

**HYDRO-QUÉBEC ENERGY SAVINGS PROGRAMS:
"WATT" ARE THEY WORTH?**

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Cahier 94-09

Groupe de Recherche en Économie de l'Énergie
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GREEN



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Résumé

Hydro-Québec a mis sur pied des programmes d'économies d'énergie qui sont partie intégrante de son plan de développement 1993. La société d'État prévoit investir 1.9 milliard de dollars (de 1992) entre 1992 et 2000 et 2.0 milliards de dollars entre 2001 et 2010 à cet effet. L'entreprise escompte ainsi une diminution de la demande de l'ordre de 9.3 TWh en 2000, soit 5.4% de la demande prévue sans ces programmes et de 18.0 TWh en 2010, soit 9.1% de la demande autrement prévue. Hydro-Québec se propose de substituer les investissements en économies d'énergie à des investissements dans des projets hydro-électriques. Dans cet article, nous effectuons une analyse coûts/bénéfices de ces programmes en tenant compte des critères financiers particuliers sous-jacents aux tarifs d'électricité payés par les consommateurs.

En résumé, les programmes d'économies d'énergie d'Hydro-Québec devraient générer des bénéfices en valeur présente de l'ordre de 2078 à 4479 millions de dollars, selon les hypothèses d'économies effectivement réalisées. Sur une base annuelle, les gains varient entre 179.3 et 386.5 millions. La plupart des bénéfices sont réalisés par les clients alors que le producteur réalise des gains marginaux. Le gouvernement, quant à lui, sort perdant dans cette histoire.

Summary

Hydro-Québec, which is a large government-owned electric utility serving the Province of Québec, launched several energy savings programs as part of its 1992 development plan. It intends to spend 1.9 billion \$ from 1992 to 2000 and 2.0 billions \$ from 2001 to 2010 on this endeavour and it expects electricity demand to be reduced by 9.3 TWh in the year 2000 or 5.4% of the demand which would otherwise be predicted and by 18.0 TWh in the year 2010 or 9.1%. The utility proposes to substitute investment in energy savings for investment in new hydro-electric power projects. In this paper we perform a cost-benefit analysis of Hydro-Québec energy savings programs while taking into account the particular financial criteria underlying electricity rates paid by the consumers.

We find that Hydro-Québec energy savings programs should lead to present value benefits ranging from 2078 to 4479 millions \$ according to the assumption about realized electricity savings. On an annual basis, the range is from 179.3 to 386.5 millions \$. Most of the benefits accrue to the consumers while the utility realizes marginal gains and the government is a net loser. The level and the distribution of the benefits among the

three parties are live to the size of electricity demand reduction associated with the energy savings programs.

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Keywords: Energy savings, electric utilities, electricity demand, energy policy

INTRODUCTION

The increasing cost of generating capacity and the growing environmental concerns have led to the implementation of energy savings programs which are now an integral part of resources development plans of most electric utilities.¹ Since their inception, energy savings programs have given rise to extensive debates about how much energy will be saved and about the associated costs in order to arrive at the supply function of the so-called negawatts. Estimates of this type rely on engineering studies and on subjective evaluation of consumers willingness to participate. Energy savings programs sponsored by electric utilities have been launched on the basis of such cost and benefit assessment and *ex post* performance evaluations are starting to become available.² In general, the *ex ante* estimates do not incorporate the quantity changes which could follow from consumers reactions to the resulting cheaper energy services.³

There is another type of price reaction which has also been overlooked. Most energy savings programs are implemented under the assumption that they are going to be net revenue neutral to ensure that program non-participants do not cross-subsidize program beneficiaries. Such claims fail to take into account that energy savings programs expenditures by electric utilities are part of revenue requirements and hence influence electricity rates. Energy savings expenses to reduce electricity demand and generating equipment investment expenses to provide service for a growing demand can be seen as two competing ways of satisfying consumer demand for heat, light or air conditioning. Each type of investment expenses receives a particular treatment under revenue requirements which underlie electricity rate determination. The resulting rates influence electricity demand, thus providing additional benefits or costs.

Our objective is to conduct a cost-benefit analysis of Hydro-Québec overall energy savings programs while taking into account programs effects on electricity rates and hence on electricity demand. Hydro-Québec is a large government-owned corporation which generates, transmits and distributes electricity in the Province of Québec. Its rates are subject to government approval. Three parties are influenced by the introduction of energy savings programs: the consumers who are supposed to be the beneficiaries, the utility which can postpone the use of new generating equipment, and finally, the government which collects specific taxes on electricity consumption and production. The

sum of the effects on the three parties determines the overall effect of Hydro-Québec's energy savings programs on Québec economic well-being whole.

The presentation proceeds in this order: the first section describes Hydro-Québec energy savings programs and the underlying economic rationale. The second section introduces the simulation model used to analyze investment development plan, electricity production, rate determination, and electricity demand. The details with respect to this particular application of cost-benefit analysis appear in section three while section four provides the results.

