOR

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	120.9	101.4	66.5	41.7	36.4
0.174	106.2	88.8	57.7	36.4	32.2
	$F_i = 0.344$			$t_i - t_o = 19.0$	

WINNIPEG

SGI	F_s				
	South	SE/SW	E/W	NE/NW	North
0.044	151.1	122.3	70.4	39.7	34.4
0.174	143.3	115.5	65.9	37.1	32.3
	$F_i = 0.570$			$t_i - t_o = 28.3$	

APPENDIX E.

STATISTICS OF MANITOBA HOUSEHOLDS

The following statistics on electricity usage in Manitoba households were obtained from the Manitoba Hydro 1991 Residential Energy Use Survey. Information pertaining to specific households, obtained from the Department of Energy and Mines of Manitoba can also be found in this appendix.

* There are approximately 98,500 all-electric single family households in Manitoba. This number is increasing by 2.5% yearly (Barakat & Chamberlin 1991).

* Over 81.0% of survey respondents live in single detached houses. The rest of the housing profile consists of apartments (7.0%), duplexes (4.9%), mobile homes (3.7%), and townhouses (3%).

* All-electric households in Manitoba consume an average of 27,470 KW.h per year.

* Natural gas (54.4%) is the most dominant heating fuel followed by electricity (32.4%). In no-gas available areas, electricity (62.2%) is the most common heating fuel, followed by oil (14.6%) and wood (11.3%). In gas-available areas, natural gas (73.4%) is the most commonly used heating fuel, followed by electricity (19.1%).

* The dominant water heating fuels are electricity (50.3%) and natural gas (46.9%).

* Close to 40% of dwellings have either a central air or window air conditioning system.

The above information is very useful for computer simulations required for this study. The following information from Manitoba Department of Energy and Mines also proved useful for computer simulations.

Manitoba

Memorandum

April 28, 1992

Grant McVicar
Director
Energy Conservation Branch

Robert Witzke
Transportation Economist

INFORMATION FOR FORT WHYTE CENTRE

This memo updates the April 6th memo on the same topic. It utilizes the 1992 rates for both natural gas and electricity. I have also taken the liberty of adding to the report the annual carbon dioxide (CO2) emissions of the two "families". The "families" (homes, appliances, automobiles) being compared here are detailed as follows :

Typical Family

- Single detached one storey Winnipeg home of wood frame construction approximately 1187 sqft in size
- occupants are 2 adults and 2 children
- average heating temperature = 70 degrees F.
- doors are wood
- windows are combination of aluminum slider and wood sash
- insulation levels are : attic (R32), main walls (R13), doors (R2), basement walls above grade (R13), basement walls (R13), perimeter area (R1), centre area (R1), windows (range from R1–R2)
- building air tightness level is average (4.55 ACH @50 Pa)
- primary space heating fuel is natural gas and the equipment is a furnace/ boiler with continuous pilot and output capacity of 77,999.9 BTU/hr (steady state efficiency = 65%)
- primary water heating fuel is natural gas and the equipment is a conventional tank with a 25 Imperial Gallon capacity, seasonal efficiency of 65%, and a daily household consumption of 40 Imperial Gallons/day.
- electrical appliances include a refrigerator, freezer, stove, clothes washer, clothes dryer, dishwasher, television, and lighting and miscellaneous uses
- family vehicle is a 1985 Chevrolet Cavalier with a 6 cylinder engine and an automatic transmission achieving fuel efficiencies of 12.2 L/100 km urban, and 7.3 L/100 km on the highway
- from 1991 CAA survey, assume average annual distance travelled is 18,442 kilometres of which 50% is urban driving.

