Employment Effects of Electricity Conservation: The Case of British Columbia

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Electricity conservation has been pursued by utilities largely because of its cost-advantages over new electricity generation and, more recently, due to its contribution to environmental goals. This study assesses the effect of electricity conservation on employment. Seventeen BC Hydro conservation programs are forecast over 20 years in order to estimate their effect on direct employment, electricity savings and total cost (including administration and incentives). The direct employment estimates are used to drive a provincial input-output model to forecast indirect and induced employment. Conservation is then compared to the employment creation and cost of new electricity generation in order to calculate the net employment created by the electricity conservation programs. Investment in conservation instead of new generation should increase employment in BC over the next 20 years by 11,859 person-years. This is in part explained by the greater labour intensity of conservation investments, but also by the economic growth that ensues when low-cost conservation is pursued instead of higher cost electricity generation. Evidence from several studies supports these findings, suggesting that conservation investments will have similar employment benefits elsewhere.

Les programmes d'économie de l'énergie électrique trouvent faveur auprès des entreprises productrices d'électricité surtout parce qu'ils présentent, par rapport à la construction de nouvelles centrales, des avantages sur le plan du coût et aussi, plus récemment, parce qu'ils contribuent à l'atteinte des objectifs en matière de protection environnementale. L'étude cherche à évaluer les effets de l'économie d'énergie électrique sur l'emploi. Les auteurs établissent des projections sur 20 ans pour 17 projets d'économie mis sur pied par BC Hydro afin d'estimer leurs effets sur l'emploi direct, l'économie d'énergie électrique et le coût total (y compris les frais d'administration et les incitations). Les estimations de l'emploi direct sont intégrées dans un modèle input-output provincial pour évaluer l'emploi indirect et l'emploi induit. L'économie d'énergie est ensuite comparée aux emplois créés et au coût de la production d'énergie électrique nouvelle afin de calculer la création nette d'emplois par les programmes d'économie d'énergie. L'investissement dans les programmes d'économie d'énergie plutôt que dans de nouvelles centrales ferait accroître l'emploi en Colombie-Britannique de 11 860 années-personnes au cours des 20 prochaines années. Cela s'explique en partie par la plus grande intensité de main-d'oeuvre des investissements dans les programmes d'économie d'énergie et aussi par la croissance économique qui résulterait des coûts plus faibles des programmes d'économie par rapport à ceux de la production d'énergie électrique. Plusieurs autres études abondent dans le même sens, ce qui laisse supposer que les investissements dans les programmes d'économie d'énergie auraient, ailleurs, les mêmes effets positifs sur l'emploi.

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1. Introduction

Demand-side management (DSM) refers to programs run by electric utilities to encourage either a shift in electricity demand to off-peak periods or a reduction in electricity demand through improved end-use efficiency. Utility-fostered DSM programs grew dramatically in the US in the 1980s as utilities often found them to be less costly than investments in new capacity to satisfy peak or total load requirements.

The diffusion of DSM to Canada has been somewhat slower, but in recent years BC Hydro and Ontario Hydro have initiated ambitious programs. By the end of 1990, BC Hydro's *Power Smart* initiative comprised 25 different programs designed to "encourage customers to use electricity efficiently, using a variety of means including financial incentives" (BC Hydro, 1990a).

Utilities are interested in DSM that is less costly than conventional electricity generation investments. Thus, DSM programs are generally evaluated against the life cycle cost[1] of the

1/ Calculation of life cycle cost involves the following: capital cost of an electricity supply (or conservation) investment is converted to an annuity, added to all annual operating and maintenance costs, then divided by the annual electricity output (or savings) to produce a ratio of costs per unit of electricity generated (or saved), usually expressed as cents/kilowatt hour (kWh).

utility's next major generation project. To quote BC Hydro (1989), "Power Smart is one of the cheapest forms of energy available today."

However, cost is not the only factor determining decisions to build or not build energy megaprojects. This is especially so in Canada, where publicly-owned electric utilities are occasionally seen as instruments of macroeconomic policy with the means to dramatically stimulate the growth of provincial economies (Bernard and Payne, 1987).

It is of interest, therefore, to compare DSM investments with investments in new generation not just in terms of cost, but also in terms of their impact on provincial employment and income. That is the objective of this study.[2] It examines the 17 DSM programs initiated in 1988 by BC Hydro and compares their projected employment and income effects on the provincial economy with alternative investment in the Site C Dam, the utility's next major hydroelectric project. The method of analysis is based on 20 year forecasts using BC Hydro's model of DSM investment and the BC Ministry of Finance and Corporate Relations' provincial input-output model.