Here is an overview of the main conclusions: Hydro-Québec energy savings programs lead to present value benefits ranging from 2078 to 4479 millions \$ according to the assumption about realized electricity savings.⁴ On an annual basis, the range is from 179.3 to 386.5 millions \$. Most of the benefits accrue to the consumers while the producer gain is marginal and the government is a net loser. The size and the distribution of the benefits among the three parties are quite sensitive to the electricity demand reduction associated with the energy savings programs.

SECTION ONE: Hydro-Québec energy savings programs

Hydro-Québec is a large electric utility with sales of 144.5 TWh and gross income of 6.8 billions \$ in 1992. Its total generating capacity was 33 573 MW at year end, including 5 428 MW obtained through a long term firm contract with Newfoundland, a neighboring province; 94% of available capacity is from hydro sources.⁵ From 1982 to 1992, the average annual growth rate of total sales was 3.4% while the growth rate for sales within the province was 4.3%. If we set aside the relatively small planned purchases from independent power producers, i.e. 760 MW, all capacity additions are expected to be utility-build hydro power stations.⁶

Hydro-Québec is a late comer to the implementation of energy savings programs. In the development plan presented by the utility in 1992 for the period 1992 to 2010, energy savings programs are an explicit part of the balancing act between electricity demand and supply along capacity additions, interruptible service and purchases from independent power producers. The government-owned enterprise expects to spend

1.9 billion \$ from 1992 to 2000 and 2.0 billions \$ from 2001 to 2010 on various energy savings programs which will apply fairly evenly to the residential, commercial and industrial sectors. The consumers are supposed to match about half the amount which will be provided by the utility. As a result of the joint energy savings efforts by the utility and the users, electricity demand is expected to be reduced by 9.3 TWh in the year 2000 or 5.4% of the demand which would otherwise be predicted and by 18.0 TWh in the year 2010 or 9.1%. Table 4 shows the annual energy savings in column (2) and the annual flow of programs expenditures in column (3) from 1992 to 2010 according to the plan set by the utility. The information concerning energy savings programs expenses is more precise in the first nine years than in the ensuing years and only an aggregate figure is available for the later period.⁷

The principles which led to energy savings estimates by the utility are quite standard.⁸ First, the enterprise assessed potential energy savings by considering all electricity uses such that the cost of the energy saving measure is gauged to be less than the marginal production cost, i.e. the cost of developing new supply to satisfy that particular demand.⁹ This includes all energy savings measures which can be considered to be optimal from a social standpoint. There is the additional problem of allocating the energy savings cost burden between the utility and the beneficiaries with the implied participation rate of the latter. Hydro-Québec plans to cover about two thirds of the cost of energy savings measures and it expects that such a sharing agreement will make one third of potential energy savings to be realized. It must be pointed out that Hydro-Québec is a low price seller and a low cost producer. This tends to reduce potential energy savings and the willingness of consumer to undertake expenditures in order to save electricity.

Hydro-Québec's share of energy savings programs costs may exceed the difference between marginal expansion cost and average revenue, so the program implementation is not necessarily net revenue neutral at least in the short term. The plan is to substitute energy savings programs in the next few years for capacity additions over the longer term. According to the utility, electricity prices with energy savings programs should not exceed prices without them in the long term and may be lower.

Our purpose is to analyze this particular trade-off within the framework of cost-benefit analysis while taking into account the financial regulatory constraints which underlie electricity price determination in the Province of Québec. Even if Hydro-Québec is not subject to the overview of an independent regulatory commission, some financial criteria are applied by the government to evaluate whether total revenues and hence electricity tariffs are at the appropriate level. Two criteria in particular are used explicitly for such a purpose, i.e. debt/equity ratio and interest coverage.¹⁰ The interrelationships between energy savings programs expenses and the financial criteria yield average electricity prices over time. This may provide an additional benefit or cost which can only be taken into account in a dynamic analysis embodying the feedback effect of program expenses on electricity price and hence on electricity demand.

Hydro-Québec claims that its energy savings programs will provide benefits to the consumers and the utility; however, there is another passive party which is the government. The latter collects specific taxes on the consumption and the production of electricity, namely, a 3% sales tax in lieu of local taxes, a 0.05% property tax, a 0.48% capital tax, and a 0.5% guarantee fee on debt financing. Taxes are part of the value associated with electricity use and it is of interest to determine the net effect of energy savings programs on government revenues.

Before describing the implementation of the cost-benefit analysis of the energy savings programs by Hydro-Québec, let us introduce briefly the analytical framework that is used to trace the evolution of Quebec electricity market up to the year 2010.

SECTION TWO: The analytical framework

In order to measure the effects of the energy savings programs as planned by Hydro-Québec, we need a model which allows to conduct comparative analysis and which encompasses the main features of electricity rate determination for the government-owned electric utility. Although there is no direct rate overview by an independent regulatory agency in Québec, the government, which is responsible for electricity rates approval, relies mostly on two financial criteria to assess tariff changes, i.e. interest coverage¹¹ and debt/equity ratio.¹² These two ratios are incorporated explicitly into the dividend formula which determines the amount paid by the utility to the government as equity

owner; no dividend is paid if one of the financial criteria is not satisfied. Electricity rates reflect average costs with modifications brought by the application of the above financial criteria. Average costs include operations and maintenance, electricity purchases, taxes, capital depreciation and net interest payments.