Energy–Efficient Family

- Single detached one storey Winnipeg home of wood frame construction approximately 1187 sqft in size

- occupants are 2 adults and 2 children
- average heating temperature = 70 degrees F.
- doors are metal insulated
- windows are triple–glazed, coated Low–E
- insulation levels are : attic (R40), main walls (R28), doors (R7), basement walls above grade (R21), basement walls (R20), perimeter area (R1), centre area (R1), windows (range from R3–R6)
- building air tightness level is tight (1.5 ACH @50 Pa)
- primary space heating fuel is natural gas and the equipment is an induced draft fan furnace/boiler with output capacity of 39,998.9 BTU/hr (steady state efficiency = 80%)
- a heat recovery ventilator (HRV) is in continuous operation
- primary water heating fuel is natural gas and the equipment is a direct vent (sealed) tank with a 25 Imperial Gallon capacity, seasonal efficiency of 94%, and a daily household consumption of 40 Imperial Gallons/day
- electrical appliances include a refrigerator, freezer, stove, clothes washer, clothes dryer, dishwasher, television, HRV, and lighting and miscellaneous uses
- family vehicle is a 1992 Honda Civic with a 4 cylinder engine and a standard transmission achieving fuel efficiencies of 6.9 L/100 km urban, and 5.2 L/100 km on the highway
- from 1991 CAA survey, assume average annual distance travelled is 18,442 kilometres of which 50% is urban driving.

APPENDIX F.

MANITOBA HYDRO AVOIDED COSTS AND SIMPLE ECONOMIC SCREEN

Table F1.

Detailed Avoided Costs for DSM Programs (1995-2004)

- for programs with greater than a 10 year life
- at customer meter

Total Annual Avoided Costs	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	27	9
Generation Deferral	0	44
Transmission	0	13
Distribution	0	13
Total Annual Avoided Cost	27	79

Avoided Costs For Winter Only Applications	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	32	5
Generation Deferral	0	44
Transmission	0	13
Distribution	0	13
Total Avoided Cost (Winter Only)	32	75

Avoided Costs For Summer Only Application:	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	19	5
Generation Deferral	0	0
Transmission	0	0
Distribution	0	0
Total Avoided Cost (Summer Only)	19	5

Table F2.

Detailed Avoided Costs for DSM Programs (2005-2028)

- for programs with greater than a 10 year life
- at customer meter

Total Annual Avoided Costs	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	27	9
Generation Deferral	8	0
Transmission	0	13
Distribution	0	13
Total Annual Avoided Cost	35	35

Avoided Costs For Winter Only Applications	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	32	5
Generation Deferral	8	0
Transmission	0	13
Distribution	0	13
Total Avoided Cost (Winter Only)	40	31

Avoided Costs For Summer Only Application:	Energy $/MWh	Capacity $/kW
Generation Production (w/o Deferral)	19	5
Generation Deferral	8	0
Transmission	0	0
Distribution	0	0
Total Avoided Cost (Summer Only)	27	5

Table F3.

[illegible] BARAKAT & CHAMBERLIN [illegible]

Fixed Dollars

Fixed 1990 Dollars

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Demand ($/kW)																														
Summer On-Peak	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Mid-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Off-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Winter On-Peak	5.0	5.0	5.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0
Mid-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Off-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy ($/kWh)																														
Summer On-Peak	0.012	0.012	0.012	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Mid-Peak	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	0.012	0.012	0.012	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Winter On-Peak	0.012	0.012	0.012	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Mid-Peak	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	0.012	0.012	0.012	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Total Annual	0.012	0.012	0.012	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Real Discount Rate	5.5%																													

Table F4.

