Costs and benefits to consumers and utilities of residential energy savings actions

Final report

Prepared for
Energy Solutions Centre Inc.

by
Malcolm Taggart
Luigi Zanasi
Janne Hicklin

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energy solutions centre

Yukon Development Corporation

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For more information, contact:

Energy Solutions Centre Inc.
206A Lowe Street
Whitehorse, Yukon Y1A 1W6
Telephone: (867) 393-7063
Fax: (867) 393-7061
info@nrgsc.yk.ca, www.nrgsc.yk.ca

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EXECUTIVE SUMMARY

This paper identifies and analyses a number of possible residential energy-saving actions. The intent is to provide information useful in designing programs aimed at improving the energy efficiency of homes in the Yukon. The actions reviewed here do not require a change in behaviour. Rather, they involve changing the "hardware" in Yukon residences.

The analysis for each section addresses five key areas that will help determine whether it is worthwhile to proceed further.

1. Who would benefit from each energy-saving action (i.e. who are the target/eligible households)?
2. How many consumers are there in the Yukon who would benefit (market size)?
3. How much would the action cost?
4. What are the effects on consumers of doing the action?
5. What are the effects on the utility?

Following this section is a discussion of issues related to program design.

The results of two surveys were used to estimate the number of households potentially benefiting from each action: the Yukon Community Housing Surveys (1999) conducted by the Yukon Housing Corporation and the Residential Energy End Use Survey (2001) conducted by the Yukon Bureau of Statistics for Yukon Development Corporation. Separate calculations were done for hydro and diesel communities, to forecast the potential effect on utility revenues and expenses for existing households. (Energy efficient technologies are now automatically incorporated into most new housing.)

For each action, only the direct costs and benefits to consumers and to the utility are calculated. Note that these are direct private costs and do not include positive or negative side effects, nor combined effects of undertaking more than one action at the same time. Thus, the dollar costs shown do not measure the total social cost or benefits of each action.

This report focuses primarily on electricity consuming devices. Most of the energy-saving actions will therefore result in a loss of power sales revenue, but these will be offset by a wide range of benefits.

In communities where electricity is generated using diesel fuel (diesel communities), reducing energy consumption is a direct and obvious financial benefit to the utility because electrical generation with diesel costs more than the revenues from electricity sales. In communities where electricity is generated using water turbines (hydro communities), as well as in diesel communities, energy efficiency improvements provide considerable additional benefits. Reduction in residential energy use through energy efficiency upgrading would have following effects:

- deferring need for added generation capacity;
- reducing peak load demand;
- deferring need for equipment maintenance;
- extending life of utility assets;
- obtaining greenhouse gas emission credits;
- better air quality in diesel communities; and
- acquiring additional goodwill by helping meet targets identified in Kyoto protocol.

First, the average cost of each action was estimated using current retail prices in Whitehorse and transportation costs where applicable. Potential energy savings in kWh were calculated using information from Natural Resources Canada and other sources such as utilities. The dollar savings were estimated by multiplying the kWh saved by the cost per kWh, both for consumers and for marginal production costs to the utility. Because the costs usually involve one-time outlays while the benefits or savings accumulate over the life of the new “hardware,” present value techniques were used to compare costs to benefits. As part of the analysis of benefits to the utility, the maximum amount of potential incentives to consumers was calculated. The maximum incentive is where the utility breaks even on direct generation costs in diesel communities.

Table 1 gives a summary of key results from the analysis of energy-saving actions. Target number is the number of households potentially benefitting from each action.

Table 2 lays out actions that were considered but were not analysed for a variety of reasons. The main reason for not undertaking the analysis of most the actions outlined in the table below was the lack of data that would allow calculations. For the rest, energy savings are simply too small relative to the cost of the action to be worth analysing.

Table 1. Summary of results: Energy-saving actions for consumers.

Action	Number of target households in the Yukon	Number of target households in diesel communities	Annual energy savings per household	Annual energy cost savings to consumer	Average cost of action per household	Maximum economic incentive in diesel communities	Comments
Recommended actions							
Install low-flow showerheads	3,626	470	670 kWh	$66.11	$15	$450	Immediate substantial benefit
Install automobile plug-in timers	2,702	391 (vehicles)	733 kWh (in Dawson)	$72.27	$28	$200	Immediate substantial benefit
Replace fridges >10 years old	2,538	370	500 kWh	$49.30	$1,200	$141.50	Underway. Extended through 2004
Replace washing machines >10 years old	3,762	412	800 kWh	$78.88	$1,500	$200	Has good potential
Replace 2 60 watt incandescent bulbs with compact fluorescent bulbs	10,755	1,510	88 kWh	$8.68	$21	$24	4+ year payback period for consumer on lights lit for 3 hours/day
Marginal benefits but some potential							
Replace washing machines >5 years old	8,509	911	700 kWh	$69.02	$1,500	$180	Replacing nearly new machines not likely to be popular
Low benefit							
Replace freezers >10 years old	3,342	476	237 kWh	$23.37	$700	$70	Not a lot of savings available
Replace 1 kitchen incandescent fixture with fluorescent.	10,755	1,510	99 kWh	$9.76	$100	$27	10+ year payback period for consumer.
Replace forced-air furnace with combo unit	1,963	185	3,541 kWh	$34.16 (net of extra oil)	$4,500	$1,145	Small net savings to consumers makes it less attractive to consumers than utility

Table 2. Energy-saving actions considered but not analysed.

Action	Reason for not analysing
Replace older dishwashers	Although there has been a large efficiency gain in dishwashers over the past 10 years, we have no data on ownership and use of dishwashers in the Yukon.
Install exterior motion sensors	There is a lack of data on the use of outside lights (e.g. continuously on or switched on as needed etc.).
Insulate hot water tanks	Benefits from this action depend upon insulation product used and installation technique.
Insulate hot water pipes	Lack of data made reasonably accurate calculations of costs and benefits difficult. However, it is a low cost action.
Install heat tape thermostats	Lack of data made reasonably accurate calculations of costs and benefits difficult.
Insulate hot tubs	Very small numbers in the Yukon.
Replace older clothes dryers	Efficiency gains over the 1990s have been relatively modest (less than 200 kWh/year between 1990 and 1999) and those gains have been inconsistent.
Replace older electric ranges	Electric ranges have seen very small efficiency gains (less than 20 kWh/year between 1990 and 1999) and improvements have been inconsistent.
Replace old furnaces	Too many variables to allow valid estimates.
Service and adjust furnaces	Lack of data on numbers needing service, and lack of data on possible fuel savings. (Results of a separate pilot study initiated in Watson Lake in 2003 are available.)
Replace older furnace burners	Uncertainty over actual fuel savings. Savings dependent on a large number of variables.

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1. INTRODUCTION

The purpose of this paper is to identify and analyse a number of residential energy-saving actions. The intent is to provide information that would be useful in designing programs aimed at improving the energy efficiency of homes in the Yukon.

ACTIONS

The actions reviewed here are not intended to change behaviour. Rather, they involve changing the "hardware" in Yukon residences. For each action, a number of financial calculations are made and the costs and benefits to consumers and to the utility are estimated. It should be noted that the analysis only addresses immediate short-term impacts of specific actions taken in isolation. The longer-term implications and broader economic benefits of combining actions in a comprehensive energy management program are beyond the scope of this study.

The actions this paper examines are:

- **Appliances**
  - Replacing older refrigerators with new models
  - Replacing older washers with energy-efficient front-load models
  - Replacing older freezers with energy-efficient models
- **Lighting**
  - Installing energy efficient fixtures
  - Energy efficient bulbs (compact fluorescent)
- **Domestic hot water**
  - Pipe insulation
  - Installing low-flow showerheads
  - Other electrical uses
  - Auto plug-in timers
- **Heating**
  - Replacing furnace burners with efficient burners
  - Replacing hot-air furnaces with combo units

LESSONS FROM OTHER PROGRAMS

Utilities across North America have run a wide variety of energy efficiency programs with widely varying levels of success. Participation rates vary widely as well.

Information and energy audit programs on their own tend to have low participation and low energy-savings rates. The most successful of these types of programs were run in the US in the 1980s. The overall participation rate reached 7% of residential customers (but took 6 years to do so) who reduced their consumption of power by an average of 3 to 5%.[1] A general finding is that information programs tend to do better when run for several years. However, these types of programs are most valuable when they are used as complements to other approaches.

Rebate programs — usually on efficient appliances and light bulbs — are the most common type of financial incentive offered to residential customers. Different program design and implementation can produce widely varying results. (See section on refrigerators, page 8.) A drawback to rebate programs is that they tend to reach only a minority of customers. There is evidence that participation in residential rebate programs tends to fall off after 2 to 3 years, especially when it has been marketed aggressively. In effect, the market becomes saturated.[2]

Payback periods play a crucial role in providing the incentive for customers to participate in energy efficiency programs. Experience in the US shows that even commercial and industrial users commonly reject out-of-hand any energy efficiency investments with a payback period longer than 1 to 5 years depending on the nature of the business. It is also commonplace for investments within these thresholds to be rejected due to such factors as perceived risk, inability to assess benefits, inaccessibility of capital, lack of management time, and lack of immediate equipment availability. Residential customers (especially low-income households) commonly reject efficiency measures even with a payback period of under one year.[3]

Perhaps the most successful program described in the literature bears a striking resemblance to the House Calls program run in the Yukon. The program — known as Homeworks — was targeted at low-income households in Connecticut between 1990 and 1995. It was a direct installation program that used what is described as a neighbourhood blitz approach. Residents in a targeted neighbourhood would first receive a direct mail circular a week or two before the blitz followed by a door-to-door canvassing to set up appointments. The installers would arrive for the appointment and install as many energy saving measures as possible — including hot water tank wraps, low-flow showerheads, pipe insulation, and efficient light bulbs while simultaneously educating the residents on energy saving techniques. The program was eventually discontinued because it had saturated its market — overall, 27% of approximately 100,000 eligible customers had taken advantage of it. The cost to the utility was a levelized $0.032 per kWh saved.[4]

METHODOLOGY

The analysis for each section addresses five key areas that will help determine whether it is worthwhile to proceed further.