To trace the effects of energy savings programs on electricity rates, demand, and production, we make use of the CANREM model. Although some parts of the model are based on optimizing principles, such as energy demand and production dispatching, the overall model is not an optimizing one. In particular, this is the case with respect to the equipment development plan. Hydro capacity additions are introduced in order to satisfy some technical criteria such as peak capacity reserve and available energy.

As it can be seen from Figure 1, the model has three main components: energy and electricity demand, production, and finances. The price of electricity is the key variable which links together the three components. Rates are set so as to cover average costs and to satisfy the two aforementioned financial criteria at least in a stable economic environment.¹³ Electricity demand elasticities with respect to price and income play an important role in the evolution of electricity demand and they are reproduced in Table 1. It can be seen that price elasticities are quite low in the short run, but not so in the long run due to strong substitution possibilities with oil products and natural gas. Except for industrial electricity demand in the long run, all income elasticities are less than one. If we take into account the relative contribution of each sector to total electricity demand, the long run income elasticity is 0.80.

Two types of exogenous information are parts of a simulation run over a given horizon: first, there are the macroeconomic variables such as Gross Domestic Product, inflation, interest rates, exchange rates, and population growth. Second, there are the oil and natural gas price forecasts. In this paper, we adopt the forecasts for these variables as presented by Hydro-Québec (1992c) in its development plan for the period 1992-2010 and they are reproduced in Table 2. It can be observed that Hydro-Québec expects economic growth to slow down and the prices of crude oil and of natural gas to increase over the next two decades. These variables, together with the costs of generation, transmission and distribution equipment, determine average prices of electricity through

the direct overview provided by government and hence influence the demand for electricity.

SECTION THREE: The cost-benefit analysis of energy savings programs

The first step in the analysis of the effects of Hydro-Québec energy savings programs is the construction of a base case scenario in the absence of energy savings measures. The base case scenario incorporates the exogenous information provided in Table 2. Then energy savings expenditures by the utility are introduced on the cost side and expected energy savings are netted out from the electricity demand which would otherwise be predicted under the base case. Adjustments are brought to production equipment required to satisfy the lower demand and investment expenses are reduced accordingly. The new plan of investment expenses by the utility, i.e. energy savings and production investment expenses, interact with the financial criteria to determine the new electricity price path over the planning horizon. In turn this leads to further demand adjustments which must be incorporated in the cost-benefit analysis.¹⁴ The first two columns of Tables 3 and 4 present the information with respect to the energy savings programs while the third column shows the production investment expenses. There is an obvious trade-off between the two types of investment expenses.

There exists a wide range of opinions over consumer willingness to participate into energy savings programs and hence over their effectiveness. Studies such as Joskow and Marron (1992) in the U.S. and Velthuisen (1993) in the Netherlands show that realized energy savings out of utility sponsored programs are quite often much lower than the forecasts based on engineering studies. A 50% reduction from the *ex ante* appraisal to the *ex post* measurement is quite common. In order to assess the impact of lower than expected energy savings, we construct another scenario which incorporates the same energy savings expenses and only 50% energy savings relative to Hydro-Québec energy savings plan.

Little information is available about the free riders, that is, consumers who would have adopted the energy savings measures without utility assistance. The longer is the horizon, the more severe is the free rider problem. In that sense, energy savings associated with utility-sponsored measures can be seen as temporary because they would

have been realized any way over the long run. In order to explore the effects of this phenomenon, we construct an additional scenario in which utility-sponsored energy savings programs generate savings only for ten years and lapse afterwards. The information with respect to this scenario appears in Table 6. Figure 2 shows the evolution of energy savings under the three scenarios considered in this paper.

Our purpose is to measure the changes in economic well-being for the consumers, the producer and the government due to Hydro-Québec energy savings programs from 1992 to 2010 under each energy savings scenario.

i. the consumers

The cost-benefit analysis of the energy savings programs incorporate three changes for the consumers:

lower bills related to lower electricity demand;

consumer surplus variations associated with the price effects. We make use of the Slutsky compensating variation which is the added amount or the savings on electricity purchases due to the price change;¹⁵

and consumer share of energy savings program costs. We adopt Hydro-Québec assumption that consumers will bear about one third of total costs.

ii. the producer

The producer makes use of two types of generating equipment over the planning horizon, that is, the equipment which is already available in 1992 and the one which is coming on line up to 2010. For the first type of equipment, we use the quasi-rent approach under the assumption that the already available equipment has no alternative use beside electricity production. So profits are simply revenues minus operating expenses and taxes. For the second type, we have to deduct investment expenses which are variable over the planning horizon.

iii. the government

The government is a passive partner which receives benefits in the form of specific taxes on the production and on the consumption of electricity.¹⁶ Dividends are not taken into account since they are part of producer surplus.

