Standby Power in the Residential Sector in Canada and Future Trends

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ABSTRACT

Standby power is defined as electricity used by consumer equipment, which is not being used or is in the off-mode. Electronic appliances such as televisions, VCR's and audio equipment all consume electricity while in the standby mode. Their cumulative effect can be substantial. In 2001, the International Energy Agency (IEA) recognized the increasing challenge that standby power poses and launched an initiative to reduce standby power consumption. This initiative has gained considerable attention worldwide. Many countries are investigating ways to reduce standby consumption.

This paper addresses standby power consumption trends and potential energy savings in Canada. This work utilizes a bottom-up approach with the National Energy End-Use Database and a simulator designed for the residential sector. Data for standby household consumption was derived from a 2001 study carried out in 75 Canadian homes.

Household growth forecast is used to estimate standby power consumption. The simulation is performed over the 2002 to 2025 period, where a One-Watt scenario option is tested and potential energy savings and GHG reductions are measured. Regional differences of this scenario were examined. The One-Watt scenario assumes that all consumer electronics will operate at One-Watt standby power.

The main findings show that by 2010 with a One-Watt strategy, Canada could save up to 1.1 Mt in GHG and 637 MW in required capacity, which could save at least $400 million.

Introduction

Standby power is the consumption of electricity by equipment that is turned off or not in use. Standby power has become a new challenge for a growing number of electrical devices in Canadian households, many of which consume energy 24 hours a day.

More and more electronic consumer goods are designed to draw power continuously. In many cases, standby power serves no useful function and consumes too much electricity.

To grasp stand-by power, it is necessary to understand the various modes under which an appliance operates. There are a number of power modes that define the functionality of household equipment. The *In-use mode* identifies that an appliance is performing its primary function. The *active standby mode* for a VCR, DVD or CD means that the appliance is turned on but not in use. The *passive standby mode* is when an appliance is switched to off and can be activated by a remote control or is performing some function (eg. a clock display). The *Off mode* describes the state in which the power is turned off and there is no obvious function being performed. It is not possible to activate the product with a remote control from this mode.

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A study (IEA, 2001) undertaken by IEA shows that standby power, although still relatively small in magnitude, has been growing quickly and is responsible for 20 - 60 W per household in developed countries. Standby power is responsible for 1 - 2 % of OECD (Organization for Economic Co-operation and Development) countries total electricity consumption and the related power generation accounts for almost 1% of their carbon emissions. IEA suggests that much of the power consumed in standby could be reduced without adversely affecting product performance or design features. Standby power reduction could be addressed during product design without the need of expensive additional components. In addition, since the design cycle for many consumer products is relatively short, new designs can be implemented quickly.

The main objective of this paper is to provide an assessment of potential opportunities to reduce standby power losses in Canada. It is also acknowledged that efforts to reduce standby consumption could make additional contributions to reduce GHG (Greenhouse Gas) emissions towards Canada's Kyoto Protocol commitment to reduce GHG emissions to six percent below 1990 by 2010.

To estimate provincial standby power consumption, penetration rates of consumer electronic products will be applied to existing and forecasted household growth patterns. The provincial household forecast data was extracted from a macro model provided by Informetrica Ltd. (Informetrica, 2003). Data for Canadian standby household consumption was derived from a study carried out in 2001 in a sample of 75 Canadian homes and from the Technology Database housed at the Office of Energy Efficiency (OEE (a), 2003).

The next section will summarize Canadian status of standby power consumption. Subsequent sections will focus on a province-by-province breakdown and will examine impact on provincial demand for capacity under business-as-usual and One-Watt scenarios. Finally, savings associated with avoiding capacity expansions to meet standby power demand will be estimated.

State of Standby Power In Canada

In 2000, standby power consumption was estimated to account for up to 4% of Canada's residential electricity consumption from all appliances, which also contributes towards electricity-generated greenhouse gas emissions.