2. Methodology

2.1 Employment and Income Effects of Investments

A dollar spent on either electricity supply or conservation[3] circulates and recirculates within the economy, multiplying the effect on overall economic activity.

Through this multiplier effect, a new investment stimulates economic activity in three ways. The initial outlay on wages and materials is referred to as the *direct expenditure* (e.g., the purchase of an electric water heater and the wages paid to labourers for its installation). Subsequent purchases by suppliers of materials and services are called *indirect expenditures* (the water heater manufacturing company's purchases from various suppliers of aluminum, fiberglass, heating elements and plumbing accessories, as well as the wages of its employees). *Induced expenditures* occur when workers in the sectors stimulated by direct and indirect expenditures spend their additional income.

A fourth effect on aggregate economic activity can result when alternative, mutually exclusive investments have different life cycle costs for the same service. For example, although extra insulation on an electric water heater and a hydroelectric project differ dramatically in nature and scale, they are alternative investments. Both are intended to provide the same level of energy service, one by reducing heat loss, the other by providing additional electric resistance heat to supplant the heat lost by a water heater with less insulation. These investments can be compared in terms of life cycle cost, one measuring the cost per kWh of electricity generated, the other measuring the cost per kWh of electricity conserved. If society makes a conservation investment which is cheaper per kWh than the supply investment, there is an increase in social income — less has been paid for the same level of well-being, freeing income for additional expenditures. This fourth effect is called the *respending effect.*

Investing in a particular sector may divert economic activity from another sector. Investment in electricity conservation will reduce the need for investments in generation, together with the direct, indirect and induced effects associated with the latter. The loss of these jobs and income is called the *displacement effect*. Investments differ in their relative requirements of labour, capital, materials and energy. Thus, it is possible that an investment that costs more per kWh than another will nonetheless produce more jobs, even though society's income will be reduced. When assessing the employment effects of an invest-

2/ This study was initiated in 1989 with funding from BC Hydro. In January 1991 the crown corporation re-emphasized its focus on electricity conservation in the coming years, increasing the DSM budget from $225 million to $600 million, with projected savings of 5,600 gigawatthours (GWh)/year instead of 2,700 GWh/year. See *Vancouver Province* (1991a and 1991b).

3/ 'Conservation,' which is the popular term for energy efficiency improvements, is used throughout this paper, despite the fact that it is a misnomer since, according to the first law of thermodynamics, energy is always conserved.

ment, it is therefore important to include the employment foregone by not making the most likely alternative investment.

All of the five effects outlined above must be accounted for if one wishes to assess the net impact on employment of an investment in electricity conservation (Margolick, 1984). The calculation should therefore add direct, indirect and induced effects, subtract displacement effects from foregone alternative investments, and add (subtract) respending effects if the investment is cheaper (more costly) relative to foregone alternative investments. Equation (1) outlines the three parts of this calculation: net employment = gross employment from Power Smart - the displacement effect from Site C + the respending effect.

(1) $NE_p = (D_p+I_p+J_p) - ((D_s+I_s+J_s) \times (E_p \backslash E_s)) + (C_s-C_p) \times E_p \times FDM$, where

NE = net employment effect (person-years);
D = direct employment;
I = indirect employment;
J = induced employment;
E = cumulative discounted electricity savings (generation);
C = life cycle cost of electricity savings (generation);
FDM = final demand multiplier, representing the total person-years of employment (D+I+J) created by $1 million increase in consumer income;
p = Power Smart; and
s = Site C.

2.2 Forecasting Conservation Investment and Savings in BC

Utilities pursue DSM because of asymmetry in electricity investment markets. While utilities are willing to invest in new generation if it meets a 6-8% rate-of-return threshold, consumers (residential, commercial and industrial) have been found to be much more demanding when they contemplate electricity conservation investments, often requiring a rate-of-return of 30 percent or higher (Fisher and Rothkopf, 1989; Jochem and Gruber, 1990; Tremain, 1990). As a result, society tends not to follow a least-cost electricity investment path, instead it over-invests in new generation relative to lower cost conservation options.