The end of the planning horizon 2010 has been selected in order to make use of all the information provided by Hydro-Québec (1992c) latest development plan. The four scenarios yield different combinations of capital stock which is built up from 1992 to 2010 and of electricity demand reduction due to energy savings programs. These two assets are of some value to society and we need to take them into account in the cost-benefit analysis. Obviously, the determination of the value of these assets requires that we probe further into the future. To close the analysis, it is assumed that the useful lives of the stocks of capital in the form of electricity demand reduction which exist in 2010 are twenty years and that they are subject to linear depreciation.¹⁷ The 2010 electricity price under the relevant scenario is used to convert the stream of demand reduction into present value which is then added to consumer benefits. As for the production equipment which comes into service between 1992 and 2010, we assume a 3% compounded interest rate depreciation over the useful lives¹⁸ and the present value of the net assets in 2010 is deducted from gross investment expenses to arrive at net investment expenses over the planning horizon. The annual flows of benefits and costs are expressed in present value terms for the year 1992 by using the real rate of discount 6.3% which is also the rate used by the utility to assess various projects.

SECTION FOUR: The results

Tables 3 to 6 contain the simulation results under the four scenarios and they show the evolution of the real price of electricity, demand, generating capacity, reserve and net secondary trade. The latter is introduced because it acts as the marginal market relative to the domestic market. If the utility is short of energy in a given year, it buys secondary power from the U.S. and conversely, if it has excess energy, it sells secondary power on the same market.

The evolution under each scenario is best seen by focusing the attention on the price of electricity. As it can be seen from Table 3, the price of electricity would fall at

the average annual rate of 0.47% from 1992 to 2000 and 0.75% over the following decade if there were to be no energy savings programs. Demand would grow at 0.75% per year; this rate exceeds by 0.68% the rate which would result from economic growth alone with no price change. The utility would have enough generating capacity, even in the next few years, although it is generally short of energy as the negative net secondary trade shows.

Figure 3 illustrates the evolution of the price of electricity with and without the energy savings programs as planned by Hydro-Québec. It is seen that the energy savings programs call for higher prices up to the year to 2000, for lower prices between 2001 and 2005 and for higher price again afterwards. Contrary to the assertion by Hydro-Québec (1992a), the two price paths do not merge over time and the energy savings scenario presents higher prices at the end of the planning horizon. The determination of electricity price through financial criteria such as interest coverage and debt/equity ratio introduces wave-like motions in the evolution of price which obscure simple comparisons. Since the prices of electricity are higher in the first period, the net demand reduction is larger in the year 2000 than the amount predicted by Hydro-Québec, i.e. 9.9 TWh *versus* 9.3 TWh, as it can be observed by comparing results in Tables 3 and 4. The utility has a higher reserve margin and it has excess energy to unload on the secondary market. The higher electricity price at the end of the planning horizon brings also a larger demand reduction, that is, 19.9 TWh *versus* 18.0 TWh. Overall annual electricity demand growth is 2.22% rather than 2.76% and capacity drops by 3629 MW or 8.0% by the year 2010 relative to the case where no energy savings are present.

The 50% energy savings scenario which is presented in Table 5 has less energy savings and more capacity additions and hence more production investment expenses. This leads to higher electricity prices in comparison with the realization of 100% energy savings. So electricity demand increase is only 7.2 TWh rather than the whole 9.0 TWh in the year 2010. The difference is due to higher prices.

Table 6 displays the results with respect to the scenario where energy savings are considered as temporary. The effect is to cause energy savings to be realized ten years earlier than otherwise with no lasting effect. This scenario is identical to the one put forward by Hydro-Québec up to the year 2001, then savings in 1992 are netted out

of the savings in 2002 and so on. This reduces drastically the efficiency of the energy savings programs in the long run. This scenario has more capacity additions with the same energy savings expenses. So it has higher prices which lead to lower electricity demand in 2010.

Table 7 presents the results of the cost-benefit analysis under the three energy savings scenarios. It can be observed that electricity consumers would be the main beneficiaries of the programs implemented by Hydro-Québec if the world unfolds as predicted by the government-owned corporation. Most of the gains take the form of bill reduction while the change in consumer surplus is relatively small. A fairly large share of the gains comes from bill decrease after 2010. The gains accruing to the producer are rather marginal. The savings realized with respect to investment expenses are nearly offset by the losses of variable profits. The losses of tax revenues are fairly large. Smaller electricity demand generates less sales tax and also less capital tax and guarantee fees. The last two taxes are linked to Hydro-Québec size which is made smaller by the energy savings programs. For society as a whole, the net gain in present value is 4 479.0 millions \$ or 386.5 millions \$ on equivalent annual basis from 1992 to 2010. This amount represents 0.24% of GDP in 1992 or 5.6% of Hydro-Québec sales in that year.