In 2001, the Demand Policy and Analysis Division (DPAD) within the Office of Energy Efficiency through the CREEDAC Centre (Canadian Residential Energy End - use Data and Analysis Centre) has undertaken preliminary steps to assess standby power in Canada (CREEDAC, 2001). The analysis of survey results indicates that standby power consumption for Canada's household appliances was estimated at 17.7 PJ/year and that it could be reduced by 60% if a One-Watt standby power consumption standard was in place.

Table 1 illustrates a sample of appliances with average standby power. These appliances alone consume about 400 MW of needed capacity, drawing about 2% of the annual electricity supplied to the residential sector.

A significant portion of the demand comes from the "other" products. We estimate that these other electronic products consume in total 20 W on average. This is a reasonable assumption considering that additional products, not captured in the original list, could consume anywhere from 3 W from an answering machine to 70 W from a laser printer. Furthermore, the

Office of Energy study (CREEDAC, 2001) identified, from a sample of 75 houses, that on average a household would have about 13 different consumer products requiring standby power.

Table 1. Appliance Standby Power Demand in Canada in 2002

End-Use	Average Standby Power (W)	Unit Energy Consumption - UEC (kWh/yr)	Million Units in Canada	Estimated Standby Power Loss (GWh/year)	Share of Residential Electricity Consumption[2]
TV sets[3]	2.7	23.7	22.0	520	0.36%
VCRs	4.9	42.9	14.6	627	0.44%
DVDs[4]	13.1	114.8	3.8	437	0.31%
CD Player	2.2	19.3	8.9	171	0.12%
Computer	1.6	14.0	7.7	108	0.08%
Microwave Ovens	2.1	18.4	11.0	203	0.14%
Satellite Receiver	15.8	138.4	2.6	354	0.25%
Cable Receiver	5.7	49.9	8.0	399	0.28%
Cellular Tel.Charger	2.0	17.5	6.1	54	0.04%
Other[5]	20.0	175.2	12.0	105	0.07%

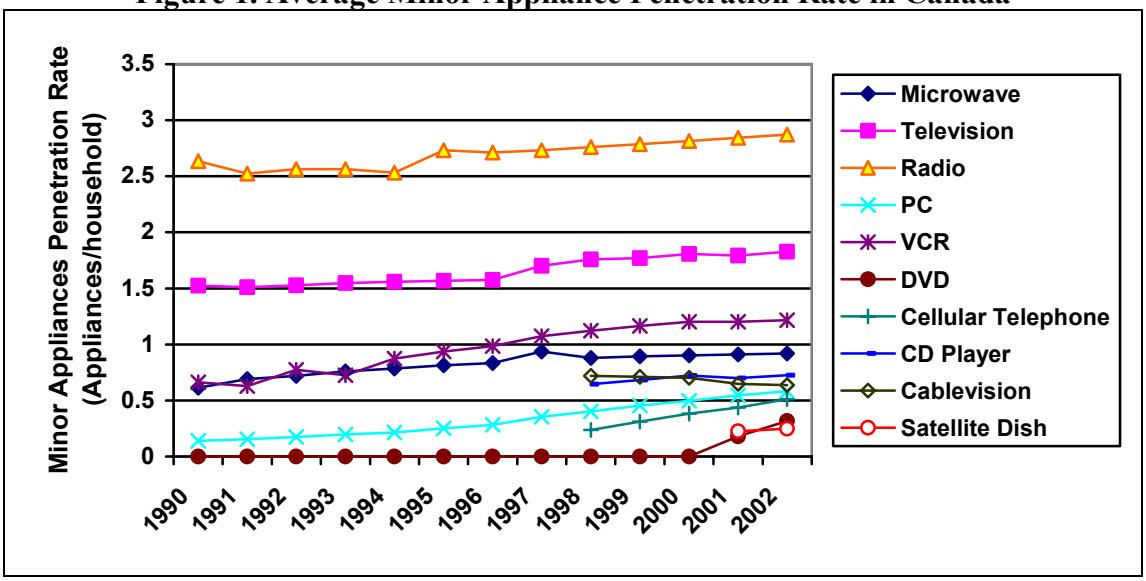
With the number of digital peripherals in households growing over the next decade, standby power consumption will likely continue to rise. In Canada, while overall demand for electricity by appliances increased by 5.4 % between 1990 and 2001(a total of 181.5 PJ in 2001, or 50,417 GWh), the greatest growth in demand for electricity originated from minor appliances such as TVs, DVDs, computers, toasters, etc. Minor appliances consumed 52% more electricity in 2001 than in 1990 (a total of 67.8 PJ in 2001 or 18,833 GWh). On the other hand, major appliances such as refrigerators and freezers have been enjoying improved energy efficiency, where uptake of energy from the total stock of refrigerators decreased by 25% and that from the stock of freezers was reduced by 29% between 1990 and 2001 (OEE (b), 2003). Also, it is interesting to note that in 2001, minor appliances consumed more electricity than all refrigerators and freezers combined in Canada.