The instruments for increasing investment in conservation can be divided into four broad categories: pricing (e.g., price increases, rate design), regulation (e.g. appliance efficiency standards, building codes), financial inducement (e.g., equipment purchase rebates and tax credits), and information (e.g., energy audits, product labelling, demonstration projects and advertising). BC Hydro is actively pursuing the first instrument, having recently submitted proposals to the BC Utilities Commission for price increases and changes in rate design, both justified on the basis of encouraging electricity conservation. The second category, regulation, is the jurisdiction of government, and beyond the utility's authority. BC Hydro's Power Smart programs are comprised of the latter two instruments, financial inducement and information.

Table 1 provides a brief description of each of the 17 Power Smart programs modelled in this study. The programs involve expenditures by consumers, but also expenditures by BC Hydro in grants, information provision and additional administrative costs. From society's point of view, all of these additional costs to BC Hydro must be included in the total social cost of electricity conservation, for without them the investments would not occur.

BC Hydro has a model, called Javelin, which forecasts the total social costs and electricity savings of each DSM program over time. Social costs are a function of the incremental capital and installation costs of more efficient equipment,[4] the forecast 20 year market penetration rate of

4/ If Power Smart incites an expenditure that would not otherwise occur (e.g. extra insulation), all installation and capital costs are counted as incremental. If Power Smart incites someone to pay more for a higher efficiency technology (e.g. an efficient refrigerator) at the normal time of equipment renewal, only the extra capital cost is counted as incremental. This distinction is to ensure that Power Smart is not credited with employment and investment that would have occurred in any case.

Table 1: Description of the Power Smart Programs

Residential Sector	
Domestic Hot Water Heaters	• rebates towards energy-efficient water heaters for new and replacement purchases.
Electric to Gas Domestic Hot Water	• a joint rebate program between BC Hydro, British Columbia Gas, and Pacific Northern Gas to convert electric hot water heaters to natural gas.
Jackets for Electric Domestic Hot Water	• insulating jackets are installed free of charge to reduce heat loss.
Refrigerator Efficiency	• cash rebates for purchase of energy-efficient refrigerators.
Quality Plus Home	• encourages construction of more energy-efficient, electrically-heated homes.
Residential Retrofit	• rebates to upgrade existing electrically-heated homes.
Commercial Programs	
New Commercial Building	• rebates for the cost of an energy-efficient building design and separate rebates for implementing EE designs.
Commercial Building Retrofit	• rebates to upgrade the efficiency of electricity use in commercial and institutional buildings.
Lighting Programs[1]	
Lighting-Custom	• provides incentives for various lighting technologies.
Lighting-Industrial	• rebates to convert to more energy-efficient "high intensity discharge" lighting equipment in industrial buildings.
Lighting-Electronic Controls	• rebates to install electronic controls that facilitate more efficient use of lighting equipment.
Lighting-Commercial Fluorescent	• rebates to convert to more energy-efficient fluorescent lighting equipment.
Lighting-Incandescent	• incentives to convert to more energy-efficient krypton-filled incandescent bulbs.
Lighting-Reflectors	• rebates to install parabolic reflectors in existing lighting fixtures.
Industrial Programs	
Plant Energy Audit Program	• funds energy audits in industrial plants. Offers incentives to implement energy-saving measures.
High Efficiency Motors	• rebates to purchase energy-efficient electric motors instead of standard models.
Variable Speed Drives	• rebates to install variable speed drives to increase energy efficiency of machinery.

1 / Residential, commercial and industrial

this equipment, and all of BC Hydro's DSM inducement and administration costs. Electricity savings are a function of the forecast market penetration rate and reduced electricity consumption of more efficient equipment. Annual electricity savings are projected to be small in earlier years, but to increase in step with the market penetration of more efficient technologies. This 20-year stream of costs and electricity savings can be discounted and converted into present value estimates of total investment, total electricity savings and life cycle cost of annual electricity savings.

The information in the Javelin model also enables one to estimate the creation of direct employment in various sectors of the economy from DSM investment. An input-output model is required to calculate the indirect and induced employment effects.

2.3 Input-Output Modelling

An input-output model is a matrix of coefficients which link all sectors of the economy, each coefficient indicating how direct expenditures in one sector lead to indirect expenditures in other sectors. Input-output models can also track employment generated by expenditures in each sector (Weber and Butcher, 1988).