A lower efficiency of the energy savings programs yields fairly dramatic reduction in consumers benefits. This would be the case in particular if energy savings turn out to be only 50% of Hydro-Québec forecasts in the respect. Consumers benefits would amount only to 1 318.5 millions \$ rather than 4 686.6 millions \$. The producer and the government would gain from the larger sales. For society as whole, the energy savings programs would still provide positive benefits even if their efficiency were to be reduced significantly.

CONCLUSION

The economic rationale behind energy savings programs is that marginal development costs are above electricity prices, so there is a margin which can be used to reduce demand while the consumers and the producer share the gains. It is this simple rationale which lies behind the energy savings programs launched by Hydro-Québec. In this paper, we conducted an overall cost-benefit analysis of these programs while taking

into account the particular framework which leads to price determination for the government-owned utility. We found that, if Hydro-Québec plans unfold according to its forecast, the consumers would capture most of the gains, while the utility would be a marginal beneficiary and the government would be a net loser. The size and the distribution of the benefits and losses among the three parties are quite sensitive to assumptions with respect to the efficiency of the energy savings programs. Consumers gains would decrease while the producer and the government would benefit if the efficiency of energy savings programs were to fall.

Since the economic rationale behind the energy savings programs is a faulty price signal, that is, electricity price being less than marginal development cost, we may ask why we should not be moving toward the first best solution. In a previous paper by Bernard and Chatel (1985), it was shown that the first best would lead to much larger welfare gains. However, the consumers would be the main losers. The implementation of the energy savings programs by Hydro-Québec does not give rise to such a problem. It must be kept in mind that the consumers elect the government which approves the electricity tariffs of the government-owned utility.

Figure 1

An Overview of the CANREM Model

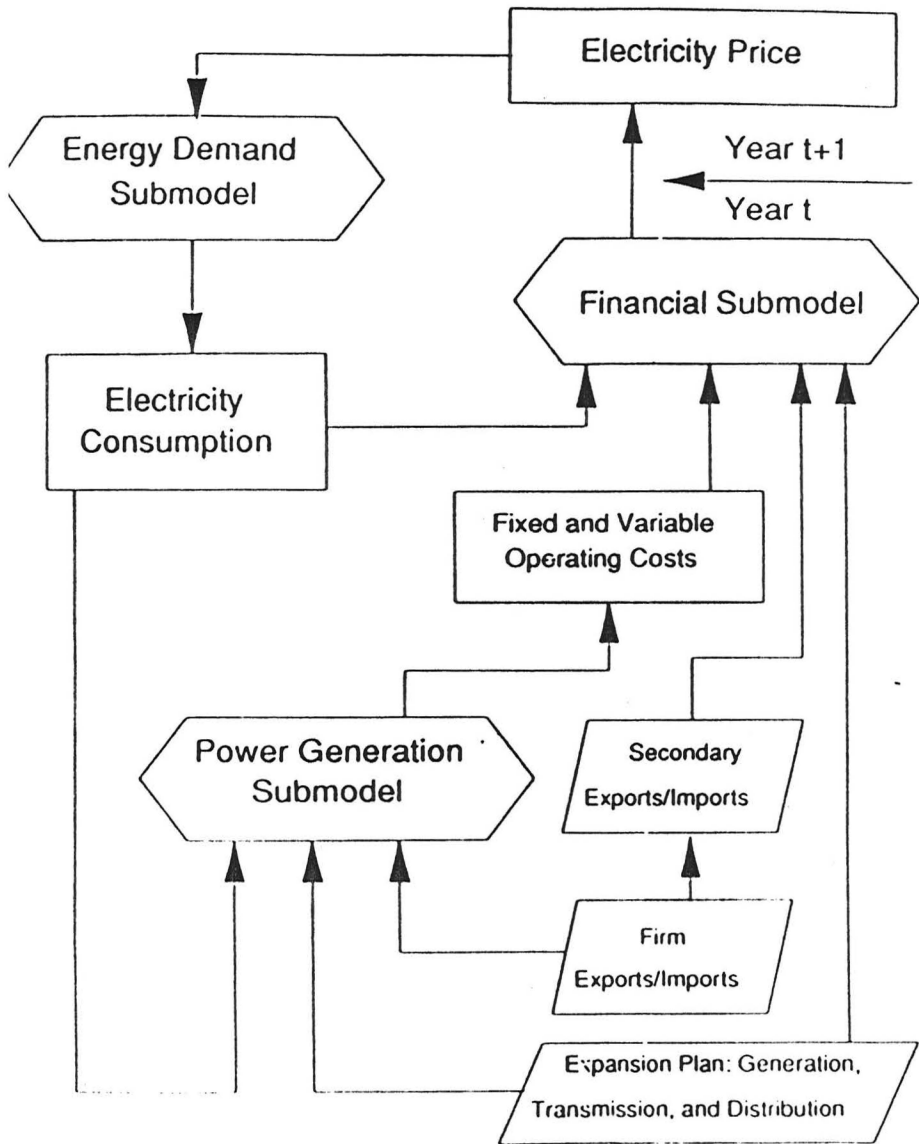


Figure 2

Energy Savings Scenarios (1992-2030)

