Public Utility Finance and Economic Waste

Glenn P. Jenkins
Department of Economics, Queen's University, Kingston, Ontario K7L 3N6, Canada and
Eastern Mediterranean University, North Cyprus
E-mail: jenkins@econ.queensu.ca

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Abstract

This paper explores the ways in which the low-cost financing of publicly owned electric utilities in Canada has resulted in both income transfers and the creation of economic waste. Economic waste arising from the low financial cost of public funds is created through the effect that subsidized capital has on the choice of technology; through the direct and indirect export of electricity sold at prices below its cost; and through the effect that low electricity prices have by inducing Canadians to overconsume electricity. Expressions are developed that enable the estimation of the magnitudes of these various economic losses. The estimated losses are very large and amount to an annual loss of approximately one percent of Canada's GNP.

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Abstract. This paper explores the ways in which the low-cost financing of publicly owned electric utilities in Canada has resulted in both income transfers and the creation of economic waste. Economic waste arising from the low financial cost of public funds is created through the effect that subsidized capital has on the choice of technology; through the direct and indirect export of electricity sold at prices below its cost; and through the effect that low electricity prices have by inducing Canadians to overconsume electricity. Expressions are developed that enable the estimation of the magnitudes of these various economic losses. The estimated losses are very large and amount to an annual loss of approximately one percent of Canada's GNP.

Le financement de services publics et le gaspillage économique. Ce mémoire examine les transferts de revenus et le gaspillage économique engendrés par le financement à bas coûts des investissements publics dans le secteur de l'électricité au Canada. Le gaspillage vient des effets de capital subventionné sur le choix de la technologie, des exportations directes et indirectes d'électricité à des prix plus bas que les coûts, et de la surconsommation d'électricité par les Canadiens à cause des prix très bas. On développe des ordres de grandeur pour chacune de ces pertes économiques. Ces pertes sont importantes et en arrivent à constituer une perte annuelle d'à peu près un pourcent du PNB canadien.

INTRODUCTION

This study examines the impact which government ownership and the resulting financing policies of electric utilities have had on the allocation of capital and economic welfare in Canada. It is found that the economic rates of return produced by capital in this sector have been much lower than the economic opportunity cost of public funds (see Jenkins 1977, 13 and 74). If the public electric utility industry were a relatively small user of the country's factors of

production, then on practical grounds one might not be particularly concerned by the present form of organization and structure of the financial incentives given to the sector. But this has not been the case. At the present time approximately 13 per cent of the total industrial capital stock in Canada is located in these public electric utilities, of which 90 per cent are owned by provincial governments. In addition, these utilities have accounted for approximately 14 per cent of gross capital investment in Canada during the past ten years.[1]

THE FINANCIAL COST OF INVESTMENT IN PUBLIC ELECTRIC UTILITIES VERSUS THE ECONOMIC COST TO CANADA

Public electric utilities have operated in Canada with varying degrees of government control. A common form of organization is one where the government owns the equity of the utility while allowing it to operate in a manner similar to that of a private business. However, approval by a government or a regulatory authority is usually required by the utility on pricing and investment policies.

Public electric utilities in Canada receive two special concessions not given to private enterprises. First, provincially owned public electric utilities are exempt from federal income taxes. Second, when they borrow in the capital markets their loans are guaranteed by the provincial governments, enabling them to borrow more cheaply because they do not have to compensate the lenders for the risk of default. These concessions, in combination, seem to be the root cause of much of the economic inefficiencies found in this sector.

The implicit or explicit government guarantee of the debt against default greatly reduces the utility's financial need for equity funds. Even though a public utility has a very high debt/equity ratio, the private capital markets may still give it a better credit rating and allow it to borrow at a lower interest rate than can a private utility or other private companies similarly situated. This puts the government-owned public utilities in a special position. It enables them to compete for scarce capital and allows them to engage in more risky and lower-return projects.[2]

The operating guidelines found in most of the legislative charters creating these enterprises instruct the utilities to operate in a manner so as to meet the economy's demand for electricity with a level of reliability consistent with 'good utility management.' This entails charging the minimum rates for electricity that will enable the utilities to recover only their financial costs.[3] However, the financial costs as seen by the utility are not the same as the

1 Computed from Statistics Canada (1929-81).

2 The marginal cost of debt usually rises with the debt/equity ratio of the firm because of the risk of default. For an empirical estimation of this effect see Tambini (1969, 185-222).