Manitoba Hydro Marginal Costs
1990 Dollars

Manitoba Hydro Marginal Costs
Fixed 1990 Dollars

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Demand ($/kW)																														
Summer On-Peak	5.0	4.7	4.5	4.3	4.0	3.8	3.6	3.4	3.3	3.1	2.9	2.8	2.6	2.5	2.4	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.2	1.1	1.1
Mid-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Off-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Winter On-Peak	5.0	4.7	4.5	63.9	60.5	57.4	54.4	51.6	48.9	46.3	43.9	41.6	39.4	15.5	14.6	13.9	13.2	12.5	11.8	11.2	10.6	10.1	9.5	9.0	8.6	8.1	7.7	7.3	6.9	6.6
Mid-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Off-Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy ($/kWh)																														
Summer On-Peak	0.012	0.011	0.011	0.016	0.015	0.015	0.014	0.013	0.012	0.012	0.011	0.011	0.010	0.013	0.013	0.012	0.011	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.006	0.006	0.006
Mid-Peak	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	0.012	0.011	0.011	0.016	0.015	0.015	0.014	0.013	0.012	0.012	0.011	0.011	0.010	0.013	0.013	0.012	0.011	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.006	0.006	0.006
Winter On-Peak	0.012	0.011	0.011	0.027	0.026	0.024	0.023	0.022	0.021	0.020	0.019	0.018	0.017	0.020	0.019	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.012	0.011	0.010	0.010	0.009	0.009	0.008
Mid-Peak	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	0.012	0.011	0.011	0.027	0.026	0.024	0.023	0.022	0.021	0.020	0.019	0.018	0.017	0.020	0.019	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.012	0.011	0.010	0.010	0.009	0.009	0.008
Total Annual	0.012	0.011	0.011	0.023	0.022	0.021	0.020	0.019	0.018	0.017	0.016	0.015	0.014	0.017	0.017	0.016	0.015	0.014	0.013	0.013	0.012	0.011	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.007
Real Discount Rate	5.5%																													

Table F5.

Manitoba Hydro Marginal Costs – Levelized
1990 Dollars Real Discount 5.5%

Base Year – 1992

Levelized Costs, 1990 Dollars

	Lockup Table #	1 Year	2 Year	3 Year	4 Year	5 Year	6 Year	7 Year	8 Year	9 Year	10 Year	11 Year	12 Year	13 Year	14	15	16	17	18	19	20	25	30
	2																						
Demand (kW)	3																						
Summer On Peak	4	5.00	9.75	14.26	18.56	22.65	26.57	30.32	33.92	37.37	40.70	43.90	47.00	50.01	52.92	55.75	58.51	61.20	63.83	66.41	68.93	77.80	87.20
Mid-Peak	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Peak	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	15				69.52					198.59			261.07							307.46		
Winter On Peak *	8	5.00	4.87	7.13	36.73	64.81	91.47	116.84	141.01	164.08	186.14	207.27	227.56	247.06	258.28	269.29	280.09	290.72	301.19	311.51	321.72	361.49	403.56
Mid-Peak	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Peak	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy (kWh)	11																						
Summer On Peak	12	0.012	0.023	0.034	0.050	0.065	0.079	0.093	0.106	0.119	0.131	0.142	0.154	0.164	0.178	0.190	0.203	0.215	0.226	0.237	0.248	0.282	0.318
Mid-Peak	13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	14	0.012	0.023	0.034	0.050	0.065	0.079	0.093	0.106	0.119	0.131	0.142	0.154	0.164	0.178	0.190	0.203	0.215	0.226	0.237	0.248	0.282	0.318
	15																						
Winter On Peak	16	0.012	0.023	0.034	0.060	0.085	0.108	0.131	0.152	0.173	0.192	0.211	0.229	0.247	0.267	0.286	0.304	0.322	0.339	0.355	0.372	0.422	0.476
Mid-Peak	17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Off-Peak	18	0.012	0.023	0.034	0.060	0.085	0.108	0.131	0.152	0.173	0.192	0.211	0.229	0.247	0.267	0.286	0.304	0.322	0.339	0.355	0.372	0.422	0.476
	19																						
Total Annual	20	0.012	0.023	0.034	0.056	0.077	0.097	0.116	0.135	0.152	0.169	0.185	0.200	0.215	0.232	0.249	0.265	0.280	0.295	0.310	0.324	0.368	0.415

* Note: The avoided cost for winter kW has been divided by 2 to evenly distribute it between the a.m. and p.m. peaks.

APPENDIX G.