1. Who would benefit from each energy-saving action (i.e. who are the target/eligible households)?
2. How many consumers are there in the Yukon who would benefit (market size)?
3. How much would the action cost?
4. What are the effects on consumers of doing the action?
5. What are the effects on the utility?

Following this section is a discussion of issues related to program design.

• Question 1: Target

Answers to the first question rely on published information and literature on energy efficiency. The aim is to identify which Yukon residences would benefit from a specific action, i.e. what is the target for a program or who should be eligible. For each action an indicator or criterion of potential market demand is developed. For example, for refrigerators, literature shows that after substantial energy efficiency improvements in the 1980s and early 1990s, refrigerators have not improved their energy efficiency much since 1994. So our target is refrigerators older than 8 years.

• Question 2: Market size

On the second question, this analysis benefits from using data from two surveys. In 1999 and 2000, Yukon Housing Corporation conducted a series of Community Housing Surveys in most Yukon communities,[5] as well as in most Whitehorse neighbourhoods. The Community Housing Surveys contain data on energy use and costs as well as building structure and envelope. To complement the information available from the Yukon Housing surveys, the Yukon Development Corporation commissioned a survey during the summer of 2001 that asked Yukon households details about their appliances and energy consumption habits. This Residential Residential Energy End Use Survey provides information on the presence and use of a number of electrical and heating appliances.

Indicators of the potential market size were developed for each action. For example, households with refrigerators older than 10 years was used as the indicator of market size for refrigerator replacement. For compact fluorescents, the indicator was the number of households with incandescent lamps in their kitchen. The survey data allows the estimation of the total number of dwellings in diesel and hydro communities who could benefit from the action, based on the market size indicator.

The incentive to replace energy-using hardware differs depending on tenure and incentives and who pays the energy cost. Where the tenant pays the electric bill, there is very little incentive for either the landlord or the tenant to improve energy efficiency by undertaking a major purchase. For the landlord, there are no savings associated with the expense, while it is not usually worth the tenant's while to spend money on improvements that have a pay-back potentially longer than the tenant's length of tenancy. Therefore, different approaches and incentives will have to be considered in designing a program for landlords where the tenant pays the energy bill. Similar considerations apply to co-ops and condominiums.

Consequently, the potential market size is split in three segments: (a) home owners (who pay their own energy bill), (b) rental units, co-op or condo units where the energy cost is paid by the tenant, and (c) rental dwellings where the energy costs are covered by the landlord as part of the rent. Separate calculations are undertaken for each segment.

• Question 3: Costs

The cost of undertaking the action is based on information available from the literature and confirmed by verifying prices with local retailers or suppliers. The total social cost of undertaking the action is also calculated by multiplying the total number of eligible dwellings by the individual costs. Where relevant, disposal costs for the old system/appliance are also included in the estimate.

Program delivery and administration costs are not presented for each action. Presumably, a program design would include a number of eligible actions, while the program administration costs would be fixed, no matter how many actions are undertaken in one dwelling. Program administration costs will depend on program design. If an energy audit and site visit are included, program administration costs could be in the neighbourhood of $200 per dwelling, based on the experience of the House Calls program.

• Question 4: Effects on consumers

Energy cost savings to consumers of undertaking the action are calculated using information available in the literature. Average annual energy cost savings per dwelling, payback period, and the present value of undertaking the action are presented. Only direct benefits to consumers are estimated.

Present value is the standard technique used in evaluating investments whose return will occur over a period of years. It is based on the idea that the alternative to spending money on an investment is to leave it in the bank or to invest it elsewhere. The technique looks at the costs and savings of each action and discounts future savings and costs. A present value calculation estimates what the action is worth in today's dollars, hence the name, present value. Future savings or costs are "discounted" using a discount or interest rate. It should be noted that present value calculations are generally very sensitive to the discount rate selected.

At high discount rates, an investment might have a negative present value (i.e. it is not worth doing) while it would be feasible at a lower discount rate. To avoid the difficulty of selecting an appropriate discount rate, we calculate the "break-even" discount rate. This can be interpreted as the maximum interest rate at which the consumer should borrow money to undertake the action. If the consumer can borrow money at an interest rate lower than the break-even interest rate, then undertaking the action is worthwhile.

The energy cost assumptions used in the analysis are shown in Table 3. Note that "marginal" costs of energy are used, i.e. the energy charge per additional kWh, not the average cost which includes a number of charges that are fixed no matter what the energy consumption is. Note, too, that the general rate is used for rental properties where the landlord pays the electrical bill, while home-owners and tenants pay the residential rate. Thus, cost savings are different depending on who owns the property and who pays the power bill.

Table 3. Electricity cost savings assumptions.

General rate	$ 0.1045 per kWh
Residential rate	$ 0.0986 per kWh

It should be noted that the electricity cost savings assumptions exclude the fuel adjustment rider which varies depending on the cost of diesel fuel to the utility. By reducing diesel fuel use, energy efficiency improvements will result in lower costs to all consumers. In the longer term, reducing diesel consumption will also stabilize electricity rates or forestall increases.

• Question 5: Effects on utility

The effects and net benefits to the utility of energy-saving actions need to be understood. While energy-saving actions will result in a loss of power sales revenue, these will be offset by a wide range of benefits. In diesel communities, reducing energy consumption is a direct and obvious financial benefit to the utility because generation marginal costs are greater than revenues. In both hydro and diesel communities, energy efficiency improvements provide considerable additional benefits. Reduction in residential energy use through energy efficiency upgrading could have following effects:

- deferring need for added generation capacity;
- reducing peak load demand;
- deferring need for equipment maintenance;
- extending life of utility assets;

- obtaining greenhouse gas emission credits; and
- acquiring additional goodwill (Corporate Social Responsibility) by helping meet regional objectives respecting implementation of the Kyoto protocol by Canada.

Also, due to the Yukon's "postage stamp" electrical rates, reducing the costs of utility diesel generation can benefit all Yukon ratepayers.

However, it is beyond the scope of this study to calculate the value of these benefits for each energy-saving action. This study is intended to use survey data to calculate potential Yukon-wide energy savings from individual hardware-related actions, not to develop a comprehensive consumer energy efficiency (demand-side management) plan. This type of analysis would require examining a series of measures or actions as a package and assessing the impact on factors such as generating capacity requirements and peak loads, and evaluating the overall business case for the utility. We believe that this study provides valuable input into the development of this business case.

Reducing residential energy consumption also reduces payments out of the Rate Stabilization Fund (RSF). RSF payments are directly linked to energy use. Consequently, there is an additional social benefit to the utility's ultimate shareholder, the Yukon government.

Direct net annual marginal benefits per kilowatt-hour saved are laid out in Table 4. It should be noted that these exclude the additional benefits of a demand-side management program. The assumptions presented in the table below are used to estimate the effects of each individual action in the rest of this paper. They are not intended to be used in isolation for the purpose of developing demand-side management planning programs. Note that there is a difference in rates charged to rental and home-owner properties, so the impacts are different.

Table 4. Utility revenue, cost and savings assumptions, per kWh.

	Hydro communities	Diesel communities
Marginal revenue assumptions		
General rate per kWh	$ 0.1045	$ 0.1045
Residential rate per kWh	$ 0.0986	$ 0.0986
Marginal cost of production assumption		
Cost per kWh	$ .005	$ 0.1300
Savings on rental properties		
Savings per non-generated kWh	-$0.100	$0.026
RSF saving percentage of energy charge	17.05%	17.05%
RSF saving per kWh saved	$0.018	$0.018
Total saving per kWh saved	**-$0.082**	**$0.043**
Savings on home-owner properties		
Savings per non-generated kWh	-$0.094	$0.031
RSF saving percentage of energy charge	33.8%	33.8%
RSF saving per kWh saved	$0.033	$0.033
Total saving per kWh saved	**-$0.060**	**$0.065**

Note that net benefits differ considerably between hydro and diesel communities. In diesel communities, savings are direct because revenues do not even cover marginal generation costs for the first 1,000 kWh per month. In hydro communities, given that there is currently surplus hydro power at off-peak times, utility savings obtained by reducing energy use appear limited at first glance. It should be recognized that energy conservation programs targeted at individual households in hydro communities have a considerable option value, for example, freeing up hydro capacity for use by potential new utility customers. Accumulated savings from households at peak times provide increased opportunities for comprehensive demand-side management programming.

Knowing the net benefits per kWh for the utility, it is possible to calculate the present value of different subsidies or incentives in an energy use reduction program. However, a discount rate must be selected to calculate the present value. Usually, the discount rate is based on the borrowing costs for an investment, or, alternatively, on the return from a risk-free investment such as Government of Canada long-term bonds.

For this study, however, a rate of 9% is used because this is the maximum allowable return on investment as set by the Yukon Utilities Board. In effect, we are assuming that monies not invested in energy conservation actions would instead be invested in production of power and could theoretically return 9% to the company. This is a very stringent test. Any action that meets the present value test will yield at least a 9% rate of return per year, a very high standard for a return on investment.

An internal rate of return (IRR) calculation is used to estimate the financial implications of different incentives. As the amount of incentive goes up, the IRR goes down. The maximum economic incentive is when the IRR equals zero.

• Program design issues

In addition to the financial calculations, program design issues based on Yukon experience as well as a literature review from other jurisdictions are considered for each potential action. A summary of the main issues and program success factors is presented along with considerations for program design in the Yukon, especially with respect to maximizing program participation or uptake.

2. ACTIONS INVOLVING APPLIANCES

Possible actions are analysed in the sections below for three major appliances — refrigerators, washing machines, and freezers. Clothes dryers are not analysed because their efficiency gains over the 1990s have been relatively modest (less than 200 kWh/year between 1990 and 1999) and those gains have been inconsistent. There was a decrease in efficiency between the 1990 and 1991 model years, followed by steadily improving efficiency till the 1997 model year, and decreasing efficiency between 1997 and 1999. In a similar vein, electric ranges have seen very small efficiency gains — less than 20 kWh/year between 1990 and 1999 — and improvements have been inconsistent. Dishwashers have not been considered because — although there has been a large efficiency gain in these appliances over the past 10 years — we have no data on ownership and use of dishwashers in the Yukon.