With a greater penetration of electronic peripherals and equipment, standby consumption will grow in the future. While actual standby growth in the future is unknown, its growth can be estimated by the forecasted number of households in Canada, coupled with a projected increase in the amount of electronic equipment.

Figure 1 illustrates household penetration rates of a sample of minor appliances in an average Canadian household. As shown, DVDs have increased the most until the end of 2002: from a household penetration rate close to zero in 1998 to almost half of the Canadian population owning a DVD in 2002. This figure, however, does not illustrate the penetration of digital televisions that are slowly replacing existing cathode ray tube televisions. Moreover, it is interesting to observe that the penetration of satellite dishes has been increasing while the penetration of cable receivers has been dropping continuously over the last few years.

[2] Given that demand for electricity in the residential sector was 142,641 GWh in 2002.
[3] Assuming TVs are 26 in and less.
[4] Assuming DVDs with one disk
[5] The Other electronic products could include answering machine (3 W), Battery Charger (2.4 W), Laser Printer (30 W to 70 W), Garage Door Opener (4 W), Fax Machine (30 W), Cordless Phone (2.8 W), Compact Audio (10.6 W), Men's Shaver (1.4 W), Security System (12 W). (Sanchez, 1998)

Figure 1. Average Minor Appliance Penetration Rate in Canada



Source: Statistics Canada, 2003

Provincial Estimates of Standby Consumption

The Office of Energy Efficiency study of household standby consumption (CREEDAC, 2001) was carried out in Halifax, Nova Scotia. The household standby consumption was measured in 75 houses by utilizing a whole-house measurement approach. The study estimated that 427 kWh/year in standby consumption can be associated with that region.

However, a closer look at the penetration of electronic consumer equipment reveals that provincial standby consumption numbers will differ. Table 2 illustrates estimated provincial household standby consumption levels for 2001. These estimates were calculated based on actual provincial penetration rates of electronic consumer products assuming that the same average standby power consumption applied. For some products, such as VCRs it was assumed that penetration will decrease as DVDs become a more popular form of media. It also assumed that the standby mode will operate 8760 hours of the year in the active and passive standby modes.

As shown, the provinces of Alberta, Ontario and British Columbia have the highest standby use per household. Interestingly, these provinces also have highest disposable income per household. In these provinces, the penetration rate of consumer electronic products is higher than in the other provinces. Quebec has lowest standby consumption. Although these numbers are estimates, they do portray differences in standby modes among provinces arising from varying penetration rates of equipment.

The Office of Energy Efficiency is currently undertaking the third Survey of Household Energy Use (SHEU) in collaboration with Statistics Canada to collect field data. The 2003 data will be released in 2005 and will provide penetration and use patterns of household electronic equipment across Canada. The survey will further improve our understanding of provincial standby power use.