SAMPLE HOT2000 OUTPUT

```
   Hot2000  Version 6.02                    Dec 21/92      09:35:57

                         ****************************************
                         *                                      *
                         *               Hot2000                *
                         *             Version 6.02             *
                         *                CANMET                *
                         *  Energy, Mines and Resources CANADA  *
                         *             July 1, 1991             *
                         *                                      *
                         ****************************************

 House Data Filename=A:\TFH1.HDF

 Weather Data is for WINNIPEG, MANITOBA

 Builder Code =TFH1.HDF        Data Entry by:HENRI P. CARRIERE, P.Eng.

 Client name:       CARRIERE
 Street address:    TYPICAL FAMILY HOUSE
 City:                                      Region:
 Postal code:                               Telephone:

                      *** GENERAL HOUSE CHARACTERISTICS ***

 House type:                  Single detached
 Number of storeys:           One storey
 South side obstruction:      1% to 25% obstruction by Trees
 Wall construction:           Single stud wall

 SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

 HOUSE THERMAL MASS LEVEL: (A) Wood frame construction, 12.5 mm gyproc walls
                                 and ceiling, wooden floor

 Occupants :  2 Adults   for  50.0 % of the time
              2 Children for  50.0 % of the time

                          *** HOUSE TEMPERATURES ***

 Heating Temperatures     Main Floor                 = 21.0 C
                          Basement                   = 19.0 C
                          TEMP. Swing from 21.0 C    =  3.5 C

                 *** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

 Foundation Construction    Attachment Sides    Insulation Placement

 Full Basement                None                Interior
```

```
Hot2000  Version 6.02


                        *** WINDOW CHARACTERISTICS ***

Direction Seq Location  # of     Type       Window        OverHang  Header     SHGC
           #    Code   Windows          Width  Height     Width    Height
                                          m       m          m        m
South      1     M2       2     000001   .990   1.300      .610     .380     .5200
           2     M2       1     000001   .990   1.300      .610     .380     .5200
East       1     M3       1     000001   .990   1.300      .610     .380     .5200
           2     M3       1     000001   .990   1.300      .610     .380     .5200
North      1     M1       1     000001   .990   1.300      .610     .380     .5200
West       1     M4       1     000001   .990   1.300      .610     .380     .5200
           2     M4       1     000001   .990   1.300      .610     .380     .5200

                   *** USER DEFINED WINDOW CODES SCHEDULE ***

     Code            Description                       R-value    Solar Heat Gain
                                                         RSI        Coefficient

 1   000001   TG BASIC                                   .48           .520
 2   000002   TG, 1-AR                                   .49           .520
 3   000003   TG, HM66                                   .57           .310
 4   000004   TG, 1-LOW E                                .52           .440
 5   000005   TG, PVC                                    .52           .520
 6   000006   TG, SS                                     .52           .520
 7   000007   TG, SS, HM66                               .66           .310
 8   000008   TG, SS, 1-LOW E, 1-AR                      .60           .450
 9   000009   TG, SS, 2-LOW E, 2-AR                      .73           .370
10   000010   TG, SS, 2-LOW E, 2-AR, PVC                 .81           .370
11   000011   TG, HM66, SS, 1-LOW E,2-AR,PVC             .88           .280
12   000012   QG, SS, HM33 (VISIONWALL)                 1.04           .330

                        *** BUILDING PARAMETERS ***

Component                      Area  (m2 )        RSI       Heat Loss   % Annual
                             Gross      Net                    MJ       Heat Loss
------------------------------------------------------------------------------------

Above Grade Components

Ceiling
 C1                          110.32    110.32      5.64
                  TOTAL:     110.32    110.32      5.64     11638.3        9.30

Main Walls