REFRIGERATOR REPLACEMENT

• Action

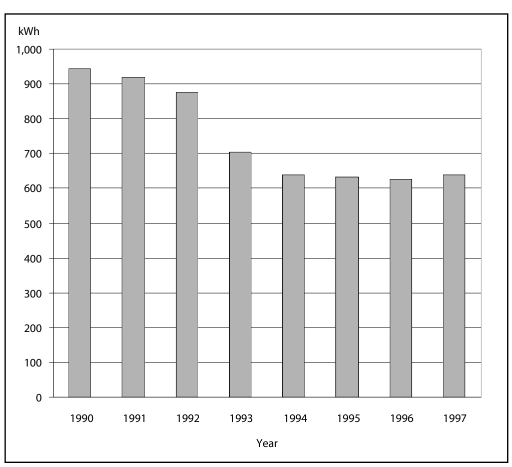
Provide incentives to replace older working refrigerators with new highly energy efficient ones.

• Target

People with newer refrigerators are unlikely to replace them. Newer refrigerators are much more energy efficient than older ones and there is little point in replacing newer refrigerators. As Figure 1 shows, between 1992 and 1993 there was a marked increase in the energy efficiency of refrigerators sold in Canada. Energy consumption in refrigerators has levelled off since 1994. There are very few energy savings gained by replacing refrigerators less than 8 years old.

The Residential Energy End Use Survey offered respondents a range of ages for their main refrigerator. The age ranges were less than 5 years old, 5 to 10 years old, and over 10 years old. For the purpose of this analysis, the indicator of

Figure 1. Average annual energy consumption (kWh) for refrigerators sold in Canada, 1990-1997.



Source: Calculated from "Energy consumption of major household appliances marketed in Canada: Trends for 1990 to 1997," Office of Energy Efficiency, Natural Resources Canada, April 2000, Figures 2.5 and 2.6.1.

market potential in the Yukon for refrigerator replacement is households with refrigerators more than 10 years old.

• Market potential indicators

The Residential Energy End Use Survey showed that there are about 2,600 households in the Yukon whose main kitchen refrigerator is older than 10 years. About 1,900 of those are homeowners and about another 120 are in households where the landlord pays the electric bill.

Table 5 shows the number of households in diesel and hydro power communities with refrigerators older than 10 years.

Table 5. Distribution of total number of households with refrigerators >10 years old by tenure and type of community.

	No. of dwellings		
	Hydro communities	**Diesel communities**	**All communities**
Rental dwellings: electric bill payer			
Tenant	386	125	511
Landlord/co-op/condo	105	11	116
Combined self/landlord	0	4	4
Homeowners	1,679	228	1,907
Total dwellings	**2,170**	**368**	**2,538**

• Costs

New energy-efficient refrigerators cost between $800 and $2,500. We assume an average of about $1,000 each. In addition, the costs for freight and delivery of new fridges and removal and decommissioning of old refrigerators are estimated at approximately $200 in hydro communities and could be up to $500 in more remote diesel communities.

The total cost of replacing all refrigerators in the Yukon over ten years old with newer energy efficient models plus removal and decommission all old fridges to ensure that they would not remain in service, would be in the range of $3 million.

• Effects on consumers

Table 6 shows predicted annual energy and cost savings of replacing an old refrigerator with a new refrigerator, as well as the total savings that could be anticipated if all old refrigerators were replaced.

In the most common fridge type and size, 16.5 to 18.4 cubic feet with a top freezer, energy consumption was about 1,000 kWh per year in the early 1990s and before.[6] Similar energy efficient refrigerators (ENERGY STAR®) for sale in 2001 consume between 480 and 554 kWh per year.[7] The calculations assume an average savings of about 500 kWh when replacing an old refrigerator.

Refrigerators have a 17-year average life expectancy. Therefore, refrigerators more than 10 years old can be assumed to have an average of 5 years of life expectancy

Table 6. Refrigerator replacement: Annual savings per dwelling and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per household			
Average annual energy savings	500 kWh	500 kWh	
Average annual dollar savings	$49.30	$49.30	
Total annual savings for all households			
Tenant	$19,030	$6,163	$25,192
Landlord/co-op/condo	$5,177	$784	$5,960
Homeowner	$82,775	$11,240	$94,015
Total dwellings	**$106,981**	**$18,187**	**$125,168**

remaining. On that basis, the pay-back from buying a new fridge now is $250 over the next five years. However, the households would have to advance their new fridge purchase by an average of five years.

In present value terms, there is very little difference between purchasing now or five years from now. Replacing old refrigerators is worth doing in terms of energy savings if the discount rate is 4.5% per year or less. This means that the action is worthwhile for the consumer if the interest cost is less than 4.5%. So if consumers can borrow at less than 4.5% or if their savings get less than a 4.5% return, it is worth buying a new energy efficient fridge now rather than waiting for five years.

• Effects on utility

Table 7 presents annual net direct benefits to the utility from replacing old refrigerators in diesel communities. This is based on the assumptions specified in the section, Effects on utility, page 5.

Table 7. Refrigerator replacement: Annual savings to utility in diesel communities.

	Diesel communities
Average annual energy savings per household	500 kWh
Total net savings per rental household	$21.659
Total net saving per home-owner household	$32.363
Total net utility savings on rental properties	$3,032
Total net utility savings on home-owner properties	$7,379
Total utility savings	**$10,411**

Net benefits in diesel communities are about $32.36 per refrigerator and total utility savings could amount to as much as $10,000 per year if all older refrigerators were replaced.

The savings in diesel communities could allow an incentive of up to a maximum of $141.50 per refrigerator replacement. At that point the internal rate of return is 0%. This amount is calculated on an average remaining life of 5 years for existing refrigerators greater than 10 years old. Of course this amount would not include program delivery and administration costs. Table 8 presents payback period as well as internal rates of return for different incentive amounts.

Table 8. Refrigerator replacement: Pay-back period and internal rate of return to utility in diesel communities.

Incentive per refrigerator	Pay-back period to utility (years)	Internal rate of return
$ 50	1.8	48.8%
$ 100	3.5	12.8%
$ 125	4.4	4.3%
$ 141.50	5.0	0.0%
$ 150	5.3	-1.9%
$ 175	6.2	-6.7%
$ 200	7.1	-10.5%
$ 250	8.8	-16.4%
$ 300	10.6	-20.8%

Note that the rate used to discount the flow of future benefits to the utility is 9% (see section, Effects on utility, page 5).

• Program design issues

There are several examples of residential refrigerator replacement programs operated by utilities in North America that have had varying levels of success. Some programs have simply offered a rebate on the purchase of an efficient new refrigerator without the requirement to remove an old, inefficient appliance from use. For these programs, the critical factor governing success appears to be the choice of eligibility level, i.e. how efficient the new model must be to qualify. If the eligibility level is set too low, the program tends to have high gross participation rates but also very high free rider (those who would have replaced their fridges without the rebate) rates, and low energy savings per rebate (due to the new appliances being only slightly more efficient than the old).[8]

A major refrigerator rebate experiment was conducted by the New York State Electric and Gas utility in 1985 and 1986. The rebate was limited to purchasers of the most efficient 25% category of models offered by industry. Different rebate and marketing strategies were tried in different areas. Participation rates — *here defined as the percentage of new refrigerator purchases during the program period that were in the efficient category* — ranged from 15% to 60%. The 15% area was the control where there were no rebates offered and no advertising done. Where there was information and advertising done but no rebate offered, 35% of new refrigerators purchased were efficient. Where advertising and a $35 cash rebate were offered, the rate jumped to 49%, and where a $50 rebate was offered with advertising and information, the rate hit 60%.[9]

A slightly different type of refrigerator replacement program was offered by BC Hydro in the Lower Mainland in the early 1990s. Part of the incentive was that the utility would remove and dispose of the old refrigerator. The rebate began at $50 per fridge but was reduced to $30 in the second year of the program. Rebates were only offered on those new fridges that met or exceeded the new efficiency standards that the utility was promoting. An evaluation done after three years showed the replacement of 40,077 fridges at a cost to the utility of $6.2m. This works out to approximately $155 per fridge. Participation rates —

again measured as the percentage of new fridges purchased that met the standard — were as high as 80%. However, the utility estimated that 21% of participants were free riders.[10] It is likely that part of the incentive for participants was the utility's commitment to dispose of the old fridge, a fairly difficult and expensive business in Vancouver and the Lower Mainland.

The four key factors for a successful refrigerator rebate program according to Nadel et al. are:

1. the active involvement of appliance dealers in the program,
2. a consumer information program to encourage buyers to seek out efficient fridges,
3. high eligibility levels to keep free rider proportions low, and
4. significant financial incentives.[11]

The savings from promoting efficient refrigerators have varied widely among the various programs depending on the efficiencies gained and the cost of the program. Energy savings have ranged from 0 to 10% per unit across a range of programs. The cost of the saved energy also varies widely, from a low of $0.01/kWh in BC Hydro's program (because the lack of minimum efficiency standards at the time meant there was ample room for improvement) up to $0.068/kWh for a very expensive effort in California.[12]

WASHING MACHINE REPLACEMENT

• Action

This action provides incentives to replace older washing machines with new, highly energy efficient ones.

• Target

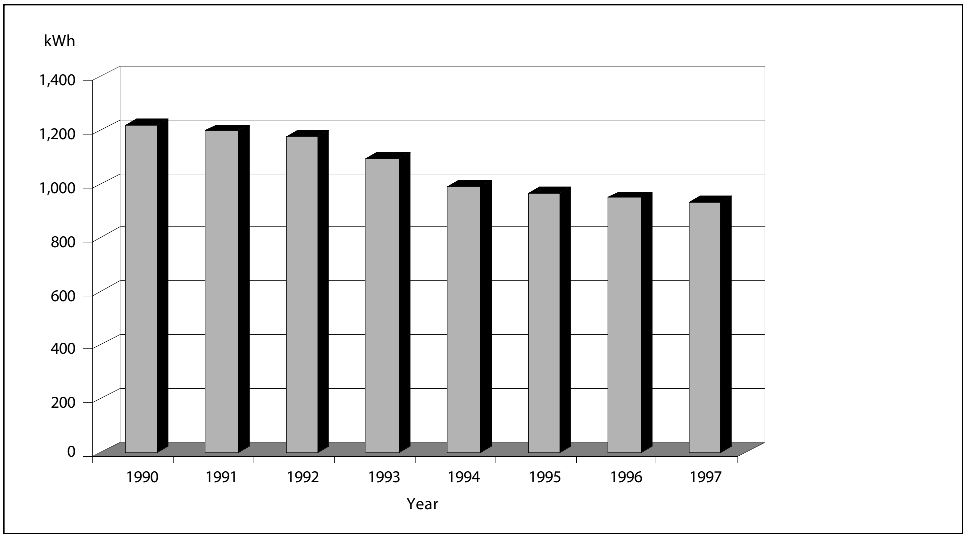
Newer washing machines are much more energy efficient than older ones. As Figure 2 shows, there has been a marked increase in the energy efficiency of washing machines sold in Canada. Unlike refrigerators, however, the average energy consumption of washing machines did not level off in the mid 1990s. Rather, efficiency has continued to improve.