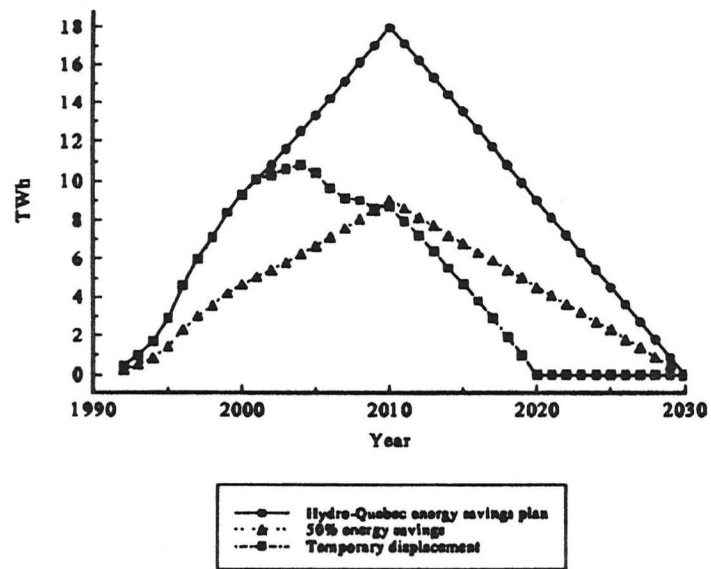


Figure 3

Electricity Price (1992-2010)
¢/kWh

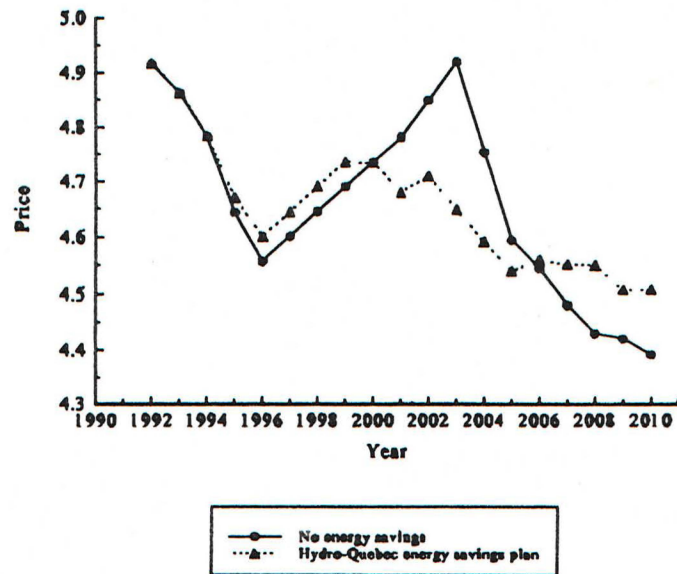


Table 1: Price and Income Elasticities of Québec Electricity Demand

	Price		Income	
	S.R.	L.R.	S.R.	L.R.
Residential	-0.30	-1.25	0.17	0.40
Commercial	-0.33	-1.33	0.38	0.67
Industrial	-0.14	-1.02	0.65	1.36
Street lighting	-0.15	-1.05	0.06	0.41

S.R.: Short run

L.R.: Long run

Source: C.W. Carr (1992)

Table 2: Macroeconomic variables (average annual growth rate)

Period	Inflation	Households	Oil Price	Natural gas price	Real GDP	Interest rate ^a	Exchange rate (\$CAN/\$US)
1992-2000	2.4	1.7	2.0	5.0	2.9	9.8	1.25
2000-2010	3.5	1.0	1.2	5.0	2.4	9.8	1.24
1992-2010	3.3	1.3	1.6	5.0	2.6	9.8	1.25

^a Average over the period

Source: Hydro-Québec (1992c), (1993)

Table 3: No energy savings

Year	Energy Savings TWh	H-Q Energy Savings Expenses Millions \$	Production Investment Expenses Millions \$	Price ¢/kWh	Demand TWh	Capacity MW	Reserve Margin %	Net Secondary Trade TWh
1992	0.0	0.00	1232.63	4.92	136.0	29130	13	0.0
1993	0.0	0.00	1042.64	4.86	143.8	30044	15	-1.0
1994	0.0	0.00	943.51	4.78	150.2	31312	18	-1.0
1995	0.0	0.00	1161.28	4.64	155.9	31998	16	-1.0
1996	0.0	0.00	1441.57	4.56	161.0	32298	14	-1.0
1997	0.0	0.00	1967.49	4.60	165.6	32308	14	-2.0
1998	0.0	0.00	2322.85	4.65	169.8	32773	13	-3.0
1999	0.0	0.00	2607.89	4.69	171.1	32773	11	-3.0
2000	0.0	0.00	2619.07	4.74	173.1	33388	11	-3.0
2001	0.0	0.00	2469.52	4.78	176.0	35490	16	-3.0
2002	0.0	0.00	2510.62	4.85	178.9	36797	18	-1.0
2003	0.0	0.00	2518.60	4.92	181.7	38532	21	0.0
2004	0.0	0.00	2738.35	4.75	185.6	39195	19	2.0
2005	0.0	0.00	2555.34	4.59	191.4	40397	18	-1.0
2006	0.0	0.00	2263.51	4.54	197.4	41489	17	-1.0
2007	0.0	0.00	2079.31	4.48	203.6	43073	17	-1.0
2008	0.0	0.00	2238.44	4.43	209.9	44273	15	-1.0
2009	0.0	0.00	2763.63	4.42	215.9	44273	12	-2.0
2010	0.0	0.00	2888.89	4.39	222.0	45118	10	-3.0