 M1                           29.42     26.27      2.29
 M2                           29.42     23.70      2.29
 M3                           22.31     19.74      2.29
 M4                           22.31     19.74      2.29
                  TOTAL:     103.46     89.44      2.29     21823.8       17.44

Doors
 D1     Location: M1           1.86      1.86       .35
 D2               M2           1.86      1.86       .35
                  TOTAL:       3.72      3.72       .35      6324.0        5.05
```

```
  Hot2000  Version 6.02

Component                         Area (m2 )       RSI        Heat Loss   % Annual
                                Gross     Net                    MJ      Heat Loss
-----------------------------------------------------------------------------------

Basement walls above grade
  B1                            38.80    38.80     2.29
                   TOTAL:       38.80    38.80     2.29        9128.7       7.29

Full Basement Area

Upper Basement Walls
                                25.86              2.29
                   TOTAL:       25.86              2.29        3382.0       2.70

Lower basement walls
                                38.80              2.29
                   TOTAL:       38.80              2.29        3670.8       2.93

Perimeter area
                                12.56               .20
                   TOTAL:       12.56               .00        4607.2       3.68

Centre area
                                97.77               .20
                   TOTAL:       97.77               .00        8952.6       7.15

WINDOWS

Orientation                      Total          RSI           Heat Loss   % Annual
  Location   Number  Type      Area(m2 )  Window  (Shutter)      MJ      Heat Loss
                     (Code)    ---------------------------------------------------

South
    M2          2    000001      2.57      .48
    M2          1    000001      1.29      .48
  TOTAL:                         3.86      .48                 4806.0       3.84

East
    M3          1    000001      1.29      .48
    M3          1    000001      1.29      .48
  TOTAL:                         2.57      .48                 3204.0       2.56

North
    M1          1    000001      1.29      .48
  TOTAL:                         1.29      .48                 1602.0       1.28

West
    M4          1    000001      1.29      .48
    M4          1    000001      1.29      .48
  TOTAL:                         2.57      .48                 3204.0       2.56
```

```
 Hot2000  Version 6.02             Dec 21/92      09:36:01

Ventilation
-----------
                          House          Air          Heat Loss   % Annual
                          Volume        Change           MJ      Heat Loss
                         -----------------------------------------------------

                          537.80 m3     .37 ACH        42799.3      34.20
                   *** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area                                  =   427.6 m2
Air Tightness Level is Average          ( 4.55 ACH @50 Pa.)
Building Envelope is NOT Sheltered from the Wind.
Estimated Equivalent Leakage Area                               =   887.6 cm2
Normalized Leakage Area                                         =  2.0759 cm2/m2
Estimated Airflow to cause a  5 Pa Pressure Difference          =      56 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference          =      88 L/s
ELA used to calculate Estimated Airflows                        =   355.0 cm2

F-326 VENTILATION REQUIREMENTS:

           Kitchen,living,dining:       3 rooms @  5 L/s    = 15 L/s
           Bedrooms:                    1 rooms @ 10 L/s    = 10 L/s
           Bedrooms:                    2 rooms @  5 L/s    = 10 L/s
           Bathrooms:                   1 rooms @  5 L/s    =  5 L/s
           Other habitable rooms:       1 rooms @  5 L/s    =  5 L/s
           Basement Rooms:                                     5 L/s

                    *** EXHAUST FLOW RATES ( L/s  ) ***

                                 Continuous          Intermittent
Dryer                                                    75.0
Kitchen                                .0                94.4
All Bathrooms                          .0                28.3
All other exhaust devices              .0                  .0
Vented central vac.                                        .0
Largest Intermittent exhaust (other than Dryer)            .0

Total continuous exhaust flow    .0 L/s