Table 2. Household Standby Power Loss by Province, 2001

Province	Household Standby Loss (kWh/yr)
Newfoundland	423
Prince Edward Island (P.E.I.)	422
Nova Scotia	428
New Brunswick	421
Quebec	399
Ontario	432
Manitoba	424
Saskatchewan	427
Alberta	446
British Columbia (B.C.)	424

Forecast of Standby Demand

Understanding of standby demand trends is vital to the planning of effective policies. With a growing penetration of electronic consumer equipment, it is inevitable that standby power consumption will also increase, unless measures can be implemented to mitigate its impact. In Canada, provincial bodies have jurisdiction of the electricity grid and generation; therefore, it is important to understand how that generation is impacted by standby demand.

Consumer products listed in Table 1 were used to derive future standby estimates. The provincial historical penetration rates of consumer electronic products were examined and it was assumed that future penetration rates would resemble historical growth patterns. A least-square regression method was used to estimate future penetration rates. Furthermore, forecasted provincial household data was compiled and projected against the provincial consumer electronics penetration data (Informetrica, 2003).

In 2001, a Canadian household on average consumed 423 kWh/year of standby power, which translated to about 5 TWh/year for all standby consumption in Canada. In 2001, standby power consumed 1% of total Canadian electricity generation and 3.6% of total residential electricity consumption. About 1.4% of total individual household electricity consumption can be attributed to standby losses[6].

In examining future standby-power demand, the year 2010 is of particular interest at this point under the Ratification of the Kyoto Protocol, Canada has committed to reduce its GHG (Greenhouse Gas) emissions to six percent below 1990 levels. Therefore, potential GHG emissions are examined. The status quo scenario is presented in Table 3.

It is clear that under the business-as-usual scenario demand for standby power will continue to grow. It is estimated, that if no action is taken, between 2001 and 2010 the household standby power consumption in Canada will increase by 28% from 423 kWh/year to 536 kWh/year.

[6] Based on an estimate where on average a Canadian Household consumes 31.2 MWh/year in electricity.

Table 3. Business-as-Usual Scenario By Province

Province	2001 (kWh/ yr /hshld)	2010 (kWh/ yr /hshld)	2020 (kWh/ yr /hshld)	2001-2010 % Change	Required Capacity 2001 (MW)	Required Capacity 2010 (MW)[7]	GHG Emissions 2001 (kt)	GHG Emissions 2010 (kt)
Newfoundland	423	544	679	22%	12	17	19	27
P.E.I.	422	489	564	14%	3	4	5	7
Nova Scotia	428	520	626	18%	22	30	36	48
New Brunswick	421	545	682	23%	17	24	29	40
Quebec	399	522	657	23%	174	253	284	414
Ontario	432	545	678	21%	272	401	444	655
Manitoba	424	511	611	17%	26	34	42	55
Saskatchewan	427	530	646	19%	23	30	38	49
Alberta	447	586	750	24%	71	115	117	188
B.C.	424	508	604	17%	96	129	156	210
Canada	*423*	*536*	*666*	*28 %*	*716*	*1,035*	*1,170*	*1,692*

Although each household consumes a fraction of the annual electricity, in absolute terms, household standby power growth translates into increased demand on existing provincial power generating capacity. It is estimated that between 2001 and 2010 the required capacity across Canada would need to increase by about 45%, from 716 MW to 1,035 MW, to meet the growing demand of standby power.

Between 2001 and 2020, provinces such as Quebec and Ontario will see capacity demand grow by about 45 and 47% respectively to meet standby power losses. These provinces are also most populated in Canada and together represent about 62% of required capacity in Canada. If no action is taken, by 2020, consumption from standby demand could increase to 1,500 MW across Canada.

As a by-product of a growing standby demand, GHG emissions would also increase. It is estimated that in 2001 standby power consumption was responsible for over 1 Megatonne of GHG emissions. Under the status quo scenario GHG emissions are estimated to increase to approximately 1.7 Megatonnes by 2010.

Under One-Watt Scenario

One way to reduce standby power consumption is to promote the design of One-Watt power use when in standby mode. For the purpose of this exercise, it is assumed that electronic appliances will reach One-Watt standby, although it is acknowledged that some products might be able to use less than One-Watt and that for some products the One-Watt standby goal may not be a feasible option[8].