Average annual growth rate

1992-2000	---	---	---	-0.47	3.06	1.72	---	---
2000-2010	---	---	---	-0.75	2.52	3.06	---	---
1992-2010	---	---	---	-0.63	2.76	2.46	---	---

Table 4: Hydro-Québec energy savings

Year	Energy Savings TWh	H-Q Energy Savings Expenses Millions \$	Production Investment Expenses Millions \$	Price ¢/kWh	Demand TWh	Capacity MW	Reserve Margin %	Net Secondary Trade TWh
1992	0.5	118.00	1175.66	4.92	136.0	29130	13	0.0
1993	1.0	201.58	924.02	4.86	142.3	30044	17	0.0
1994	1.7	235.89	694.63	4.78	147.9	31312	20	1.0
1995	2.9	248.47	730.66	4.67	152.1	31998	20	2.0
1996	4.6	223.81	832.92	4.60	155.9	32298	18	2.0
1997	6.0	220.97	1090.03	4.65	158.9	32308	20	3.0
1998	7.1	205.34	1369.51	4.69	161.9	32773	19	2.0
1999	8.4	185.04	1772.26	4.74	161.8	32773	19	3.0
2000	9.3	200.00	1942.09	4.73	163.2	32773	18	2.0
2001	10.1	200.00	1882.45	4.68	166.3	33373	17	0.0
2002	10.8	200.00	1660.87	4.71	169.6	35070	20	0.0
2003	11.6	200.00	1550.76	4.65	173.4	36384	21	0.0
2004	12.5	200.00	1578.24	4.59	176.7	37361	21	1.0
2005	13.3	200.00	1632.23	4.54	181.0	38470	20	0.0
2006	14.2	200.00	1813.98	4.56	185.0	38883	18	0.0
2007	15.1	200.00	2108.78	4.55	189.1	39662	17	-1.0
2008	16.1	200.00	2405.48	4.55	193.1	40027	15	-1.0
2009	17.0	200.00	2594.86	4.51	197.7	40567	13	-2.0
2010	18.0	200.00	2659.73	4.51	202.1	41489	13	-3.0

Average annual growth rate

1992-2000	---	---	---	-0.47	2.30	1.48	---	---
2000-2010	---	---	---	-0.49	2.16	2.39	---	---
1992-2010	---	---	---	-0.48	2.22	1.98	---	---

Table 5: 50% energy savings

Year	Energy Savings TWh	H-Q Energy Savings Expenses Millions \$	Production Investment Expenses Millions \$	Price \$/kWh	Demand TWh	Capacity MW	Reserve Margin %	Net Secondary Trade TWh
1992	0.3	188.00	1193.33	4.92	136.0	29130	13	0.0
1993	0.5	201.58	937.05	4.86	143.1	30044	16	-1.0
1994	0.9	235.89	748.42	4.78	149.1	31312	19	0.0
1995	1.5	248.47	869.20	4.68	153.7	31998	18	1.0
1996	2.3	247.87	997.43	4.59	158.2	32298	16	1.0
1997	3.0	223.81	1285.17	4.64	162.0	32308	17	0.0
1998	3.6	220.97	1668.48	4.68	165.5	32773	16	-1.0
1999	4.2	205.34	2036.09	4.73	166.1	32773	15	0.0
2000	4.7	185.04	2170.58	4.77	167.6	32773	14	-1.0
2001	5.1	200.00	2126.10	4.82	170.0	33988	16	-1.0
2002	5.4	200.00	2157.14	4.89	172.6	35782	19	0.0
2003	5.8	200.00	2159.83	4.96	174.9	36384	19	0.0
2004	6.3	200.00	1990.00	4.79	178.3	37774	21	0.0
2005	6.7	200.00	1871.50	4.63	183.6	39297	21	0.0
2006	7.1	200.00	1999.82	4.58	189.1	40207	19	0.0
2007	7.6	200.00	2173.90	4.57	194.2	40941	17	0.0
2008	8.1	200.00	2482.19	4.53	199.4	41489	15	-1.0
2009	8.5	200.00	2716.69	4.52	204.6	42078	13	-2.0
2010	9.0	200.00	2907.20	4.53	209.3	42673	11	-3.0
Average annual growth rate								
1992-2000	---	---	---	-0.37	2.64	1.48	---	---
2000-2010	---	---	---	-0.51	2.24	2.67	---	---
1992-2010	---	---	---	-0.45	2.42	2.14	---	---