3 For the example of British Columbia see B.C. Hydro (1975).

economic costs the country bears from the operation of this sector. In addition to the exemptions from paying income taxes and earning a rate of return on their borrowed funds equal to the social opportunity cost of these funds, public electric utilities are generally not required by the provincial governments to earn the normal private sector rate of return on their equity capital. The combination of these factors is likely to ensure that these enterprises will not earn a return as large as the economic opportunity cost of the capital they employ.

During the past twenty-five years the private manufacturing and non-manufacturing sectors of the Canadian economy have earned a private rate of return on their total invested capital net of taxes and inflation, of approximately 6 per cent annually.[4] In addition, these investments have produced tax payments (corporate income, property and sales taxes) averaging approximately 5 per cent of their net replacement value. Using estimates of the economic return generated by various private sectors of the economy for the period 1965-74, along with estimates of the cost of foreign borrowing by Canada, a calculation has been made of the economic opportunity cost of borrowed funds invested in the public sector. This variable is estimated to be equal to a real (net of inflation) rate of about 10 per cent per year, and in the analysis that follows values of 8 and 10 per cent are used (Jenkins, 1977, 128-40). Stated simply, unless the projects undertaken by the electric utilities can produce a rate of return of at least equal to the economic opportunity cost of borrowed funds, the country is made economically worse off by investing funds in such enterprises.

It has sometimes been suggested that a significant part of the implicit subsidy given to public enterprises could be eliminated by making them subject to the same corporation income tax legislation and tax rates applied to private corporations (see Gillis and McLure, 1976). Unfortunately, this prescription will not be effective.

Provided the government stands willing to guarantee the repayment of the utility's debt should financial difficulties arise, the debt/equity ratio of a public electric utility can be set almost arbitrarily. Hence, as interest payments are deductible from taxable income, the base for the income tax can be almost completely eliminated simply by financing most capital expenditures by borrowing.

In order to ensure that investments made in this sector produce an economic rate of return that is at least as large as the social opportunity cost of public funds, it would be necessary for the government to set a minimum acceptable

4 For the period 1955 to 1965 private and social rates of return from investment are presented in Jenkins (1972). For the period 1965 to 1974 see Jenkins (1977). During this period the net private real rate of return in manufacturing and non-manufacturing has averaged 5.9 per cent, while the gross economic rate of return (but net of inflation) has averaged 10.8 per cent.

rate of return for the total invested capital in each enterprise. This rate of return must be calculated irrespective of the proportion of the investments that are financed by borrowing, new equity, or retained earnings.

Because public electric utilities generally have a monopoly in the supply of electricity, a minimum rate of return criterion will not guarantee that the utilities will operate efficiently, in the sense of operating in a cost minimizing manner.[5] However, it would eliminate the types of economic efficiency losses that arise because the perceived cost of capital is low, which encourages utilities to adopt production technologies which are too capital intensive; and because the average price for electricity is set below its economic cost. These factors also create an incentive for too much electricity to be consumed domestically and embodied in exports. The estimation of these economic efficiency losses is the subject of the remainder of this paper.[6]

THE ECONOMIC LOSS FROM UNDERVALUATION OF THE ECONOMIC COST OF CAPITAL IN PUBLIC ELECTRIC UTILITIES

The subsidization of the cost of capital results in several adverse economic welfare effects. Economic losses are created through the incorrect choice of technology used to produce electricity and the overconsumption of electricity, and through the subsidization of both direct electricity exports and indirect electricity exports arising from the sale of electricity-intensive goods.

Impact on domestic electricity consumption and choice of technology

The subsidization of the cost of capital and the financial cost recovery pricing policies of the public electric utilities lead to a situation where consumers are being charged prices for electricity that are below the economic costs of its production. These lower prices induce domestic consumers to expand their demand to a point where the value of the benefits they receive from this incremental consumption is less than the marginal economic cost of production. This results in a net loss of economic welfare.

At the same time, the use of a lower financial cost of capital instead of its economic opportunity cost causes the utility managers to develop production facilities that are too capital intensive. Highly capital-intensive technologies, such as remote hydro dams, tidal power, and nuclear generation stations, will become less attractive relative to fossil fuel plants if the economic rather than

5 The lack of cost-minimizing behaviour among regulated utilities, popularly known as the Averch-Johnson effect, will lead to economic losses over and above those estimated in this paper. Here only the economic losses created by the overconsumption and export of subsidized electricity and the use of the incorrect mix of inputs are estimated.