Figure 2 summarizes Canadian trends until 2025 and relative savings under the One-Watt policy scenario. In 2001, if all electronic consumer products were operating at One-Watt standby, standby loss could be reduced by about 60% from 422 kWh/yr to 171 kWh/yr. This finding is similar to the potential reduction found in the CREEDAC study (CREEDAC, 2003). Based on the sample in Nova Scotia, they estimated that standby power could be reduced by 59% to 177 kWh/yr.

[7] Assuming generation factor of 80%

[8] In communication with the Housing and Equipment Division, Standards and Labelling Branch, at Office of Energy Efficiency.

As illustrated, by the year 2010, almost 5,000 GWh could be saved. This reduction also translates to 1.1 Mt in GHG savings in 2010, and 1.6 Mt by 2020[9].

Figure 2. Standby Power Trend in Canada and Potential Savings

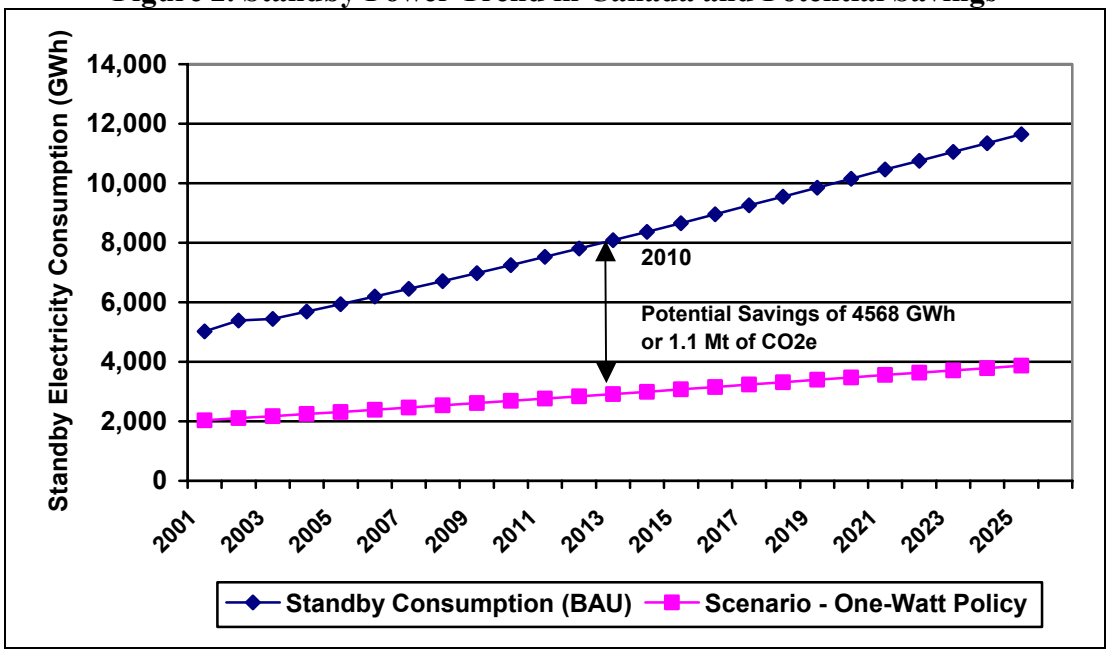


Table 4 represents potential growth and demand in capacity if a One-Watt policy were to be implemented for all Canadian consumer products.