It should be noted that the energy consumption of washing machines includes the energy needed to heat water for warm and hot washes. The Office of Energy Efficiency bases its figures on an assumed use of 392 "Normal Cycles" per year but does not specify how many of those cycles use hot, warm, or cold water.

The Residential Energy End Use Survey of Yukon households offered respondents several age categories for their washing machine. The age categories were: less than 1 year old, 1 to 5 years, 5 to 10 years old, 10 to 20 years, and over 20 years old. As Figure 2 shows, there was a marked increase in the energy efficiency of washing machines between 1992 and 1994. To take advantage of this leap in energy efficiency, this analysis uses households with washing machines more than 10 years old as one indicator of market potential for washing machine replacement in the Yukon. But because efficiency has continued to improve — efficient front-loading washing machines, even large ones, now consume less than 300 kWh per year on average — this analysis will also examine the possibility of using machines older than 5 years as an indicator of market potential.

Figure 2. Average annual energy consumption (kWh) of washing machines sold in Canada, 1990 to 1997.

Source: Calculated from "Energy consumption of major household appliances marketed in Canada: Trends for 1990 to 1997," Office of Energy Efficiency, Natural Resources Canada, April 2000, Figure 4.1.



• Market potential indicators

Estimates based on the Residential Energy End Use Survey show that there are about 3,700 households in the Yukon whose washing machine is older than 10 years. About 2,000 of these are rental dwellings where the tenant pays the power bill. About 1,700 are homeowners and a handful of washers are in households where the landlord pays the electric bill.

Table 9 shows the number of households in diesel and hydro communities — broken out by tenure — with washing machines older than 10 years.

Table 9. Distribution of total number of households with washing machines >10 years old by tenure and type of community.

	No. of dwellings		
	Hydro communities	Diesel communities	All communities
Rental dwellings: electric bill payer			
Tenant	1,793	241	2,034
Landlord/co-op/condo	0	16	16
Combined self/landlord	0	0	0
Homeowners	1,557	155	1,712
Total dwellings	**3,350**	**412**	**3,762**

There are approximately 8,500 households in the Yukon with washing machines older than 5 years (including the 3,700 older than 10 years). Table 10 shows the distribution of households with washing machines greater than 5 years old.

Table 10.Distribution of total number of households with washing machines >5 years old by tenure and type of community.

	No. of dwellings		
	Hydro communities	Diesel communities	All communities
Rental dwellings: electric bill payer			
Tenant	4,028	481	4,509
Landlord/co-op/condo	24	81	105
Combined self/landlord	0	0	0
Homeowners	3,546	349	3,895
Total dwellings	**7,598**	**911**	**8,509**

• Costs

A new front-loading energy-efficient washing machine retails for approximately $1,500 in Whitehorse. It is assumed that there will be no significant disposal costs for washing machines.

The total estimated cost of replacing all washing machines in the Yukon over ten years old with newer energy efficient models would be in the range of $5.6 million. To replace all machines older than 5 years would cost approximately $12.8 million. These estimates are based on the Residential Energy End Use Survey.

• **Effects on consumers:** >10 year old washing machine replacement

Table 11 shows predicted annual energy and cost savings of replacing washing machines older than 10 years with new washing machines, as well as the total savings that could be anticipated if all machines older than 10 years were replaced.

Table 11. Washing machine replacement >10 years old: Annual savings per dwelling and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per household			
Average annual energy savings	800 kWh	800 kWh	
Average annual dollar savings	$78.88	$78.88	
Total annual savings for all households			
Tenant	$141,432	$19,010	$160,442
Landlord/co-op/condo	$0	$1,338	$1,338
Homeowner	$122,816	$12,226	$135,043
Total dwellings	**$264,248**	**$32,574**	**$296,823**

In the most common washing machine type and size — top-loading with a 75 to 85 litre capacity — average energy consumption was about 1,100 kWh per year in the early 1990s model years.[13] Front-loading energy efficient washing machines (ENERGY STAR®) for sale in 2001-2002 consume between 259 and 362 kWh per year with many machines in the 80 litre range consuming around 300 kWh per year.[14] The calculations therefore assume an average savings of 800 kWh per year when replacing a 10-year-old washing machine.

The life expectancy of a typical washing machine is 14 years.[15] For this analysis, washing machines more than 10 years old are assumed to have an average of 3 years remaining life expectancy. On that basis, the payback in energy savings (using $.10/kWh) from buying a new washing machine now is approximately $240 over the next three years. However, the households would have to advance their new washing machine purchase by an average of three years.

In present value terms, there is little incentive for a consumer to purchase now rather than three years from now. Replacing an 11-year old washing machine becomes worthwhile in terms of energy savings if the interest cost (discount rate) is 3.5% per year or less. Specifically, if the consumer can borrow at less than 3.5% or if their savings get less than a 3.5% return, it is financially advantageous to buy a new energy efficient washing machine now, rather than waiting for three years.

For consumers paying for water delivery, particularly with rising delivery costs, the reduction in water costs for a front loading washer significantly improves the economics of replacement.

• **Effects on consumers:** >5 year old washing machine replacement

Washing machines in the mid-to-late 1990s model years used approximately 900 kWh of energy per year. As noted above, current efficient machines use approximately 300 kWh of energy annually. Replacing a 5-year-old machine would therefore result in savings of 600 kWh per year. For the purpose of this analysis, however, approximately 45% of washing machines older than 5 years are actually older than 10 years. Therefore we estimate that the average energy savings in replacing machines older than 5 years will be 700 kWh per year.

Table 12. Washing machine replacement >5 years old: Annual savings per dwelling and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	**Diesel communities**	**All communities**
Savings per household			
Average annual energy savings	700 kWh	700 kWh	
Average annual dollar savings	$69.02	$69.02	
Total annual savings for all households			
Tenant	$281,960	$33,670	$315,630
Landlord/co-op/condo	$1,680	$5,670	$7,350
Homeowner	$248,220	$24,430	$272,650
Total dwellings	**$531,860**	**$63,770**	**$595,630**

For the >5 years category we are estimating that the average remaining life of the machines being replaced is 6 years. Thus the consumer will reap the benefit of reduced energy use for an average of 6 years but must also advance the purchase of the washing machine by an average of 6 years.

In present value terms there is very little incentive for consumers to replace an 8-year-old washing machine which has 6 years of life remaining in it. From the consumer's perspective, replacing an 8-year-old washing machine only becomes worthwhile in terms of energy savings if the interest cost (discount rate) is 3.0% per year or less. Specifically, if the consumer can borrow at less than 3.0% or if their savings get less than a 3.0% return, it is financially advantageous to buy a new energy efficient washing machine now, rather than waiting for six years.

Table 13. Washing machine replacement >10 years old: annual savings to utility in diesel communities.

	Diesel communities
Total net savings per rental household	$34.65
Total net saving per home-owner household	$51.78
Total net utility savings on rental properties	$8,906
Total net utility savings on home-owner properties	$8,026
Total utility savings	**$16,932**

• **Effects on utility:** >10 year old washing machine replacement

Table 13 presents annual net direct benefits to the utility from replacing washing machines older than 10 years in diesel communities. These are based on the assumptions discussed in the section, Effects on utility, page 5.

Net benefits of this action in diesel communities are about $41.26 per washing machine and could amount to savings in the order of $17,000 per year if all older washing machines were replaced.

The savings in diesel communities would allow for an incentive up to a maximum of $200 per washing machine replacement in those communities, at which point the internal rate of return approaches 0%. The payback period will be approximately 5 years. This is calculated on an average remaining life of 3 years for existing washing machines more than 10 years old. This amount does not include program delivery and administration costs. Table 14 presents the payback periods as well as internal rates of return for different incentive amounts for a program directed at diesel communities only.

Table 14. Washing machine >10 years replacement in diesel communities: Payback period and internal rate of return to utility.

Incentive per washing machine	Pay-back period to utility (years)	Internal rate of return
$50	1.2	77.5%
$100	2.4	30.0%
$125	3.0	19.2%
$150	3.6	11.5%
$175	4.3	5.6%
$200	4.9	0.9%
$250	6.1	-6.2%
$300	7.3	-11.4%

• **Effects on utility:** >5 year old washing machine replacement

Table 15 presents annual direct net benefits to the utility from replacing washing machines older than 5 years in diesel communities. As in the section above looking at the >10 year category, this is based on the assumptions specified in the section, Effects on utility, page 5.

Net benefits of this action in diesel communities are about $36 per washing machine and could amount to savings in the order of $33,000 per year if all washing machines older than 5 years were replaced.

Table 15. Washing machine replacement >5 years old: annual savings to utility in diesel communities.

	Diesel communities
Total net savings per rental household	$30.32
Total net saving per home-owner household	$45.31
Total net utility savings on rental properties	$17,041
Total net utility savings on home-owner properties	$15,813
Total utility savings	**$32,854**

Table 16. Washing machine >5 years replacement in diesel communities: Payback period and internal rate of return to utility.