Exhaust Fan Power                .0 watts

F-326 Required continuous ventilation rate         =   50.0 L/s (  .33 ACH)

                      *** SPACE HEATING SYSTEM ***

PRIMARY Heating Fuel            : Electricity
Equipment     : Forced air furnace
Manufacturer                    :
Model                           :
Output Capacity                 =       20.0 kW

Steady State Efficiency         = 100.0 %

Fan Mode : Auto                  Fan Power     388. watts
```

```
   Hot2000  Version 6.02                    Dec 21/92      09:36:01

                     *** ANNUAL SPACE HEATING SUMMARY ***

 Design Heat Loss at -33.0 C      =    21.28 Watts/m3       = 11446. Watts

 Gross Space Heating Load                                   =125143. MJ
 Sensible Daily Heat Gain From Occupants                    =    2.40 kWh/day
 Usable Internal Gains                                      = 23749. MJ
 Usable Internal Gains Fraction                             =   19.0 %
 Usable Solar Gains                                         = 13306. MJ
 Usable Solar Gains Fraction                                =   10.6 %
 Ventilation Equipment Electrical Contribution              =     0. MJ
 Auxiliary Energy Required                                  = 88087. MJ

 Space Heating System Load                                  = 88087. MJ
 Furnace/Boiler Seasonal efficiency                         =  100.0 %
 Furnace/Boiler Annual Energy Consumption                   = 86411. MJ

                    *** DOMESTIC WATER HEATING SYSTEM ***

 PRIMARY Water Heating Fuel  : Electricity
 Water Heating Equipment     : Electric tank

 Manufacturer                          :
 Model                                 :
 Tank Capacity                         =  149.8 Litres
 Seasonal Efficiency                   =   93.0 %

                *** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

 Daily Hot Water Consumption                                  =  236.0 Litres  /day
 Estimated Domestic Water Heating Load                        = 17132. MJ

 PRIMARY Domestic Water Heating Energy Consumption            = 18421. MJ

                   *** LIGHTING AND APPLIANCES SUMMARY ***

 Total Electrical Load                                        =  16.0 kWh/day
 Average External Electrical Load                             =   2.0 kWh/day
 Total Annual Energy Consumption                              = 5840. kWh

                     *** FAN OPERATION SUMMARY (kWh) ***

 Hours       HRV/Exhaust Fans          Space Heating        Space Cooling

 Heating             .0                    465.7                  .0
 Neither             .0                       .0                  .0
 Cooling             .0                       .0                  .0

 Total               .0                    465.7                  .0
```

```
  Hot2000  Version 6.02                      Dec 21/92      09:36:01

         *** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption    =  86411. MJ = 24003.0 kWh
Ventilator Electrical Consumption: Heating Hours     =      0. MJ =      .0 kWh
Estimated Annual DHW Heating Energy Consumption      =  18421. MJ =  5117.0 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION      = 104832. MJ = 29120.0 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET =  64041. MJ = 17789.2 kWh

Estimated  Annual Base Electrical Energy Consumption=  21024. MJ =  5840.0 kWh
Ventilator Electrical Consumption: Non Heating Hours=      0. MJ =      .0 kWh

               *** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel                     Space     Space     DHW    Appliances    Total
                        Heating   Cooling  Heating

Electricity (kWh)       24468.7       .0   5117.0    5840.0      35425.7

             *** ESTIMATED ANNUAL FUEL CONSUMPTION COSTS ***

Fuel Costs Library = D:\H2K\User\FUELPRN3.CST

          Electricity Natural Gas        Oil      Propane        Wood        Total
RATE       (ManHydr1)  (FtNelGas)  (    Oil1)  (    Prop1)  ( AvRate1)

   $          1433.84         .00        .00          .00         .00    1433.84

                             ********************

   Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

   The calculated heat losses and energy consumptions are only
   estimates, based upon the data entered and assumptions
   within the program. Actual energy consumption and heat
   losses will be influenced by construction practices,
   localized weather, equipment characteristics and the
   lifestyle of the occupants.
```