Table 4. One-Watt Scenario by Province

Province	2001 (kWh/ yr /hshld)	2010 (kWh/ yr /hshld)	2020 (kWh/ yr /hshld)	Required Capacity 2001 (MW) [10]	Required Capacity 2010 (MW)	GHG Emissions 2001 (kt)	GHG Emissions 2010 (kt)
Newfoundland	173	203	237	5	6	8	10
P.E.I.	170	194	222	1	2	2	3
Nova Scotia	173	199	229	9	11	15	18
New Brunswick	169	197	225	7	9	11	14
Quebec	165	193	222	72	94	118	153
Ontario	174	202	232	110	150	179	242
Manitoba	171	196	224	10	13	17	21
Saskatchewan	171	194	221	9	11	15	18
Alberta	177	205	236	28	41	46	66
B.C.	172	196	222	39	50	64	81
Canada	*171*	*198*	*228*	*290*	*383*	*474*	*626*

Under the One-Watt policy scenario, provinces such as Ontario and Quebec could save in capacity about 251 MW and 159 MW respectively. Ontario would benefit the most from the

[9] Assuming that electricity GHG intensity is 64.8 tonne/TJ from electricity generation.
[10] Assuming that generation is 80% efficient.

One-Watt policy by carrying about 40% of the potential savings in Canadian capacity. Overall, by 2010, about 652 MW of Canadian capacity could be saved.

Potential Cost Savings

Reduction in standby consumption will also have an impact for both users and producers of electricity. Canadian consumers would be saving directly through lower power consumption about 31 million dollars[11] over the 2001 and 2010 period.

However, the indirect cost, which would be passed to consumers, is the savings from not building a new generating capacity. Table 5 lists provinces in order of biggest savings from avoiding additional capacity. Of interest will be the provinces of Ontario, Quebec, British Columbia and Alberta, which demand most capacity based on the growth in standby power. It is assumed that new capacity would be met by building a conventional combustion turbine (CCT) at $562/kWh[12] (EIA, 2004).

Table 5. Potential Savings from Avoided Additional Capacity

Province	BAU - Required Capacity in 2010 (MW)	One-Watt - Required Capacity in 2010 (MW)	Savings in Required Capacity (MW)	Potential Savings from Avoided New Capacity (2002 $)
Ontario	401	150	251	$140,981,680
Quebec	253	94	159	$ 89,307,120
British Columbia	129	50	79	$ 44,372,720
Alberta	115	41	74	$ 41,564,320
Manitoba	34	13	21	$ 11,795,280
Saskatchewan	30	11	19	$ 10,671,920
Nova Scotia	30	11	19	$ 10,671,920
New Brunswick	24	9	15	$ 8,425,200
Total Savings			*637*	*$ 357,790,160*

Therefore, avoiding the construction of additional capacity due to reduced standby power consumption could save 400 million Canadian dollars ($ 2002). Over half of that cost would originate in the provinces of Ontario and Quebec.

In addition to avoiding construction cost, there are side benefits to society. The costs listed above do not take into account the impact that additional construction would have on plant's marginal operating cost, which would be passed onto consumer. Avoided generation of a CCT plant also implies that there would be less demand on natural gas and, therefore, reduced pressure on the price of natural gas. Avoided investments in capacity would mean that investors could benefit other segments of the economy.

Conclusion

It is estimated that household standby power will continue to grow and between 2001 and 2010 will increase by 28% in Canada. It is estimated that an average Canadian household

[11] Assumes 8.44 cents per kWh

[12] The total overnight cost in US dollars was 413 $ (2002)/kW, at 1.36 conversion rate in Canadian dollars becomes 562 $ (2002)/kW.

consumed 422 kWh/year in 2001 and by 2010 this figure could reach 535 kWh/year in standby mode. This growing demand in standby power translates to about 1,035 MW in additional needed capacity by 2010.

The preliminary data clearly shows a need to further develop strategies to limit standby energy consumption. By 2010, with a One-Watt standby strategy, Canada could be saving up to 1.1 Mt in GHG emissions and, therefore, making a contribution towards the Kyoto agreement. Reduction in standby power to One-Watt could save Canada 637 MW in required capacity by 2010 and over $400 million.

Since Canada is a geographically vast country, taking a closer look at provincial differences is important. As it was shown in this paper, Quebec and Ontario are the two provinces that could most benefit from reduced standby consumption.

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