Incentive per washing machine	Pay-back period to utility (years)	Internal rate of return
$50	1.4	66.5%
$100	2.8	23.5%
$125	3.5	13.6%
$150	4.2	6.5%
$180	5.0	0.1%
$200	5.5	-3.4%
$250	6.9	-10.0%
$300	8.3	-14.9%

The savings in diesel communities would allow for an incentive up to a maximum of $180 per washing machine replacement in those communities, at which point the internal rate of return approaches 0%. The payback period will be approximately 5 years. This is calculated on an average remaining life of 6 years for existing washing machines more than 5 years old. This amount does not include program delivery and administration costs. Table 16 presents the payback periods as well as internal rates of return for different incentive amounts for a program directed at diesel communities only.

• Program design issues

Developing a program around washer replacement offers many potential promotional opportunities. In addition to reduced operating costs of the new energy efficient (ENERGY STAR®) washers, front-loading machines use only one third to one half as much water as their top-loading counterparts, resulting in significant hot water savings. They also spin clothes dryer than top-loading machines, thereby reducing dryer time.

There is also good potential for marketing a washing machine replacement program for residences on water delivery, a fairly common situation for homes not serviced by the local municipality. At present, Yukon municipalities do not charge customers based on metered water use. If this practice changes, residents will have greater interest in the reduced water usage of front-loading clothes washers.

Delivering a washer replacement program in partnership with the municipality could be explored as well, since as a result of reduced overall water use, additional savings to the municipality in terms of preheating winter supply water could be calculated.

FREEZER REPLACEMENT

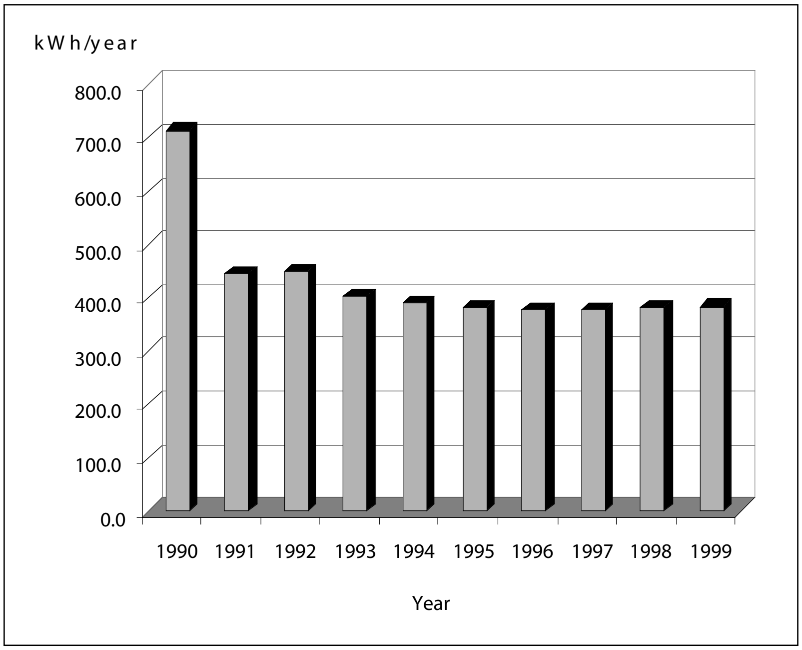
• Action

This action provides incentives to replace older freezers with new, highly energy efficient ones.

• Target

Newer freezers are much more energy efficient than older ones. As Figure 3 shows, there has been a marked increase in the energy efficiency of freezers sold in Canada between 1990 and 1999. But nearly 75% of the efficiency gain over the decade happened between the 1990 and 1991 model years.

Figure 3. Average annual energy consumption (kWh) of freezers sold in Canada, weighted by market share of type: 1990 to 1999[16].



The Residential Energy End Use Survey of Yukon households offered respondents several age categories for their freezers. The age categories were: less than 1 year old, 1 to 5 years, 5 to 10 years old, 10 to 20 years, and over 20 years old. Households were also asked how many freezers they had and whether they were chest or upright style.

To take advantage of the leap in energy efficiency between 1990 and 1991, this analysis uses the number of freezers more than 10 years old as the indicator of market potential for freezer replacement in the Yukon. The number of freezers, rather than the number of households, is used because a significant percentage of households report that they have more than one working freezer. (Approximately 8.5% of households have two freezers and about 1% have three freezers.)

• Market potential indicators

The Residential Energy End Use Survey showed that there are approximately 3,342 freezers older than 10 years in the Yukon. Of these, approximately 320 are upright models which are less efficient than chest models.

Table 17 shows the number of freezers older than 10 years in diesel and hydro power communities, distributed by tenure.

Table 17. Distribution of total number of freezers >10 years old by tenure and type of community electricity generation.

	No. of freezers		
	Hydro communities	Diesel communities	All communities
Rental dwellings: electric bill payer			
Tenant	139	100	239
Landlord/co-op/condo	81	41	130
Combined self/landlord	0	0	0
Homeowners	2,638	335	2,973
Total freezers	**2,858**	**476**	**3,342**

• Costs

The Office of Energy Efficiency recommends that households have approximately 4.5 cubic feet of freezer space per person. Because many Yukoners freeze large amounts of game and fish, however, we are using the 13 to 15 cubic foot size range for this analysis.

New, energy-efficient, 15 cubic foot chest freezers retail for approximately $550 in Whitehorse. In addition, the costs for freight and delivery of new freezers and removal of old freezers are estimated at approximately $150 in hydro communities and could be up to $300 in more remote diesel communities.

The total cost of replacing all freezers in the Yukon over ten years old with newer energy efficient models, plus removal and decommission all old freezers to ensure that they would not remain in service, would be in the range of $2.4 million.

• Effects on consumers

Table 18 shows predicted annual energy and cost savings of replacing old freezers with new models, as well as the total savings that could be anticipated if all old freezers were replaced.

A 1990 model year chest freezer has an annual energy consumption of 658 kWh (averaged across all sizes). The 1990 average upright freezer consumes 992 kWh (again averaged across all sizes). Weighing the proportion of older upright to chest freezers in the Yukon, we estimate that the average older freezer consumes 692 kWh.

A new — 2001 model year — 15 cubic foot chest freezer consumes 437 kWh. A new 15 cubic foot upright consumes 509 kWh. As upright freezers have steadily closed the efficiency gap with chest freezers they have also become popular, increasing their market share from under 17% in 1990 to about 23% by 1999. For this analysis, we will assume that 25% of the replacement freezers will be upright models, which will result in an average consumption of 455 kWh for the replacement freezers. This means an average energy savings of 237 kWh per freezer.

Table 18. Freezer replacement: Annual savings per freezer and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	**Diesel communities**	**All communities**
Savings per household			
Average annual energy savings	237 kWh	237 kWh	
Average annual dollar savings	$23.37	$23.37	
Total annual savings for all households			
Tenant	$3,248	$2,337	$5,585
Landlord/co-op/condo	$2,080	$1,015	$3,095
Homeowner	$61,645	$7,828	$69,474
Total dwellings	**$66,973**	**$11,181**	**$78,154**

Freezers have a 21-year average life expectancy. Therefore, freezers more than 10 years old can be assumed to have an average of 8 years of life expectancy remaining. On that basis, the pay-back from buying a new freezer now is about $200 over the next eight years. However, the households would have to advance their new freezer purchase by an average of eight years.

In present value terms, there is a difference between purchasing now or 8 years from now. Replacing an old freezer becomes worth doing in terms of energy savings if the discount rate is 3% per year or more. This means that the action is worthwhile for the consumer if the interest cost is less than 3%. So if consumers can borrow at less than 3% or if their savings get less than a 3% return, it is worth buying a new energy efficient freezer now rather than waiting for 8 years.

• Effects on utility

Table 19 presents annual net direct benefits to the utility from replacing old freezers in diesel communities. This is based on the assumptions specified in the section, Effects on utility, page 5.

Table 19. Freezer replacement: Annual savings to utility in diesel communities.

	Diesel communities
Average annual energy savings per household	237 kWh
Total net savings per rental household	$10.27
Total net saving per home-owner household	$15.34
Total net utility savings on rental properties	$1,448
Total net utility savings on home-owner properties	$5,139
Total utility savings	**$6,587**

Net benefits in diesel communities are about $12.50 per freezer and could amount to as much as $6,500 per year if all older freezers were replaced.

The savings in diesel communities could allow an incentive of up to a maximum of about $70 per freezer replacement in those communities. At that point the internal rate of return approaches 0%. This amount is calculated on an average remaining life of 8 years for existing freezers more than 10 years old. This amount does not include program delivery and administration costs. Table 20 presents payback period as well as internal rate of return for different incentive amounts.

Note that the rate used to discount the flow of future benefits to the utility is 9% (see the section, Effects on utility, page 5).

Table 20. Freezer replacement: Pay-back period and internal rate of return to utility.

Incentive per freezer	Pay-back period to utility (years)	Internal rate of return
$ 50	3.6	11.9%
$ 60	4.3	4.9%
$ 70	5.1	-0.4%
$ 80	5.8	-4.7%
$ 100	7.2	-11.1%

• Program design issues

Given the assumptions used, the overall financial benefits of freezer replacement are small. A freezer replacement program would require an imaginative marketing approach as opposed to direct incentives. The margin of difference in energy performance is negligible between any new freezer and an ENERGY STAR® labelled freezer, while the cost of the ENERGY STAR® labelled freezers are often considerably higher. In this case, emphasizing the benefits of energy efficiency and encouraging the search for ENERGY STAR® could help with market transformation, despite the fact that the ENERGY STAR® payback advantage does not apply to freezers.

3. ACTIONS INVOLVING LIGHTING

Possible actions analysed in the sections below are the installation of energy efficient fixtures (i.e. replacing incandescent with fluorescent fixtures in kitchens) and the replacement of inefficient bulbs with efficient compact fluorescents. The installation of exterior motion sensors to control outside lights was also considered but not analysed due to the lack of data on the use of outside lights (e.g. continuously on or switched on as needed etc.). Without a reasonable estimate on the possible energy savings, the analysis would not be meaningful.

REPLACING INEFFICIENT BULBS WITH EFFICIENT COMPACT FLUORESCENTS

• Action

This action provides incentives for replacing inefficient incandescent bulbs with efficient compact fluorescents.

• Target

Fluorescent lights are approximately three times more efficient than incandescents.[17] Replacing two 60 watt incandescent bulbs with 20 watt compact fluorescent bulbs will save 88 kWh per year (while producing the same amount of light) assuming both fixtures are on for 3 hours per day.