Table 6: Temporary energy savings

Year	Energy Savings TWh	H-Q Energy Savings Expenses Millions \$	Production Investment Expenses Millions \$	Price \$/kWh	Demand TWh	Capacity MW	Reserve Margin %	Net Secondary Trade TWh
1992	0.5	188.00	1175.66	4.92	136.0	29130	13	0.0
1993	1.0	201.58	924.02	4.86	142.8	30044	16	0.0
1994	1.7	235.89	694.63	4.78	148.5	31312	19	0.0
1995	2.9	248.47	750.83	4.65	152.9	31998	19	1.0
1996	4.6	247.87	854.74	4.60	156.1	32298	18	2.0
1997	6.0	223.81	1127.01	4.64	159.0	32308	19	3.0
1998	7.1	220.97	1448.04	4.69	162.0	32773	19	2.0
1999	8.4	205.34	1973.17	4.73	161.9	32773	19	3.0
2000	9.3	185.04	2197.70	4.75	163.2	32773	18	2.0
2001	10.1	200.00	2260.89	4.72	166.0	33373	17	0.0
2002	10.3	200.00	2166.40	4.76	169.4	35070	20	0.0
2003	10.6	200.00	2100.84	4.73	173.2	36384	21	0.0
2004	10.8	200.00	2059.65	4.66	177.0	37361	20	0.0
2005	10.4	200.00	1949.50	4.61	182.2	39297	22	0.0
2006	9.6	200.00	2246.75	4.63	187.8	39662	19	0.0
2007	9.1	200.00	2514.05	4.60	193.4	40567	17	-1.0
2008	9.0	200.00	2841.26	4.59	198.6	40941	14	-2.0
2009	8.6	200.00	2973.66	4.55	204.4	42078	13	-3.0
2010	8.7	200.00	3399.60	4.62	208.8	42673	12	-3.0
Average annual growth rate								
1992-2000	---	---	---	-0.44	2.30	1.48	---	---
2000-2010	---	---	---	-0.27	2.50	2.67	---	---
1992-2010	---	---	---	-0.35	2.41	2.14	---	---

Table 7: Cost-benefit analysis of energy savings (millions \$)

	Hydro-Québec plan		50% energy savings		Temporary displacement	
	Present value	Annual equivalent	Present value ^a	Annual equivalent	Present value	Annual equivalent
Consumers						
- Bill savings						
1992-2010	4045.75	349.14	2536.13	218.86	3517.06	303.51
2011-2030	1691.44	145.97	728.13	62.84	376.26	32.47
- Consumer surplus	122.43	10.57	-772.77	-66.69	-372.01	-32.10
- Cost	-1173.02	-101.23	-1173.02	-101.23	-1173.02	-101.23
- Total	4686.60	404.44	1318.46	113.78	2348.29	202.65
Producer						
- Variable profits						
- Net investment expenses	-1379.85	-119.08	-94.06	-8.12	-547.42	-47.24
- Total						
Government						
	1580.15	136.36	1066.40	92.03	1308.28	112.90
	200.30	17.29	972.33	83.91	760.86	65.66
	-407.93	-35.20	-213.08	-18.39	-288.59	-24.90
TOTAL	4478.97	386.52	2077.72	179.30	2820.56	243.41

Notes

1. For a presentation of the adoption of Demand Side Management programs by U.S. electric utilities, see Mitchell (1992).
2. For a critical analysis, see Joskow and Marron (1992).
3. For an exception, see Dumagan and Mount (1993).
4. All monetary amounts are in terms of 1992 Canadian \$.
5. See Hydro-Québec (1992d).
6. Hydro-Québec (1992c).
7. For the purpose of this study, the aggregate amount is distributed evenly from 2001 to 2010.
8. Hydro-Québec (1992a).
9. Hydro-Québec did not consider substitution to other energy sources such as natural gas or oil products as a way of reducing electricity consumption.
10. The two criteria will be described more at length in the following section.
11. Interest coverage is defined as the ratio of income before interest payment over gross interest payment. It measures the capacity of the utility to cover interest payment without borrowing for such a purpose and its expected value is at least one.
12. The target value of the debt/equity ratio is equal to or less than 3/1. At least 25% of investment expenses have to be paid out of net income.
13. For a more detailed presentation of the model, see Bélanger and Bernard (1992).

14. No electricity demand adjustments are made due to the changes in the price of energy services. Dumagan and Mount (1993) found these additional effects to be small in the residential sector.
15. See Varian (1984, p. 144). Hicks compensating variation is also used frequently for such purpose. For small price changes, Hicks and Slutsky compensating variations are approximately equal.
16. No allowances are made for non electricity specific taxes since their net effects would embody activities transfer from one sector to the others. This is a task which goes beyond the limits of the present analysis.
17. The annual demand reductions under this assumption are displayed in Figure 2.
18. This is the assumption made by Hydro-Québec.

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