APPENDIX H.

SAMPLE WINDOW 4.0 OUTPUT

```
WINDOW 4.0 Report

      ID:5                                      FrID:  4
    Name:TG BASIC                  ==============================
    Mode:Design                    ||                          ||
 EnvCond:1                         ||                          ||
                                   ||       GlzSysID:  7       ||
    Type:Picture         FrID:   4 ||         Div ID:  0       ||FrID:   4
    Tilt: 90                       ||                          ||
    Size:Custom                    ||                          ||
   Width:1219.20mm                 ||                          ||
  Height: 914.40mm                 ||                          ||
    Area:   1.11 m2                ==============================
                                                FrID:  4
 U-value: 2.086 W/m2-C
      SC: 0.608
    SHGC: 0.523
      Vt: 0.522


Data for Glazing Systems

                     COG
ID  Name             Area #Lay  Tilt      Uc     SCc   SHGCc  Vtc    RHG
                      m2                W/m2
--- ---------------- ----- ----  ----   --------  ----  -----  ----  -----
  7 TG BASIC         0.617   3    90      1.769   0.76   0.66  0.70   499

Glass and Gas Data for Glazing System '7 TG BASIC'

ID   Name            D(mm) Tsol  1 Rsol 2 Tvis  1 Rvis 2  Tir  1 Emis 2 Keff
---- --------------- ----- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
Outside
6104 CLEAR             5.0 .816 .071 .071 .881 .080 .080 .000 .840 .840 .900
   1 Air              12.7                                               .063
6104 CLEAR             5.0 .816 .071 .071 .881 .080 .080 .000 .840 .840 .900
   1 Air              12.7                                               .070
6104 CLEAR             5.0 .816 .071 .071 .881 .080 .080 .000 .840 .840 .900
Inside
```

```
WINDOW 4.0 Report                 Page 2

Frame Data
                                                          Frame    Edge
Location          ID   Name           Source              Area     Area    Uframe  Uedge
                                                           m2       m2       W/m2-C
----------------  ---  -------------  --------------      -----    -----   ------  ------
Left Jamb         4    Wood           ASH/LBL             0.059    0.045    2.27    2.74
Header            4    Wood           ASH/LBL             0.080    0.065    2.27    2.74
Right Jamb        4    Wood           ASH/LBL             0.059    0.045    2.27    2.74
Sill              4    Wood           ASH/LBL             0.080    0.065    2.27    2.74


Gas Data

ID   Name                 Cond   dCond   Visc     dVisc     Dens     dDens     Pran   dPran
                          W/m-K  W/m-K2  kg/m-s   kg/m-s-   kg/m3    kg/m3-C
                                                     K
                                 x e-5   x e-5    x e-8
___  _______________     ______ ______  _______  ________  _______  ________  ______ ______

 1   Air                 .0241  7.6000  1.7300  10.0000   1.2900  -0.0044   .7200  .00180

Environmental Conditions: 1 NFRC/ASHRAE

             Tout    Tin   WndSpd   Wnd Dir     Solar    Tsky   Esky
             (C)     (C)   (m/s)               (W/m2)   (C)
            -----   ----   ------  ---------   ------   ----   ----
Uvalue      -17.8   21.1    6.71   Windward      0.0  -17.8   1.00
Solar        31.7   23.9    3.35   Windward    783.0   31.7   1.00
```

```
WINDOW 4.0 Report                     Page 3

Frame Library Data
                                         U-value      Edge GlzSys GlzSys Width
ID  Name              Source          Frame   Edge    Corr Width    Uc   (PFD)   Abs
                                      W/m2-C W/m2-C          mm   W/m2-C  mm
___ _____________    ___________     ______ ______   _____ ______ ______ _____  _____

  4 Wood              ASH/LBL           2.27 N/A         1 var    N/A    69.85  0.90

Divider Library Data
                                         U-value      Edge GlzSys GlzSys Width
ID  Name              Source           Div    Edge    Corr Width    Uc   (PFD)   Abs
                                      W/m2-C W/m2-C          mm   W/m2-C  mm
___ _____________    ___________     ______ ______   _____ ______ ______ _____  _____

No Dividers for this Glazing System

Optical Properties for Glazing System '7 TG BASIC'

    Angle    0    10    20    30    40    50    60    70    80    90   Hemis

    Vtc  : 0.696
    Rf   : 0.192
    Rb   : 0.192

    Tsol : 0.551
    Rf   : 0.151
    Rb   : 0.151

    Abs 1: 0.124
    Abs 2: 0.098
    Abs 3: 0.076
    Abs 4:
    Abs 5:
    Abs 6:
    SHGCc: 0.657

 SCc: 0.76 Color Properties     DomWL        Purity       L*       a*      b*
 Tdw: N/A  Transmittance           um            %
 Tuv: N/A  Reflectance             um            %
```

```
Temperature Distribution (degrees C) for '7 TG BASIC'

                                                Condensation
Env. Conditions:  1 NFRC/ASHRAE         U-value      RH             Solar
                 Outside Air             -17.8                       31.7
                 Outer Surface           -15.4       N/A             37.5
        Layer 1  Center                  -15.2                       37.9
                 Inner  Surface          -15.0                       38.0
                 Outer Surface            -1.1                       42.5
        Layer 2  Center                   -0.9                       42.6
                 Inner  Surface           -0.7                       42.5
                 Outer Surface            11.8                       36.4
        Layer 3  Center                   12.0                       36.3
                 Inner  Surface           12.2      56.6%            36.0
                 Inside Air               21.1                       23.9
```