• Market potential indicators

Table 21 shows the distribution of Yukon households with kitchen incandescent fixtures by community type and housing tenure.

Table 21. Distribution of kitchen incandescent fixtures and bulbs by tenure and type of community .

	Hydro community		Diesel community		Total	
Electrical bill payer	**No. of households**	**No. of light bulbs**	**No. of households**	**No. of light bulbs**	**No. of households**	**No. of light bulbs**
Tenant	1,713	3,567	605	1,455	2,318	5,022
Landlord/co-op	717	1,030	100	306	817	1,336
Tenant/landlord	24	48	4	28	28	76
Homeowner	6,791	18,120	801	1,903	7,592	20,023
Total	**9,245**	**22,765**	**1,510**	**3,692**	**10,755**	**26,457**

The Residential Energy End Use Survey of Yukon households found approximately 10,750 Yukon households had incandescent fixtures in the kitchen which used about 26,500 light bulbs. The distribution of these kitchen incandescents is shown in Table 21.

From Table 21 it can be seen that the average household has approximately 2.5 incandescent bulbs in its kitchen. For this analysis we will assume that there is a potential to replace one kitchen fixture in each of these households and that that fixture contains two 60 watt incandescent bulbs.

• Costs

Twenty watt compact fluorescent light bulbs retail for approximately $20 in Whitehorse. Replacing 21,500 light bulbs in the Yukon would therefore cost approximately $430,000.

• Effects on consumers

The benefits to consumers come from the energy savings from the new fixtures as shown in Table 22.

Table 22. Light bulb replacement: Annual savings per household and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per household (2 bulbs)			
Average annual energy savings	88 kWh	88 kWh	
Average annual dollar savings	$8.68	$8.68	
Total annual savings for all households			
Tenant	$14,863	$5,249	$20,113
Landlord/co-op/condo	$6,430	$956	$7,386
Homeowner	$58,924	$6,950	$65,874
Total dwellings	**$80,217**	**$13,156**	**$93,373**

The payback period for consumers is just under 4.5 years. In net present value terms, replacing the two 60 watt incandescents with compact fluorescents is worth doing provided future costs are not discounted more than 25%. It should be noted that the longer a light bulb is on, the greater the benefit. Conversely, a bulb that is on for only 1 hour per day on average would mean a payback period of over 13 years.

• Effects on utilities

Table 23 shows the savings to utilities of replacing two 60 watt incandescent light bulbs with 20 watt compact fluorescent bulbs in diesel community kitchens. In diesel communities, total annual savings of approximately $7,200 are possible if all households replace 2 light bulbs.

Table 23. Light bulb replacement: Annual savings to utilities in diesel communities.

	Diesel communities
Average annual energy savings per household	88 kWh
Total net savings per rental household	$3.81
Total net saving per home-owner household	$5.70
Total net utility savings on rental properties	$2,703
Total net utility savings on home-owner properties	$4,562
Total utility savings	**$7,265**

Table 24 shows that the utility could offer an incentive of up to $24 per household in diesel communities to replace two 60 watt incandescent bulbs with 20 watt compact fluorescents before the internal rate of return approaches zero.

Table 24. Light bulb replacement in diesel communities: Pay-back period and internal rate of return to utility.

Incentive per household	Pay-back period to utility (years)	Internal rate of return
$ 5	1.0	92.6%
$ 10	2.1	38.8%
$ 15	3.1	18.1%
$ 20	4.2	6.5%
$ 24	5.0	0.1%
$ 30	6.2	-6.9%

Note that the rate used to discount the flow of future benefits to the utility is 9% (see the section, Effects on utility, page 5).

• Program design issues

A light bulb replacement program will be most effective if it helps replace lights that are on for at least several hours per day. In net present value terms, it is not worth replacing a bulb that burns for one hour per day or less.

Generally speaking, light bulbs are considerably more “disposable” than other items discussed in this paper, and therefore the capital cost is much lower. The promotional value of distributing compact fluorescent light bulbs is high, in the sense that compared to large appliances, it could be relatively inexpensive to reach a wide audience.

A light bulb replacement project on its own is probably not worth the effort, but in combination with other promotional products and practices, it can become part of a broader promotion, as was the experience with the House Calls 2000 project. In the House Calls project, each household was given a hot water blanket, a low-flow showerhead and a compact fluorescent light bulb. The overall program savings from this initiative were significant.

INSTALLING ENERGY EFFICIENT FIXTURES

• Action

This action provides incentives for replacing incandescent light fixtures with fluorescent fixtures in kitchens only. It is considered unlikely that people will place fluorescent fixtures in living rooms or bedrooms, for example, no matter what the incentive offered.

• Target

Fluorescent lights are approximately four times more efficient than incandescents.[18] Replacing a fixture with two 60 watt incandescent bulbs with a fluorescent fixture producing the same amount of light will save 99 kWh per year assuming both fixtures are on for 3 hours per day.

• Market potential indicators

The potential market for this action is the same as for the replacement of fixtures in the previous section, Replacing inefficient bulbs with efficient compact fluorescents, page 22. The Residential Energy End Use Survey of Yukon households found approximately 10,750 Yukon households had incandescent fixtures in the kitchen which used about 26,500 light bulbs.

• Costs

A standard fluorescent fixture retails for approximately $50 in Whitehorse. With the additional costs of installation, we assume that the total cost to change out an incandescent fixture will be $100.

The total cost of replacing one fixture in every Yukon kitchen that has one will approach $1.1m.

• Effects on consumers

The benefits to consumers come from the energy savings from the new fixtures as shown in Table 25.

Table 25. Lighting fixture replacement: Annual savings per fixture and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per household			
Average annual energy savings	99 kWh	99 kWh	
Average annual dollar savings	$9.76	$9.76	
Total annual savings for all households			
Tenant	$16,721	$5,905	$22,627
Landlord/co-op/condo	$7,233	$1,076	$8,309
Homeowner	$66,290	$7,819	$74,109
Total dwellings	**$90,244**	**$14,800**	**$105,045**

We assume that it will cost $100 to change the fixture. Additional assumptions include a much longer bulb life for the fluorescent tube (1,250 hours per incandescent versus 15,000 for a fluorescent),[19] but a $4 per bulb replacement cost (for full spectrum lighting) versus $0.50 per incandescent. Given these assumptions, the consumer's payback period for this action is in excess of 10 years.

While the payback period is very long, the net present value of replacing fixtures remains positive over a 20+ year time horizon until future costs are discounted at 8.5% or more. (Because so much of the increased cost of continuing to use incandescents is spread out over all future years, the more those future costs are discounted the less attractive changing them appears).

• Effects on utility

Table 26 shows that the action of replacing incandescent fixtures with fluorescent fixtures could produce savings of up to $8,100 annually if all diesel community households changed one fixture.

Table 26. Fixture replacement: Annual savings to utilities in diesel communities.

	Diesel communities
Average annual energy savings per household	99 kWh
Total net savings per rental household	$4.29
Total net saving per home-owner household	$6.41
Total net utility savings on rental properties	$3,040
Total net utility savings on home-owner properties	$5,133
Total utility savings	**$8,173**

Table 27 shows that the utility could offer incentives of up to $27 per incandescent fixture replaced in diesel communities before the internal rate of return approaches zero. This does not include any program administration or delivery costs.

Table 27. Fixture replacement in diesel communities: Pay-back period and internal rate of return to utility.

Incentive per household	Pay-back period to utility (years)	Internal rate of return
$ 10	1.8	46.0%
$ 20	3.7	11.0%
$ 27	5.0	0.1%
$ 40	7.4	-11.8%
$ 50	9.2	-17.5%

Note that the rate used to discount the flow of future benefits to the utility is 9% (see section, Effects on utility, page 5).

• Program design issues

This action appears to be of dubious value given the small amount of utility savings available, and the likely difficulties in persuading people to change their fixtures. Many people regard fluorescent lights as cold and institutional and don’t want them in their homes. With a $27 incentive, the consumer’s payback period for changing one fixture is more than 7 years. As the section, Replacing inefficient bulbs with efficient compact fluorescents, page 26 shows, replacing bulbs rather than the full fixture is a better alternative.

4. ACTIONS INVOLVING DOMESTIC HOT WATER

The energy used to produce domestic hot water consists of a very large part of residential energy use. This section reviews the costs and benefits of installing low-flow showerheads. Installation of hot water tank blankets was considered but the benefits are not evident. It has been argued that hot water tank insulation blankets provide very little additional energy savings. Insulating hot water pipes was also considered as a possible action but lack of data made accurate calculations of costs and benefits difficult.

INSTALLING LOW-FLOW SHOWERHEADS

• Action

Provide incentives to replace conventional full-flow and older low-flow showerheads with new low-flow showerheads.

• Target

In the past, low-flow showerheads had a bad reputation and many people went back to conventional showerheads.

The Residential Energy End Use Survey asked respondents whether they had a low-flow showerhead, how old it was and how many showers their household took per week, to aid in calculating the potential savings. For the purpose of this analysis, the indicator of market potential in the Yukon for low-flow showerheads is people who take at least one shower a week and either do not have a low-flow showerhead or whose showerhead is more than 10 years old. Respondents who did not know the age of their showerhead or whether they had a low-flow showerhead were excluded from the analysis.

• Market potential indicators

The Residential Energy End Use Survey showed that there are about 2,800 households in the Yukon who know that they have a conventional showerhead. About 1,900 of those are homeowners and about another 260 are in households where the landlord pays the electric bill. In addition, another 700 households have low-flow showerheads that are 10 years old and more. Note that the 740 households who did not know what type of showerhead they had are excluded from the analysis, as are the 425 households who stated they did not take showers.

Table 28 shows the number of households in diesel and hydro power communities with conventional showerheads and low-flow showerheads older than 10 years.

Table 28. Distribution of total number of households with conventional or low-flow shower 10 years or older.

	No. of dwellings		
	Hydro communities	Diesel communities	All communities
Rental dwellings: electric bill payer			
Tenant	663	176	839
Landlord/co-op/condo	375	41	416
Homeowners	2,118	253	2,371
Total dwellings	**3,156**	**470**	**3,626**

• Costs

New low-flow showerheads can be obtained for less than $10. Sophisticated units with different massage settings are in the $30-$50 range.