The British Columbia Input-Output Model (BCIOM), used in this study, is operated by the BC Ministry of Finance and Corporate Relations. Like most input-output models, the BCIOM is static in that its coefficients (calculated from 1984 data) represent a one time snap-shot of intersectoral linkages in the economy. Therefore, data from the Javelin model, on all direct conservation expenditures and employment over time, were discounted back to one time period in order to be compatible with the BCIOM. With these direct expenditures and employment allocated to the BCIOM's 602 commodity categories, a separate run was executed for each of the 17 Power Smart programs to estimate indirect and induced expenditures and employment.[5]

Table 2: Power Smart Employment in Person-Years

Program	Direct (D)	Indirect (I)	Induced (J)	Gross (G)
EE DHW	13.2	15.4	16.2	44.8
E to G DHW	180.2	46.2	74.3	300.7
DHW Jack	15.0	32.5	37.0	84.5
EE Refrig.	5.3	39.6	12.8	57.7
Q Plus Home	272.8	194.9	145.7	613.4
Res Retro	507.4	240.8	353.0	1101.2
New Comm Bldg	485.3	386.0	281.4	1152.7
Comm Bldg Retro	194.6	65.2	86.1	345.9
L-Custom	21.3	3.3	6.7	31.3
L-Industrial	664.4	228.7	244.9	1138.0
L-Elec Controls	152.3	28.8	52.3	233.4
L-Comm Fluor	66.0	13.6	24.6	104.2
L-Incand	63.4	6.8	21.9	92.1
L-Reflect	133.6	46.6	50.8	231.0
Plant Audit	112.9	180.9	86.2	380.0
Elec Motors	6.2	11.7	7.7	25.6
Vari Drive	288.1	34.1	98.2	420.4
PS Total	3182.0	1575.1	1599.8	6356.9

3. Results

3.1 Gross Employment Effects of Power Smart

Table 2 presents the aggregate results of the 17 simulations of the BCIOM model. The Power Smart programs are forecast to create 6,357 person-years of employment over the next 20 years and save a present value of 24,421 GWh[6] at a weighted average life cycle cost of 1.91 cents/kWh ($1990). A standard indicator of the multiplier effect is the ratio of total employment to direct employment. For Power Smart it is 6357/3182 = 2. One would expect a higher ratio in a province such as Ontario, where additional manufacturing employment and income would result from investments in electricity conservation.

The results in Table 2 represent gross employment effects. As indicated by Equation 1, the calculation of net employment effects requires estimates of the cost and employment creation of the most likely alternative investment. The Site C Dam was chosen since it has already undergone the energy project review process of the BC Utilities Commission and is considered to be BC Hydro's preferred next major hydroelectric project.[7]

3.2 Net Employment Effects of Power Smart

Previous research by Margolick (1984) provided a means of estimating the gross employment resulting from the Site C Dam and therefore the displacement effect of investing instead in con-

5/ The BCIOM is the BC portion of Statistics Canada's Interprovincial Model (1984 data), modified to include updated estimates of labour productivity (1988) and relative prices (1990), and to include the estimation of induced effects in addition to indirect effects. Allocation of income to imports and taxes is endogenously calculated by the model.

6/ A kWh, just like a dollar, is worth more in the present than in the future. Thus, future streams of costs and electricity savings are discounted back to the present using a 6% real discount rate.

7/ However, more recent BC Hydro plans suggest that smaller hydroprojects are likely to proceed ahead of Site C, and a wealth of potential from conservation and non-utility alternatives has lead to the project's postponement until at least the end of the decade.

Table 3: Site C: Employment, Electricity and Cost

Employment (person-years)	12,191
Electricity Output[1] (GWh)	81,801
Life Cycle Cos (cents/kWh)	5.03

1. Annual electricity output over 70 years discounted (6%) back to present and summed.

Table 4: Comparison of Gross Effects: Scaled Site C and Power Smart

	Scaled Site C	Power Smart
Employment (person-years)	3,641	6,357
Electricity Output[1] (GWh)	24,421	24,421
Life Cycle Cost[2] (cents/kWh)	5.03	1.91
Jobs/$1 Million[3]	3	13.5

1. Annual electricity output over 70 years discounted (6%) back to present and summed.
2. Life cycle cost of Power Smart is an average of the 17 programs, weighted by the contribution of each to total electricity savings.
3. Person-years of employment created per million dollars of investment.

servation.[8] Table 3 shows the gross employment effects of 12,191 person-years of the Site C Dam, as well as present value of electricity production of 81,801 GWh and life cycle cost of 5.03 cents/kWh (BC Hydro, 1990b).

For comparison with Power Smart, the Site C results must be scaled down so that Site C's present value of electricity generation equals Power Smart's present value of electricity savings of 24,421 GWh. Table 4 shows the scaled results, including a ratio of person-years of employment created per million dollars of expenditure. The results show that electricity conservation in BC is both labour intensive and cost-effective relative to large hydroelectricity generation. Per kWh of electricity produced or saved, Power

Table 5: Calculation of Respending Effect

Program	Savings[1] ($)	FDM[2] (P-Y)	Respending (P-Y)[3]
EE DHW	8,679,946	12	104.16
E to G DHW	122,817,794	12	1473.81
DHW Jack	11,301,633	12	135.62
EE Refrig.	11,781,429	12	141.38
Q Plus Home	-16,403,847	12	-196.84
Res Retro	-51,175,384	12	-614.10
New Comm Bldg	52,928,882	12	635.15
Comm Bldg Retro	24,871,039	12	298.45
L-Custom	22,089,016	12	265.07
L-Industrial	72,255,434	12	867.07
L-Elec Controls	23,386,877	12	280.64
L-Comm Fluor	84,249,112	12	1010.99
L-Incand	101,167,913	12	1214.02
L-Reflect	42,077,752	12	504.93
Plant Audit	50,624,138	12	607.49
Elec Motors	107,784,314	12	1293.41
Vari Drive	93,537,804	12	1122.45
PS Total	761,973,861		9143.70

1. Savings is the difference in cost per GWh, multiplied by the output of Power Smart. This was divided by 1 million before multiplying by the final demand multiplier (FDM).
2. The FDM is the number of jobs created by $1 million of typical consumer spending. This multiplier was generated by the BCIOM.
3. P-Y = Person-years.

Smart creates almost twice as many person-years of employment as Site C. Also, the weighted average life cycle cost of Power Smart electricity is less than half that of Site C. Finally, per dollar of investment, Power Smart creates more than four times as many person-years of employment as Site C.

The increase in provincial income associated with investment in Power Smart instead of Site C would generate a substantial respending effect. The respending benefits are those arising

8/ The British Columbia Utilities Commission (1983) states that the Site C Dam would create 5418 person years of direct employment. Margolick (1984) ran the BCIOM to estimate indirect and induced employment from the Keenleyside and Murphy hydroelectric projects and calculated a multiplier of 2.25 (total employment divided by direct employment). Applying this multiplier to Site C gives an estimate of total person-years of employment of 12,191.

from the lower cost of the Power Smart electricity savings. A BCIOM run was used to estimate the final demand multiplier, which is the total employment resulting from the expenditure of $1 million in a typical spending pattern.[9] The final demand multiplier was then multiplied by the total monetary savings or additional costs of each Power Smart program relative to Site C. The results are presented in Table 5. For a total present value electricity output of 24,241 GWh, investing in the Power Smart program instead of the Site C Dam would increase provincial income by a present value of $762 million. Note that some programs, such as Residential Retrofit, have a negative respending effect; this is because these programs, as initially designed in 1988, were forecast to have higher life cycle costs than Site C.[10]

With the respending effect calculated, it is now possible to estimate the net employment effect of investment in the Power Smart program, as in Equation 1 above. Table 6 summarizes this calculation for each of the 17 programs. The first and second columns indicate the gross employment effects of Power Smart and the scaled-down Site C, this latter being the displacement effect. The third column restates the respending effect results from Table 5. The final column shows the net employment effects for each program. Note that although Residential Retrofit had a negative respending effect, its net effect on employment is positive. This is because of its high labour intensity relative to Site C (columns one and two).

The total net employment generation of the Power Smart programs assessed in this study is 11,859 person-years. Of this total, 9,144 person-years (77%) is attributable to the respending effect, the lower life cycle cost of conservation relative to new supply.

4. Discussion and Caveats

This study is based on many assumptions, some of which have important implications for interpreting the results. Several of these are discussed in this section.

1) Although it is here assumed that Power Smart and Site C are mutually exclusive, they need not be. If both investments produce a positive economic return (perhaps in concert with an electricity export policy) they could both be undertaken. Nonetheless, it is valid to argue that extra investment in electricity conservation should, all things being equal, reduce investment in electricity supply.

2) An input-output model is a static representation of the economy, estimated from the transactions that occurred in one recent year. How-

Table 6: Net Employment Benefit in P-Ys of Investing in Power Smart instead of Site C

Program Name	Power Smart (P-Y)		Site C Equiv (P-Y)		Respending Effect (P-Y)		Results (P-Y)
EE DHW	44.80	-	36.19	+	104.16	=	112.77
E to G DHW	300.70	-	389.15	+	1473.81	=	1385.36
DHW Jack	84.50	-	56.78	+	135.62	=	163.34
EE Refrig.	57.70	-	60.92	+	141.38	=	138.16
Q Plus Home	613.40	-	67.81	+	-196.85	=	348.74
Res Retro	1101.20	-	95.95	+	-614.10	=	391.15
New Comm Bldg	1152.70	-	345.90	+	635.15	=	1441.95
Comm Bldg Retro	345.90	-	127.20	+	298.45	=	517.15
L-Custom	31.30	-	70.37	+	265.07	=	226.00
L-Industrial	1138.00	-	549.82	+	867.07	=	1455.25
L-Elec Controls	233.40	-	123.71	+	280.64	=	390.33
L-Comm Fluor	104.20	-	267.87	+	1010.99	=	847.32
L-Incand	92.10	-	321.87	+	1214.01	=	984.24
L-Reflect	231.00	-	191.65	+	504.93	=	544.28
Plant Audit	380.00	-	205.95	+	607.49	=	781.54
Elec Motors	25.60	-	340.73	+	1293.41	=	978.28
Vari Drive	420.40	-	389.06	+	1122.45	=	1153.79
PS Total	6356.90	-	3640.93	+	9143.68	=	11858.68

9/ This simplistically assumes that all electricity conservation cost savings will appear in the economy via higher disposable incomes. In reality, electricity conservation in the residential sector will reduce consumers' electricity bills, thereby increasing disposable income. But savings in the industrial and commercial sectors may show up in higher taxes to government or higher dividends to shareholders. Some of the dividends may leak from the economy. And there are several alternative uses for higher government revenues (e.g. tax reductions, debt reduction, greater spending) each with its own particular effect on employment.

10/ The residential retrofit program has since been redesigned so that its life cycle cost is substantially reduced.

ever, BC Hydro's expenditure patterns may alter the structure of the provincial economy over time by creating favourable opportunities for new businesses and services. Thus, the Power Smart program can be expected to foster the emergence of local economic activity and linkages related to electricity conservation, thereby increasing the indirect and induced employment effects over that suggested by the provincial economic structure of 1984. For this reason, the input-output simulations may have underestimated Power Smart's effect on provincial employment. This also explains why the calculated multiplier of two is at the low range of most multiplier estimates.

3) There are other assumptions in input-output models that can be in error. These include: (a) that lower-level structural change within each sector in the input-output model does not affect the results, and (b) that the cost of production and the prices of goods and services do not vary with the level of output. If any of these assumptions are invalid, the estimated employment benefits of Power Smart may be biased. Since in this study the existence of such bias is unknown, it is impossible to say if Power Smart's employment benefits are under or overestimated.

4) The decision to scale-down the Site C investment and output to match the electricity savings of the Power Smart programs (2700 GWh/year) assumes a stable cost of additional electricity conservation. If it became necessary to conserve electricity equal to the output of the Site C dam (4730 GWh/year), would the weighted average cost per kWh of electricity conservation remain roughly constant or increase? If the cost increased significantly, the advantages of conservation associated with the respending effect would diminish, although this may be partly offset by the labour-intensity of the next set of conservation measures.

5) The gross employment creation of Site C was estimated using the multiplier that resulted from the Keenleyside and Murphy hydroelectric projects in the 1979 version of the BCIOM (Margolick, 1984). To the extent that these projects differ from Site C, and that the 1979 version of the BCIOM differs from the 1984 version, the results will be biased. Again, the direction of the bias is unknown.