6 An additional source of efficiency loss arises when the structure of electricity rates charged at different times of the day and year does not reflect the relative economic costs of producing electricity during these periods. The analysis of this cause of economic waste, however, is outside the scope of this paper.

the financial cost of capital to the economy is recognized as the cost of capital for purposes of choosing generation and transmission technologies. Thus, the choice of an excessively capital-intensive technology for the production of electricity leads to economic inefficiency, since the value of the marginal product of capital in this activity is below the marginal economic cost of these resources to the country.

To measure the amount of economic loss created by the inefficient use of capital in public electric utilities it is necessary to estimate the increase in the quantity of capital used in electricity production in Canada over the amount that would be used if the investments were required to earn the economic cost of capital.

The measurement of the efficiency loss from the overconsumption of electricity and the excessive use of capital in production are estimated together, because they both are caused by the subsidization of a factor input, in this case capital, in the production of electricity. If no other distortions exist in other factor markets, the combined economic efficiency loss can be evaluated as the difference between the marginal economic cost of capital to the public utility sector and the marginal value of the capital as measured by the derived demand curve for capital in this sector (see Wisecarver, 1974, 359-72).

The method used here to determine economic loss from the misallocation of capital follows the approach developed by Harberger for the measurement of the deadweight losses created by non-neutral taxes and other similar distortions (1974, 25-75). In the case where distortions exist in other factor markets and the derived demand curves for factors are linear, the economic loss caused by the overconsumption of electricity and the use of too much capital in its production can be expressed as follows:

$$\text{EL}(1) = -(1/2D_i^*\Delta K_i + \sum_{j \neq i}^{m} D_j^*\Delta K_j), \tag{1}$$

where

$$\Delta K_j = \int_{D_i=0}^{D_i} (\partial K_j/\partial D_i)dD_i;$$

D_i^* is the difference between the social opportunity cost of capital and the rate of return earned by capital in the public electric utility sector and is expressed as a fraction of a dollar of capital; and K_i is the net replacement value of the capital stock in the ith sector. The subscript j refers to industries other than public electric utilities.

Some of the distortions (D_i^*) in the other economic activities will have negative values in the subsidized or low taxed sectors; also the term $\partial K_j/\partial D_i$ will have a positive or negative sign depending on whether the output of the jth sector is a complement or substitute for the ith sector. Therefore, the sign of the second term in equation (1) cannot be determined a priori. However, in the case of electricity we are able to make a prediction as to the likely sign this expression will take.

The sectors that are heavy users of electricity will have the largest incentive to expand when the price of electricity falls. These are activities such as pulp and paper production, primary metal industries, non-metallic mineral products, chemical industries, and street lighting. All these activities except chemicals produce less than the average amount of taxes and therefore, the externalities (D_i*s) associated with these activities are additional economic losses (see Jenkins 1977, 251). In addition, if capital is not in perfectly elastic supply to Canada, industries that use electricity less intensively will on average expand more slowly than they would have if electricity was more expensive. Since these industries in Canada have tended to pay relatively high rates of taxes, restricting their expansion will create a further welfare loss. Because of the differential taxation of capital, the economic loss from this distortion would be greater than that measured only by the first term of equation (1). In the empirical estimation of the economic losses below we assume that these secondary losses net out to zero; thus, the value of this loss is likely to be biased downward. Rewriting equation (1) to reflect this assumption, we have

$$\text{EL}(1) = -(1/2D_i^*\Delta K_i). \tag{2}$$

For an industry where factor prices are fixed, the relationship among the total demand for the factor, the demand for the output produced, and the factor substitution properties of the production function are as follows:[7]

$$N_k^T = a_k N_e^T + N_k^s; \tag{3}$$

where

N_k^T is the total elasticity of demand for capital defined negatively; N_e^T is the *total own price* elasticity of demand for electricity defined negatively;

N_k^s is the *substitution-effect-only own price* elasticity of demand for capital in the public electric utility sector, defined negatively; and

a_k is the share of the value added of capital net of depreciation in total output of the public electric utility sector.

The expression for the economic loss (2) can be rewritten as follows:

$$-1/2D_i^*\Delta K_i = -1/2(R_e - R_s)(\partial K/\partial R)(R_e/K_o)(K_oR_e) \times (V_D/V_T)(R_s - R_e) \tag{4}$$

or

$$\text{EL}(1) = 1/2[(R_e - R_s)/R_e]^2(V_D/V_T)K_oR_eN_k^T. \tag{5}$$

Now substituting equation (3) into equation (5) we obtain

$$\text{EL}(1) = 1/2[(R_e - R_s)/R_e]^2(V_D/V_T)K_eR_e(a_kN_e^T + N_k^s), \tag{6}$$

7 For a derivation of this relationship see R.G.D. Allen (1938) or J.R. Hicks (1963).

where EL(1) denotes the value of the economic loss from the misallocation of capital investments in electricity generation and the overconsumption of electricity because of the low return on capital in the public electric utility sector; R_e is the gross of tax rate of return from capital in the publicly owned electrical sector;[8] R_s is the social opportunity cost of public investment funds; K_e is the net replacement value of the capital stock of the public electric utility; V_D is the value of electricity produced by public electric utilities but consumed by Canadian residents; and V_T is the total electricity produced by public electric utilities.

The measure of these economic losses includes only the inefficiency that is related to the proportion of the electric utility industry producing electricity for domestic consumption. By ignoring the misallocation of capital investments on the part of the electricity generation industry that produces electricity either directly or indirectly for export, we are biasing downward our estimates of the economic inefficiency associated with publicly owned electric utilities.

Implicit subsidy given to export goods by electricity

A further economic loss occurs because Canada exports large quantities of primary materials whose production tends to be electricity intensive. If electricity is being sold at a price below its economic cost, then there is an implicit subsidy being given to these exported products.

If this electricity subsidy resulted in higher profits to owners of the production facilities who are Canadian residents, then there would be no economic loss, just an income transfer. However, the industries that are electricity intensive and also export products, such as pulp and paper and chemicals, are significantly foreign owned.[9] When this implicit electricity subsidy results in either higher profits to foreigners or serves as an offset to other financial costs of production, then the entire amount of the subsidy is a resource cost to Canada.

Although the electricity subsidy might assist in offsetting other higher production costs in Canada, its effective value is significantly less than the difference between its economic and financial cost. If public utilities charged higher prices, then many firms would switch to other sources of energy which would be relatively cheaper. Part of the response of a sector such as the forest industry would be to move more towards self-sufficiency in energy production. The forest industry can use hog fuel (waste wood) very effectively to generate steam and electricity. Because of the level of electricity rates and the declining block rate structure given to this industry in some parts of Canada, there is no

8 These taxes include some sales taxes on the value added of capital, provincial taxes on water rights, and municipal property taxes.

9 The percentages of the book values of these Canadian industries which were owned by foreigners in 1973 were: pulp and paper, 46 per cent; and chemicals, 81 per cent. Statistics Canada (1973-81).

financial incentive for the industry to self-generate. As a result, the industry in British Columbia is now paying to dispose of hog fuel as a waste product, although the cost to the economy of using it as fuel to generate electricity is less than the cost via additional dams or fossil-fuel generators.[10] In the following analysis it is assumed that Canada loses the full amount of the implicit electricity subsidy given to the export of goods. The same losses occur if electricity is generated for direct export; however, until recently the net direct export of electricity from Canada has been relatively small.

If we assume that the electric power industry in Canada has expanded to the point where it can be approximately characterized by constant returns to scale[11] and the value of the subsidy is equal to the loss of resources by Canada, then the economic loss from the export of electricity, directly or indirectly in goods, can be expressed as follows:

$$\begin{array}{l}\text{Economic loss}\\ \text{from export}\\ \text{subsidy}\end{array} = \begin{array}{l}\text{Economic cost less}\\ \text{price charged}\end{array} \times \begin{array}{l}\text{Quantity of electricity exported}\\ \text{directly or indirectly in}\\ \text{exported goods.}\end{array}$$

This expression can also be written as

$$\text{EL}(2) = (R_s - R_e)[(V_a + V_I)/V_T]K_e \tag{7}$$

where

$$V_I = \sum_{i=1}^{n} B_i E_i;$$

EL(2) is the dollar value of economic loss from exporting electricity both directly and embodied in goods;

V_a is the value of electricity exported directly;

V_I is the value of electricity embodied in goods which have been exported;

V_T is the total value of electricity generated by the Canadian publicly owned electric utilities;

B_i is the ratio of the value added of electricity to total output from the ith industry;

10 Comparisons of the costs of generating electricity via the use of hog fuel (wood chips) and other modes of production has been done by Helliwell and Cox (1978).

11 In a recent study by Christensen and Greene (19?) the range for economies of scale has been estimated. By the time a utility system has grown to a size where it produces 18 billion kWh of electricity, further expansion is estimated to take place at approximately constant returns to scale. In Canada, 85-90 per cent of the electricity generated is provided by utilities with production levels greater than this amount. Therefore, the assumption of constant returns to scale is a fair characterization of public electric utilities as a whole in Canada.

E_i is the value of goods exported by the ith industry.

Empirical measurement of economic losses

In order to calculate the economic losses that have been incurred by the public electric industry, it is first necessary to estimate its rates of return through time. In this study the real rates of return for public electric utilities in Canada have been estimated annually for the period 1967 to 1981 and are presented in Table 1.[12] This investigation shows that the rate of return to capital, gross of all taxes but net of inflation, has averaged 3.68 per cent over this fifteen-year period. This is to be contrasted with an economic opportunity cost of public funds that is not likely to be less than 8 per cent and probably is closer to 10 per cent.

To estimate the component of the economic loss arising from the overconsumption of electricity and the use of too much capital relative to other inputs in electricity production, we must evaluate equation (6). To solve this equation we also need estimates of the own-price elasticity of demand for electricity, the substitution-effect-only elasticity of demand for capital in the utility sector and the share of the value added of capital of total output of the sector.

From recent studies of the own-price elasticity of demand for electricity we find that the estimated values of this parameter range all the way from a lower-bound short-run elasticity of -0.1 to an upper-bound long-run elasticity of -1.8. To develop a low range for our estimates of the economic loss from subsidized capital we have used values of the long-run own-price elasticity of demand of -0.5, and -1.0. (See Lim, 1978, appendix B; Beals, 1977; Smith, 1980; and Taylor, 1975.)

Recently, Laurits R. Christensen and William H. Green estimated the substitution-effect-only own price elasticity of demand for capital by electric utilities in the United States (1976, table 6). These estimates were carried out on data from a sample of 114 electrical companies. Their estimated value for this parameter is -0.238. As this study is by far the most complete of any done on this topic to date, and as there is no reason for the available technology to be different in Canada than in the United States, we will use this estimate for the value of the parameter N_k^s in equation (6).

12 Sources used include Statistics Canada (1967-81) and Statistics Canada (1929-81). Six basic corrections are needed to translate accounting data to a form suitable for calculating economic rates of return. These are (1) adjustment of the value of capital stock from original cost dollars, usually recorded in accounts of corporations, to current dollars in order to eliminate the upward bias of inflation rate of return; (2) elimination of financial assets from the analysis; (3) use of economic rather than financial depreciation; (4) inclusion of debt charges which represent expenses from the accountant's point of view but are part of income for rate of economic return analysis; and (5) inclusion of part of the sales taxes paid on the output of the publicly owned electric industry as income produced by capital. For a comprehensive discussion of the problems involved in using financial data to measure economic variables see Jenkins (1977).

TABLE 1

Rates of return from public electric utilities in Canada

Year	(1) Net fixed assets[a]	(2) Working capital	(3) Total invested capital (1 + 2)	(4) Net income to capital[b]	(5) Taxes paid[c]	(6) Gross income to capital (4 + 5)	(7) Rate of return (per cent) (6/3)	(8) Sales taxes[d] (per cent)	(9) Gross of tax rate of return on capital (7 + 8)
	($million current prices)								
1967	11,324.23	757.44	12,081.67	378.13	64.32	442.45	3.66	0.22	3.88
1968	12,612.10	750.75	13,025.41	410.45	73.32	483.77	3.71	0.22	3.93
1969	13,621.10	769.15	14,390.25	473.94	78.25	552.19	3.84	0.22	4.06
1970	15,568.85	837.57	16,406.42	529.42	84.26	613.68	3.74	0.23	3.97
1971	17,273.43	970.73	18,266.16	574.53	87.56	662.09	3.62	0.22	3.84
1972	18,958.85	1,098.40	20,057.25	612.03	91.83	703.86	3.51	0.22	3.73
1973	21,961.28	1,066.54	23,027.77	746.13	101.02	847.15	3.68	0.19	3.87
1974	29,899.19	1,378.42	30,277.61	857.51	109.22	966.73	3.19	0.16	3.35
1975	37,396.76	1,964.24	39,361.00	787.63	125.34	912.97	2.32	0.11	2.43
1976	42,834.64	3,689.04	46,523.68	1,250.67	145.73	1,396.40	3.00	0.13	3.13
1977	48,239.11	3,827.52	52,066.63	1,403.46	164.39	1,567.85	3.01	0.13	3.14
1978	58,609.06	4,175.00	62,785.06	2,300.51	176.21	2,476.72	3.94	0.14	4.08
1979	70,702.91	4,012.32	74,715.24	2,775.11	176.23	2,951.34	3.95	0.12	4.07
1980	81,604.43	3,745.43	85,349.86	2,907.33	238.64	3,145.97	3.69	0.11	3.80
1981	94,521.02	5,122.59	99,643.62	3,383.46	396.18	3,779.94	3.79	0.10	3.89

[a] Net fixed assets are measured in net current replacement prices.

[b] Includes profits plus interest payments adjusted for economic depreciation.

[c] Taxes include all municipal, provincial and federal taxes.

[d] Sales taxes are the value added of capital's share of sales taxes paid on sale of electricity expressed as a percentage of net current replacement value of capital stock.

SOURCE of financial data: Statistics Canada, *Electric Power Statistics* (1967-81). The adjustments of these data were made using industrial statistics from Statistics Canada (1926-81) 1982.

TABLE 2

Economic loss from overconsumption of electricity and inefficient use of capital of publicly owned electric utilities in Canada ($million, current prices)

Year	Own price elasticity of demand for electricity			
	−0.5	−1.0	−0.5	−1.0
	$R_s = 0.10$		$R_s = 0.08$	
1967	241.6	343.9	109.5	155.9
1968	252.9	360.1	113.7	161.9
1969	257.1	366.0	113.1	161.1
1970	307.0	437.1	138.6	197.3
1971	367.0	522.5	170.0	242.0
1972	423.4	602.9	196.4	279.6
1973	441.0	627.9	200.2	285.0
1974	778.1	1,107.9	380.5	541.7
1975	1,861.9	2,650.9	1,008.1	1,435.2
1976	1,412.5	2,011.0	709.8	1,010.5
1977	1,502.4	2,139.1	754.1	1,073.6
1978	1,033.5	1,471.4	471.6	671.5
1979	1,207.2	1,718.7	557.5	793.8
1980	1,626.0	2,315.0	746.2	1,062.3
1981	1,783.5	2,539.2	806.8	1,148.7

From the estimates of the return to capital in table 1, and from data on the value of output, we find that the ratio of the value added capital (net of depreciation) to total value of output is approximately 0.35 for the years 1967 to 1981. We can now substitute these values for the variables and parameters into equation (6) to estimate the economic loss due to the overconsumption of electricity and the overinvestment in capital by the public electric utilities in Canada. These estimates of the economic waste created by this sector are presented in table 2.

From table 2 we see that by 1981 the overconsumption of electricity and inefficient use of capital in this sector resulted in an annual economic loss to Canadians of between $806.8 million (assuming own price of elasticity of -0.5 and $R_s = 0.08$) and $2,539.2 million (assuming own price elasticity of -1.0 and $R_s = 0.10$); the economic loss when the elasticity of electricity demand is -0.5 and $R_s = 0.10$ is estimated to be equal to approximately $1,783.5 million in 1981. Because the estimate of the economic loss is a function of the square of the size of the capital distortion, it is quite sensitive to the value of economic opportunity cost of public funds. When these annual losses from 1967 to 1981 are all expressed in terms of the 1981 price level, we find that the magnitude of the economic waste (assuming $R_s = 0.10$) has grown from $728.2 to $1,783.5 million over this period. From 1967 to 1981 this economic waste has grown from approximately 0.42 per cent to 0.53 per cent of gross national product.

To obtain estimates of the value of electricity embodied in exports it is first

TABLE 3

Economic loss from direct and embodied export of electricity, and total economic loss of publicly owned electric utilities in Canada ($million, current prices)

Year	Economic loss from direct and embodied export of electricity		Total economic loss[a]			
			Own price elasticity of demand for electricity			
			−0.5	−1.0	−0.5	−1.0
	$R_s = 0.10$	$R_s = 0.08$	$R_s = 0.10$		$R_s = 0.08$	
1967	43.07	29.07	284.7	387.0	138.6	185.0
1968	48.06	32.22	301.0	408.2	145.9	194.1
1969	62.23	41.28	305.2	428.2	154.4	202.4
1970	99.28	66.35	406.3	536.4	205.0	263.7
1971	107.29	72.46	474.3	629.8	242.5	314.5
1972	132.21	90.04	555.6	735.1	286.4	369.6
1973	178.90	120.53	619.9	806.8	320.7	405.5
1974	290.40	203.06	1,068.5	1,398.3	583.6	744.8
1975	359.16	264.27	2,221.0	3,010.1	1,272.4	1,699.5
1976	454.43	322.14	1,866.9	2,465.4	1,031.9	1,332.6
1977	528.57	374.47	2,031.0	2,667.7	1,128.6	1,448.1
1978	602.10	398.69	1,635.6	2,073.5	870.3	1,070.2
1979	726.60	481.54	1,933.8	2,445.3	1,039.0	1,275.3
1980	883.70	598.64	2,509.7	3,198.7	1,344.8	1,660.9
1981	1,016.70	683.90	2,800.2	3,555.9	1,490.7	1,832.6

[a] Equals sum of economic loss from direct and embodied export of electricity (column 1) and table 2 figures.

necessary to estimate the ratio of the value added of electricity to the total value of output in each sector during the period. These data were obtained from the Census of Manufacturing Division of Statistics Canada.

Annual values of exports by industrial sector were estimated by aggregating the appropriate commodity classes into their corresponding industrial categories (Statistics Canada, 1967-81). By multiplying the values of exports by the ratios of the value added of electricity to the total value of output for the corresponding industrial sector, we obtain values of (V_I) by sector. After aggregating the values of (V_I) across sectors by year, the values of electricity embodied in exported goods are estimated for each year from 1967 to 1981.

Employing the rates of return from investment in public electric utilities reported in table 1, column 9, along with the net current replacement values of the capital stock in this sector, table 1, column 3, and the values of electricity produced as well as exported, an estimation is made of the economic loss to Canada from the direct and indirect export of electricity by solving equation (7).

From table 3, columns 1 and 2, we find that the value of the implicit subsidy given to exports through the underpricing of electricity has risen dramatically from 1967 to 1981. In 1967 this subsidy was equivalent to between 2.5 to 3.7 per cent of the total sales of the public electric utilities, but has about tripled to

between 7.4 and 11 per cent by 1981. The value of this subsidy is an economic loss to Canadian residents unless it is captured as higher profits by Canadian owners of the exporting firms who use this cheap electricity.

Combining the three sources of economic inefficiency arising from the subsidization of capital, we find that the annual magnitude of this economic waste in 1981 was between $2,800.2 million and $3,555.9 million if the economic opportunity cost of funds is 10 per cent. If the value of this parameter is 8 per cent, the estimated amount of economic waste was between $1,490.7 million and $1,832.6 million in 1981. The range of these estimates indicates that in 1981 the economic loss due to inefficient use of capital in the public electric utilities amounted to between 0.45 and 1.1 per cent of GNP.

The present value in 1981 prices (and using a 10 per cent discount rate) of this economic loss over the fifteen-year period has cumulated to approximately $60,108 million, an amount equal to about 60 per cent of the net replacement value of the total capital stock of the public electric utilities as of 1981.

Throughout this evaluation an attempt has been made to provide an underestimate of these efficiency losses. For example, it is assumed that the indirect economic externalities created by the pricing policy of the electric utilities net out to zero. In actual fact, it is likely that the indirect externalities have created an additional net economic cost. As mentioned previously, this is expected because the industries that use electricity intensively tend to be taxed relatively less. In addition, the estimates of the welfare cost of electricity under the assumption that the long-run price elasticity of demand for electricity is between -0.5 and -1.0 will almost certainly be lower-bound values of the actual economic waste generated by these policies.

These economic losses are a complete waste of resources, which can result only in a reduction in the total well-being of Canadian residents. They arise primarily because the electric utilities are publicly owned and governments have not maintained stringent enough investment criteria to ensure that the special provisions these enterprises receive do not lead to a wasteful use of Canada's capital resources. It need not always be the case that investments made in regulated or public utilities produce a low economic rate of return. On the contrary, we find that the private telephone industry in Canada, although heavily regulated, has consistently produced a real economic rate of return (gross of tax but net of inflation) in excess of 10 per cent on the investment capital in this sector (Jenkins, 1977, 256). These estimates of the amount of economic waste created by the present policies governing the public electric utilities are of sufficient magnitude that a re-examination of these policies by governments is warranted.

IMPLICATIONS FOR PRICING POLICIES

To correct for this capital market distortion, two adjustments must be made in the prices used in the planning process of the electric utilities and regulatory

bodies in Canada. First, the economic opportunity cost of capital, not its financial cost, should be used to determine which technology is the least costly way to produce and deliver electricity. Second, the output of electricity should be priced so as to recover the full economic opportunity cost of the resources used.

If in 1980 the price of electricity had been adjusted so that capital earned a gross economic rate of return of 10 per cent rather than its actual yield of 3.80 per cent, then total revenue would have been increased by $5,291.7 million.[13] If its capital had earned a rate of return of 8 per cent, then total revenue would have been increased by $3,584.7 million. The actual value of electricity sold by these utilities was $8,401.6 million (Statistics Canada, 1967-81). Hence, the price of electricity would have to be increased by 43 to 63 per cent above its current levels.

REFERENCES

Allen, R.G.D. (1983) *Mathematical Analysis for Economists* (New York)

Averch, H. and L.L. Johnson (1962) 'Behavior of the firm under regulatory constraint.' *American Economic Review* 52, 152

Beals, Ralph E. (1977) *Elasticity Estimates for Domestic Electricity Consumption Under Time-of-day Pricing: An Analysis of Data Generated in the Domestic Tariffs Experiment Conducted by the Electricity Council, London* (Ottawa: Prepared for Program Assessment and Evaluation Branch, Department of Regional Economic Expansion, Government of Canada)

British Columbia Hydro and Power Authority (1975) *Alternatives 1975 to 1990: Report of the Task Force on Future Generations and Transmission Requirements* (Vancouver)

Christensen, Laurits R. and William H. Green (19?) 'Economies of scale in U.S. electric power generation.' *Journal of Political Economy* 84, 655-76

Gillis, Malcolm S. and Charles E. McLure Jr (1976) 'Tax Policy and Public Enterprises.' Study prepared for the Musgrave Commission for Bolivia, Harvard University

Harberger, Arnold C. (1974) 'Taxation, resource allocation and welfare.' In *The Role of Direct and Indirect Taxes in the Federal Revenue System* (Princeton: Princeton University Press)

Helliwell, John F. and Alan J. Cox (1978) 'Wood wastes as an energy source for the B.C. pulp and paper industry: economic implications and institutional barriers.' Resources Paper N-19, University of British Columbia

Hicks, J.R. (1963) *The Theory of Wages*, 2d ed. (New York)

Jenkins, Glenn P. (1972) 'Analysis of rates of return from capital in Canada.' Ph. D. dissertation, University of Chicago

13 This is estimated as the difference between the economic opportunity cost of capital and the economic rate of return earned in 1980 by the public electric utilities times the current net replacement value of the capital stock in government-owned electric utilities in 1980: $(0.1 - 0.038)(85{,}349.9) = \$5{,}291.7$ million.

— (1977) 'Capital in Canada: its social and private performance,' 1965-1974, Economic Council of Canada Discussion Paper 98, Ottawa
Lim, Henry B.F. (1978) 'Cost-benefit analysis for peak-load pricing and load management.' Ph. D. dissertation, University of Chicago
Smith, U. Kerry (1980) 'Estimating the price elasticity of U.S. electricity demand.' *Energy Economics*, April, 81-5
Statistics Canada (1967-81) *Electric Power Statistics*, Volume 2. Catalogue No. 57-202 (Ottawa)
— (1982) *Fixed Capital Flows and Stocks, Manufacturing and Non-Manufacturing 1929-1981* (Ottawa)
— (1973-81) *Corporation and Labour Unions Returns Act* (Ottawa)
— (1967-81) *Trade of Canada, Exports* (Ottawa)
Tambini, Luigi (1969) 'Financial policy and the corporation income tax.' In Arnold C. Harberger and Martin J. Bailey, eds., *The Taxation of Income from Capital* (Washington, DC: Brookings Institution)
Taylor, Lester D. (1975) 'The demand for electricity: a survey.' *Bell Journal of Economics and Management Science* 6, 74-110
Wisecarver, Daniel (1974) 'The social costs of input-market distortions.' *American Economic Review* 64, 359-72.