The total cost of replacing all conventional showerheads and older low-flow showerheads in the Yukon would be about $50,000 (assuming an average cost of $15).

• Effects on consumers

Low-flow showerheads save considerable energy by reducing the amount of hot water needed to take a shower. BC Hydro estimates savings of about $175 per year for a family of three taking about a thousand showers a year. These numbers are based on conventional showerheads having a flow of 19 litres per minute and low-flow showerheads having a flow of 10 litres per minute, giving a net saving of 9 litres per minute. However, measurements done by Energy Solutions Centre staff showed that conventional or older showerheads' flow averaged 5 litres/minute, while good quality low-flow showerheads averaged 2.5 litres/minute, giving a savings of 2.5 litres/minute in hot water.

Nevertheless, savings are considerable and higher in the Yukon for two reasons. First, the calculated BC savings are based on electricity rates of $0.0575 per kWh rather than the $0.0986 per kWh that Yukoners pay. Secondly, the change in temperature is greater in the Yukon because water is delivered at a considerably lower temperature. In BC, the temperature change (ΔT) was assumed to be 33 degrees Celsius. In the Yukon, a ΔT of 38°C is to be expected in raising a typical cold water temperature of 4°C to a low hot water temperature of 42°C (108°F).

Based on these cost and temperature assumptions, even a single person taking three ten-minute showers a week would save about $17 per year, more than recouping the cost of a low-flow shower-head. Table 29 shows the savings to be obtained by different sized households taking different numbers of showers a week.

Table 29. Energy savings from low-flow showerheads, by number of people and frequency of showering.

Showers/ week/ person	Number of people 1	2	3	4	5	6
1	$5.66	$11.32	$16.98	$22.64	$28.30	$33.96
2	$11.32	$22.64	$33.96	$45.28	$56.60	$67.92
3	$16.98	$33.96	$50.94	$67.92	$84.90	$101.88
4	$22.64	$45.28	$67.92	$90.56	$113.20	$135.84
5	$28.30	$56.60	$84.90	$113.20	$141.50	$169.80
6	$33.96	$67.92	$101.88	$135.84	$169.80	$203.76
7	$39.62	$79.24	$118.86	$158.48	$198.10	$237.72
10	$56.60	$113.20	$169.80	$226.40	$283	$339.59

Assuming a 10-minute shower, 5 litres/minute for conventional showerheads, 2.5 litres/minute for low-flow showerhead, change of temperature of 38°C (4°C to 42°), and $0.0986 per kWh.

The Energy Use Survey asked households about the total number of showers household members typically took in a week. This, combined with the calculations outlined above, allowed calculating the total potential cost savings presented in Table 30.

Table 30. Low-flow showerheads: Annual savings per dwelling and total annual savings by tenure and type of community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per household			
Average annual energy savings	670 kWh	618 kWh	
Average annual dollar savings	$70.06	$64.56	
Average annual dollar savings (homeowner)	$66.11	$60.92	
Total annual savings for all households			
Tenant	$43,830	$11,635	$55,465
Landlord/co-op/condo	$24,791	$2,710	$27,501
Homeowner	$140,019	$16,726	$156,744
Total dwellings	**$208,640**	**$31,071**	**$239,711**

• Effects on utility

Table 31 presents annual net direct benefits to the utility from replacing showerheads in diesel communities. This is based on the assumptions specified in the section, Effects on utility, page 5.

Table 31. Showerhead replacement: Annual savings to utility in diesel communities.

	Diesel communities
Average annual energy savings per household	618 kWh
Total net savings per rental household	$26.76
Total net saving per home-owner household	$39.99
Total net utility savings on rental properties	$5,807
Total net utility savings on home-owner properties	$10,117
Total utility savings	**$15,925**

Net benefits in diesel communities are about $40 per showerhead annually and could amount to as much as $16,000 in net saved generating costs per year if all older and conventional showerheads were replaced.

The savings in diesel communities could allow an incentive of up to a maximum of $450 per showerhead. At that point the IRR is 0%. This is considerably more than the cost of replacing showerheads, even if any conceivable installation labour cost is included.

At these levels of savings, almost any incentive is worth offering in diesel communities.

• Program design issues

Many Yukoners have installed low-flow heads at some point over the past fifteen years. Early designs were simply a plastic disc with a small hole in the centre. This constricted the opening to reduce the volume and resulted in unsatisfactory water flow, giving many older low-flow heads a bad reputation.

More modern low-flow showerheads on today's market have greatly improved the quality of water delivery, but a promotional program would need to convince people that new ones are better.

Developing a program around showerhead replacement offers many potential promotional opportunities. Low-flow showerheads typically use only one third to one half as much water as conventional showerheads, resulting in significant hot water savings.

There is also good potential for marketing a showerhead replacement program for residences on water delivery, a fairly common situation for homes not serviced by the local municipality. At present, Yukon municipalities do not charge customers based on metered water use. If this practice changes, residents will have greater interest in the reduced water usage of low-flow showerheads.

Delivering a showerhead replacement program in partnership with the municipality could be explored as well, since as a result of reduced overall water use, additional savings to the municipality in terms of preheating winter supply water could be calculated.

5. ACTIONS INVOLVING OTHER ELECTRICAL USES

A number of other electrical uses were initially considered for possible actions, but only automobile plug-in timers are examined here. Lack of data led to the elimination of possible actions involving heat tape thermostats, while very small numbers led to the elimination of hot tubs from the study.

AUTO PLUG-IN TIMERS

• Action

This action provides incentives for people to purchase timers for use when they plug in their vehicles.

• Target

Although the purpose of all the actions considered in this paper is to change the hardware in Yukon residences and not to change behaviour, this action requires a minor change in behaviour as well. Timers must be set and used to be effective.

The Residential Energy End Use Survey of Yukon households asked homeowners how many vehicles they plugged in during the winter and whether the vehicle(s) had an oil pan heater, battery blanket and interior heater in addition to the block heater. They were also asked whether they used a timer, plugged in manually when necessary, or plugged in all night without a timer. The targets for this action are those people who plug in all night without a timer.

• Market potential

The Residential Energy End Use Survey of Yukon households found approximately 2,702 vehicles being plugged in overnight regularly without a timer — 2,311 in hydro communities and 391 in diesel communities.

Table 32 shows the number of vehicles regularly plugged in all night without timers, broken down by hydro versus diesel community and housing tenure.

Table 32. Distribution of vehicles plugged in all night without timers by tenure and type of community.

	Hydro community				Diesel community			
Electrical bill payer	**No. of vehicles**	**No. of oil pan heaters**	**No. of battery blankets**	**No. of interior heaters**	**No. of vehicles**	**No. of oil pan heaters**	**No. of battery blankets**	**No. of interior heaters**
Tenant	538	235	240	48	146	100	44	15
Landlord/co–op	152	104	48	56	44	21	14	0
Tenant/landlord	–	–	–	–	4	0	4	0
Homeowner	1,621	1,009	1,096	120	197	99	83	23
Total	**2,311**	**1,348**	**1,384**	**224**	**391**	**220**	**145**	**38**

The potential market for an auto plug-in timer program could include both homeowners and tenants who pay their own power bills.

• Costs

An auto plug-in timer retails for approximately $28 in Whitehorse. The total cost of equipping all those Yukoners who plug in all night with timers would therefore be approximately $75,000.

• Effects on consumers

The average energy draws of auto heating devices are[20]:

- block heater — 750 watts
- oil pan heater — 100 watts
- battery blanket — 75 watts
- interior car warmer — 850 watts

It is assumed that people will plug in their vehicles when the temperature reaches -20^{0}C or colder. Meteorological records show that Whitehorse, a hydro community, can expect 56 days a year with that temperature, while diesel communities like Dawson City and Watson Lake have 107 and 95 days respectively.[21] For this analysis, we will therefore assume that there are an average of 60 plug-in days in hydro communities and 100 plug-in days in diesel communities.

When people plug-in all night, we assume that the devices are drawing power for 12 hours. With a timer, that draw is reduced to 4 hours, a savings of 8 hours.

Table 33 lays out the potential savings in energy and money for those who currently plug-in all night.

Table 33. Annual savings to consumers through timer use, by device and community.

	Predicted energy savings		
	Hydro communities	Diesel communities	All communities
Savings per block heater			
Average annual energy savings	360 kWh	600 kWh	
Average annual dollar savings (landlord)	$36	$60	
Savings per oil pan heater			
Average annual energy savings	48 kWh	80 kWh	
Average annual dollar savings (landlord)	$4.80	$8	
Savings per battery blanket			
Average annual energy savings	36 kWh	60 kWh	
Average annual dollar savings (landlord)	$3.60	$6	
Savings per interior car warmer			
Average annual energy savings	408 kWh	680 kWh	
Average annual dollar savings (landlord)	$40.80	$68	
Total annual savings for all households			
Tenant	$23,000	$10,700	$33,700
Landlord/co-op/condo	$8,300	$3,100	$11,400
Homeowner	$71,000	$14,500	$85,500
Totals	**$102,300**	**$28,300**	**$130,600**

• Effects on utility

Table 34 presents annual net direct benefits to the utility from installing auto plug-in timers in diesel communities. This is based on the assumptions specified in the section, Effects on utility, page 5.

Table 34. Auto plug-in timer use: Annual savings to utility in diesel communities.

	Diesel communities
Average annual energy savings per household	733 kWh
Total net savings per rental household	$31.52
Total net saving per home-owner household	$47.65
Total net utility savings on rental properties	$6,115
Total net utility savings on home-owner properties	$9,386
Total utility savings	**$15,501**

Net benefits in diesel communities are about $40 per timer and could amount to as much as $15,500 per year if all diesel consumers who currently plug in all night use timers.

From Table 35, it can be seen that the utility can offer large incentives to diesel community residents to install auto plug-in timers. Targeting those in diesel communities who currently plug in all night means that an incentive of up to $200 (for a $30 device) can be offered before the utility's internal rate of return approaches zero.

Table 35. Utility pay-back period and rate of return: Auto plug-in timers in diesel communities.