6) Perhaps the most tenuous component of this study is the estimate from the Javelin model of the quantity and life cycle cost of electricity savings. Although this estimate is in part based on past experience in BC and elsewhere, it is largely a best guess of the rates of penetration and the performance characteristics of efficient technologies in response to BC Hydro's financial inducements and information campaigns.[11] If financial inducements must be dramatically increased to achieve the projected penetration rates, the life cycle cost of electricity conservation will increase and employment benefits due to the respending effect will decrease. As a sensitivity analysis, we tested a higher life cycle cost for Power Smart induced electricity conservation. We arbitrarily increased the weighted average cost of Power Smart electricity conservation from 1.91 cents/kWh to 3 cents/kWh. As a result, jobs from the respending effect decreased from 9144 to 5948, thus giving a net employment creation effect of 8664 instead of the initial estimate of 11,859.

7) It is assumed in this analysis that there is an available surplus of unemployed labour, either in BC or elsewhere, over the next 20 years. In a country with a stable or declining labour force at full employment, such as Sweden, one could argue that the cost savings of electricity conservation would translate into higher income levels but not greater employment.

8) The results of this study are not without implications for the estimation of electricity savings from conservation programs. The logic of the respending effect applies not just to the labour input to production, but also to inputs like electricity. If the savings from investing in low cost conservation lead to an increase in the de-

11/ Fortunately, an increasing number of hindsight evaluations of US utility DSM programs of the 1980s are improving the ability to forecast the market response to various types of inducements. BC Hydro analysts refer to these studies when generating input estimates for the Javelin model.

mand for goods and services, this may lead to increased employment, but also to increased demand for some of the services for which electricity is an input. The magnitude of this rebound effect is difficult to estimate, but for some energy services it may be significant.

5. Conclusion

Governments simultaneously pursue many objectives, often involving difficult trade-offs. One objective is that energy investments be economically efficient. Another is that they create employment. Ideally they would do both.

The electricity conservation investments investigated in this study appear to meet the dual objectives of economic efficiency and net employment creation. Power Smart-induced electricity conservation investments in BC are forecast to produce more jobs per dollar invested and per kWh saved (or generated) than the Site C Dam. Moreover, because these conservation investments are less costly, the resulting increase in income will add additional job creation to the already positive result. This is consistent with other studies comparing the employment benefits of electricity conservation and new electricity generation from various sources, including nuclear power and fossil fuels (Buchsbaum et al., 1979; Charles River Associates, 1984).

The employment created by conservation and new generation can differ in timing, location and type. This may have policy implications.

Almost all the employment creation of a large hydroelectric project occurs during the construction phase, a period of seven years for the Site C Dam. In contrast, the employment created by conservation programs is associated with market penetration rates and is therefore more evenly spread over time. A hydroelectric project represents a significant stimulus to a provincial economy, which makes it a potential macroeconomic tool for offsetting cyclical downturns. However, the long construction period may not correspond with the economic cycle, so that much of the construction activity may occur when the economy is already into an upswing. Those conservation programs that are tied to the acquisition of new equipment (e.g., electric motors) and construction of buildings (e.g., electrically heated homes) offer negligible timing flexibility; the opportunity for conservation only presents itself at the time of acquisition. However, many types of conservation programs allow considerable macroeconomic flexibility because their financial inducements can be increased or decreased on short notice. This is especially true for programs designed to retrofit existing equipment (e.g., water heater insulating covers) and buildings (e.g., residential retrofit). Thus, the results of this study suggest that regions that are particularly affected by economic recession, such as Ontario in 1991, would benefit by quickly intensifying certain but not all of their electricity conservation programs.

Compared to an electricity megaproject, conservation-induced employment is also more evenly spread geographically. The resource to be tapped is located in homes, shops and factories throughout the province instead of in one valley in its northeast corner (such as Site C). It is possible to vary the conservation effort as an instrument of regional development; this potential is currently being explored in the US Pacific Northwest where some districts with high unemployment have launched particularly aggressive conservation programs (Colletta, 1989).

The types of jobs created by electricity conservation may differ from those associated with a large hydroelectric project. The latter will have a high ratio of well-paid construction jobs. However, conservation also provides substantial opportunities for electricians, carpenters and various trades associated with light manufacturing, opportunities that will not require relocation to remote sites.

The socially desirable level of electricity conservation investment will not occur on its own. Research consistently shows that electricity markets require some form of intervention, whether by government or utilities. This necessity has become even more obvious in recent years, as mounting concerns for the negative environmental externalities caused by electricity production have made electricity conservation even more attractive. The results of this study provide empirical evidence in support of the argument that electricity conservation is an investment that can help governments to achieve several objectives simultaneously: economic growth, employment, regional development, and environmental improvement.

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