Incentive per household	Pay-back period to utility (years)	Internal rate of return
$ 5	0.1	805%
$ 15	0.4	268%
$25	0.6	160%
$50	1.2	76%
$100	2.5	29%
$150	3.7	11%
$200	5.0	0.2%

Note that the rate used to discount the flow of future benefits to the utility is 9% (see section, Effects on utility, page 5).

• Program design issues

Achieving the benefits laid out in the sections above require that any program reach those who plug in all night. The obvious problem is how to identify and target those people. A further issue is that some of those plugging in all night are well aware of the benefits of timers — and perhaps even have one — but choose to plug in for a variety of reasons.

6. ACTIONS INVOLVING HEATING

A number of possible actions to reduce energy use in residential heating were initially considered for analysis, including: replacing old furnaces with new, furnace servicing, replacing older furnace burners with new, highly efficient Riello burners, and replacing hot air furnaces with combo units (combination oil-fired, domestic hot water and furnace units). Of these possibilities, only the last has been analysed below.

Complete furnace replacement was not analysed in detail because there were too many variables to be considered, including: fuel type, whether the old furnace could simply be serviced to bring up its efficiency or whether just the burner would need replacing.

Furnace servicing as a possible action was not analysed because of a lack of hard data on how many furnaces need service and adjustment, what the average fuel saving would be, and how to allow for possible poor quality work by the person doing the work.

Burner replacement was not analysed in detail because of a number of unknowns. Riello claims that using its burners can produce fuel savings of up to 30%, but Energy Solutions Centre staff experience has shown this to be highly unlikely. For example, a 10-year-old burner that is properly serviced can deliver close to the same efficiency as a new Riello burner.

A separate furnace pilot project in Watson Lake involved a complete assessment of 62 residential oil-fired furnaces.

REPLACING HOT AIR FURNACES WITH COMBO UNITS

• Action

Provide incentives to replace older forced air furnaces with new combination oil-fired, domestic hot water and furnace units.

• Target

Combo units are in themselves less energy efficient than electric hot water tanks, while their efficiency for heating is similar to furnaces. So total energy use expressed in kWh is likely to increase. However, depending on the relative costs of electricity to fuel oil, the use of a combo unit can result in cost savings. Further, if the electricity is generated using fossil fuels, there is an overall net energy saving as the efficiency losses from power generation are avoided.

Yukon Housing Corporation converted a number of town houses it owns on Taylor Street in Whitehorse to combo units. Data on energy consumption before and after the conversion was available. A simple linear regression model was developed to estimate the average daily impact on electricity and fuel oil use. The model took into account heating degree days, and number of occupants, as well the energy efficiency of each dwelling.

The model results showed that combo units resulted in an average reduction in electricity use of 9.7 kWh per day and an increase of 19.2 kWh worth of fuel oil. The oil use in kWh was then converted to litres at 11.07 kWh per litre, giving 1.73 litres per day. This assumes 80% efficiency in burning fuel oil.

A proposal to refine this analysis is being prepared to be submitted to CMHC. The proposed study would include more complete energy consumption data for a longer period (two years before and after the conversion) as well as the use of more appropriate statistical techniques (two stage least squares rather than simple regression). CMHC has indicated serious interest in this study.

• Market potential indicators

The Residential Energy End Use Survey did not inquire about the type of heating system, but the information is available from Yukon Housing's Community Housing Surveys. The Residential Energy End Use Survey did ask people about their main heating fuel; and offered respondents a range of responses for the age of their furnace or boiler. People with newer furnaces are unlikely to replace them. The possible responses were "less than 5 years old," "5 to 10 years old," and "over 10 years old." For the purpose of this analysis, the indicator of market potential in the Yukon for combo units is households with oil-fired hot air furnaces more than 10 years old.

The Yukon Community Housing Survey combined with furnace age data from the Residential Energy End Use Survey showed that there are close to 2,000 dwellings in the Yukon whose oil-fired furnace is older than 10 years. About 1,200 of those are homeowners and about another 400 are in households where the landlord pays the heating bill.

Table 36 shows the estimated number of households in diesel and hydro power communities with oil fired hot air furnaces older than 10 years.

Table 36. Distribution of total number of households with oil-fired hot air furnaces >10 years old, by tenure and type of community.

	No. of dwellings		
	Hydro communities	**Diesel communities**	**All communities**
Rental dwellings: electric bill payer			
Tenant	369	48	417
Landlord/co-op/condo	324	54	378
Homeowners	1,085	83	1,168
Total dwellings	**1,778**	**185**	**1,963**

• Costs

It is assumed that a combination unit costs $4,500 to supply and install. Consumers also need to pay more for the increased consumption of fuel oil. The increased daily consumption of 1.73 litres translates into 633 litres per year, or $315 per year. However, the increased fuel oil costs are offset by reduced electricity costs.

• Effects on consumers

Table 37 shows predicted annual energy and cost savings of replacing forced air furnaces with combo units. This is based on the figures outlined above: an average 9.2 kWh per day reduction in electricity use and an average daily increase in diesel communities of 1.73 litres of fuel oil. Note that these numbers depend on the number of occupants of the house. Additional occupants mean greater savings.

Table 37. Annual savings to consumers from switching a hot air furnace to a combo unit.

	Diesel communities
Average annual electrical savings per household	3,541 kWh
Average annual dollar electricity savings per household (landlord) ($0.1045 per kWh general rate)	$369.98
Average annual dollar savings per household (homeowners) ($0.0986 per kWh residential rate)	$349.09
Increased fuel use	633 litres
Increased fuel oil cost (@ $0.4976/litre)	$314.93
Net saving (homeowners)	**$34.16**

The net saving to homeowners is just under 10 cents per day. At a $4,500 cost for replacement, this implies a 132-year payback period. There is very little incentive for consumers to replace their furnace with a combo unit before the end of the useful life of the furnace.

• Effects on utility

Table 38 presents annual net direct benefits to the utility from replacing hot air furnaces with combo units in diesel communities. This is based on the assumptions specified in the section, Effects on utility, page 5.

Table 38. Predicted annual savings to utility of combo units in diesel communities.

	Diesel communities
Average annual energy savings per household	3,541 kWh
Generating cost per kWh	$0.130
Utility savings on rental properties	
Savings per non-generated kWh	$0.026
RSF saving percentage of energy charge	17.05%
RSF saving per kWh saved	$0.018
Total saving per kWh saved	$0.043
Savings per rental household	$153.36
Total potential savings by utility (rental dwellings)	**$15,643**
Utility savings on home-owner properties	
Savings per non-generated kWh	$0.031
RSF saving percentage of energy charge	33.8%
RSF saving per kWh saved	$0.033
Total saving per kWh saved	$0.065
Savings per home-owner household	$229.17

The savings to the utility per furnace replacement are considerable in diesel communities at close to $230 per home-owner household.

The savings in diesel communities could allow an incentive of up to a maximum of $1,145 per furnace replacement. At that point the internal rate of return is 0%. This amount is calculated on an average remaining life of 5 years for existing furnaces greater than 10 years old. Doing a present value calculation with a 9% discount rate (i.e. the rate of return on investment allowed to Yukon Energy Corporation by the YUB), the maximum incentive would be $891. With that level of incentive, YEC would still obtain a 9% rate of return.

However, the total magnitude of savings is not great, at about $35,000 if all hot-air oil-fired furnaces older than 10 years are replaced in diesel communities. Of course those incentive amounts do not include program delivery and administration costs and assume that consumers pay their electric bill to YEC. Table 39 presents payback period as well as internal rate of return for different incentive amounts.

Table 39. Furnace replacement with combo unit: Pay-back period and internal rate of return to utility.

Incentive per combo unit	Pay-back period to utility (years)	Internal rate of return
$300	1.3	71.2%
$400	1.7	49.7%
$500	2.2	36.0%
$600	2.6	26.3%
$700	3.1	19.0%
$800	3.5	13.3%
$900	3.9	8.6%
$1,000	4.4	4.7%
$1,100	4.8	1.4%
$1,145	5.0	0.0%
$1,200	5.2	-1.5%

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FOOTNOTES

[1]Nadel, Steven. Critical Review of DSM Programs. American Council for an Energy Efficient Economy, 1993.

[2]Ibid.

[3]Holt, Gordon, and Tumidaj. Low Cost Energy Efficiency Programs Summary. The Regulatory Assistance Project. 1995.

[4]Pye, Miriam. Energy Efficiency Programs for Low-income Households. ACEEE. 1996.

[5]Surveys were not conducted in Faro, Pelly Crossing and Old Crow.

[6]Energy Consumption of Major Household Appliances marketed in Canada: Trends for 1990 to 1997, Office of Energy Efficiency, Natural Resources Canada, April 2000, Figure 2.6.1.

[7]EnerGuide Appliance Directory 2001, Office of Energy Efficiency, Natural Resources Canada, p.13.

[8]Nadel, Steven. Critical Review of Utility DSM Programs. ACEEE. 1993(?)

[9]Ibid.

[10]BC Hydro. Demand-Side Management Evaluation Summary and Plan. 1993.

[11]Nadel et al. Achieving High Participation Rates: Lessons taught by successful DSM Programs. ACEEE. 1994.

[12]Nadel et al. Achieving High Participation Rates: Lessons taught by successful DSM Programs. ACEEE. 1994.

[13]Energy Consumption of Major Household Appliances marketed in Canada: Trends for 1990 to 1997, Office of Energy Efficiency, Natural Resources Canada, April 2000, Figure 4.1.

[14]EnerGuide Appliance Directory 2001, Office of Energy Efficiency, Natural Resources Canada, p.77.

[15]EnerGuide Appliance Directory 2001, Office of Energy Efficiency, Natural Resources Canada, p.vi.

[16]Office of Energy Efficiency. November 2001. Energy Efficiency of Major Appliances Shipped in Canada — Trends for 1990 to 1999. p.13.

[17]BC Power Smart. http://www.bchydro.com/business/guides/guide746.html

[18]BC Power Smart. http://www.bchydro.com/business/guides/guide746.html

[19]BC Power Smart. http://www.bchydro.com/business/guides/guide746.html

[20]These are averages taken from manufacturer's literature. Block heaters for large engines draw more power than those for small engines.

[21]Environment Canada. http://www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm