Economic Analysis of Electricity Cogeneration

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This panel of papers and comments represents the Proceedings of a session on the economic analysis of electricity cogeneration at the June, 1993 meetings of the Canadian Economics Association (CEA) at Carleton University in Ottawa. It provides evidence that current policy issues can indeed motivate academic work in a very direct way. The session can be traced back to a concern on the part of the Special Projects Branch of Industry and Science Canada (ISC) that the US pulp and paper industry was realizing substantial advantages, relative to its Canadian counterpart, from having implemented electricity cogeneration. After conducting engineering and financial analyses of representative US pulp mills, ISC concluded that the benefits of cogeneration were in the range of 7.5 to 22.5% of sales for the mills examined. ISC then engaged Professor Arnold Harberger to assist in sorting out issues related to economic efficiency and subsidization. They also proceeded to conduct detailed engineering and financial analyses on a representative sample of 29 Canadian pulp and paper establishments. As outlined in Burns *et al* (1993), included in this

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feature,[1] the ISC study indicates that if electric utilities were able to use incremental power cogenerated by Canadian pulp and paper mills, financial benefits in the order of \$55 million per mill are available and do not depend on subsidization.

The CEA session, and this feature on cogeneration in *Energy Studies Review*, have provided an opportunity to disseminate the results of ISC's research program to a wider audience.

In order to set the stage for Professor Harberger's paper on the interaction between electricity pricing and cogeneration and the response to it by three discussants, this note provides a brief introduction to the financial and economic analyses of industrial cogeneration and to some of the issues associated with it. Though the ISC study referred to above was not presented at the CEA meeting, it has also been included in these proceedings to provide further background.

Background

Industrial electricity cogeneration is the production of electricity in conjunction with process steam for industrial purposes. The potential energy savings from producing electricity and process steam together rather than separately are impressive. While fossil-fuel power plants generally convert less than 40% of the energy contained in the fuel into electricity, cogeneration is often 80 to 90% efficient. The mix of electric and industrial thermal energy produced depends on the cogeneration technology chosen. The electricity is either used by the firm or sold to an electric utility. Whether there is a market for cogenerated electricity depends on the firm's costs, the cost structure and policies of the utility, and the regulations that govern its purchasing decisions.

Although the efficiency gain from industrial electricity cogeneration is considerable, Joskow and Jones (1983) point out that energy savings from cogeneration do not necessarily imply economic or financial savings. Capital and operating costs can offset the technical advantage. Thus, it is customary to distinguish between the technical potential of cogeneration and its economic and financial potential, and it is important to realize that the economic and financial returns are not typically identical.

Economic Potential: The economic value of the electricity produced through cogeneration is the corresponding **avoided cost** to the utility; that is, the long-run cost of the generated power that the utility need not produce, measured in terms of the economic opportunity cost of the resources saved. Since avoided cost can vary with the season and time of day, the dispatchability and reliability of cogenerated power must be taken into account when determining its economic value. Furthermore, as Harberger points out in his paper, the economic potential depends on how cogeneration is introduced. It could be greater if firms are allowed to sell all their power, as opposed to just their excess power, to a utility. He also shows that the economic benefits will be affected by the fact that the introduction of cogeneration could induce firms to increase their own consumption of electricity.

The resources required to cogenerate electricity must also be measured in terms of their economic opportunity costs. Because taxes and subsidies are generally transfers, not resource costs, they are excluded from an economic analysis. Economic externalities, as well as any infrastructure costs provided by governments, are included. A social discount rate is used to discount economic benefits and costs generated in different time periods.

Financial Potential: In a financial feasibility analysis of cogeneration, incremental outputs and inputs are valued at market prices. Whenever energy purchases by the cogenerating firm are eliminated, the financial value of the electricity produced by that firm has two components, namely: (a) the cost saving from no longer having to pay the utility the industrial rate for electricity consumed by the firm, and (b) the incremental revenue from any excess power sales to the utility at its purchase

1/ See below, pp. 107-13.

price. That price is based mainly on the long-run avoided financial cost of utility generated power. Public ownership affects the financial potential of cogneration because publicly owned electric utilities in Canada are for the most part effectively tax exempt. This is one reason why the avoided financial cost of power for a publicly owned utility, and hence the price it is willing to pay for cogenerated power, will be less than if that utility were privately owned.[2]

The financial costs borne by a cogenerating firm are also measured in terms of market prices; these costs include taxes (and are reduced by subsidies) if the cogenerator is a privately owned firm. Since a financial feasibility analysis does not include economic externalities, it would not take into account any reduction in pollution as a result of cogeneration. A weighted average of the costs of debt and equity capital faced by the firm is used to discount the cash receipts and disbursements occurring at different time periods.

To illustrate the above discussion, a recent study of industrial cogeneration potential in Ontario, by the Independent Power Producers' Society of Ontario (IPPSO, 1993) concluded that the technically available capacity amounts to over 7,000 MW, most of which is economically attractive. With regard to the pulp and paper industry, the technical potential is over 2,500 MW, or about 35% of the industry potential.

Despite this potential, the Ontario system currently has (as of July, 1993) only about 883 MW of in-service cogeneration capacity (313 MW of purchase capacity for Ontario Hydro and 570 MW of load displacement).[3] This represented less than 3% of Ontario Hydro's total installed capacity. About 30% of the cogeneration capacity (258 MW) is located in Ontario's pulp and paper industry.

By contrast, cogeneration is much more firmly established in the United States. A number of states (e.g., Maine, California, Louisiana, Texas, and Michigan) have more than 10% of their total generation based on cogeneration. In traditional forest-product states like Maine and Alabama, over 80% of cogeneration capacity comes from the pulp and paper sector (Burns *et al*, 1993).

Among the many reasons why the potential for cogeneration in Canada has not been realized are the cost structure and pricing policies of publicly owned Canadian utilities. The income tax exemption and implicit subsidies that result from public ownership create a cost disadvantage for industrial cogenerators. Canadian utilities also base the prices they are willing to offer to cogenerators on average (historic) costs, which are usually lower than marginal costs. In Canada, furthermore, there is no legislation comparable to the Public Utilities Regulatory Policies Act (PURPA) in the US that would compel utilities to consider non-utility generation alternatives on the basis of a level playing field.

In practice, therefore, the purchase price offered to cogenerators in Canada is usually less than the marginal avoided economic resource cost of utility generated power. Hence, the profit to the cogenerator is less than the cost saving to society, or in other words, the financial benefit from cogeneration is less than its economic benefit. The result is a suboptimal level of cogeneration capacity in Canada.

The CEA Panel

In his paper Professor Harberger illustrates how, under some circumstances, the pricing of

2/ The avoided financial cost of a publicly owned electric utility is also lower because it has a lower cost of capital than a privately owned firm. Public ownership allows a utility to borrow more than a privately owned firm and the cost of debt is often subsidized because of the government debt guarantee. In addition, most governments do not require a competitive rate of return on the equity invested in a utility. Jenkins (1977) and Evans (1992).

3/ These figures are based on data obtained from Mr. Keith Brown, Non-Utility Generation Division, Ontario Hydro. Ontario Hydro did not establish a non-utility generating division until 1988.

industrial electricity and the regulation of electricity cogeneration in the United States create a "crosshaul" subsidy that lowers the cost of power for American pulp and paper mills and makes it more difficult for Canadian pulp and paper mills to compete.[4] Harberger demonstrates how economic well-being can be improved as a result of cogeneration and how a crosshaul subsidy, depending on initial circumstances, may or may not be necessary in order to obtain a gain in economic efficiency. Using data gathered by Burns *et al*, (1993), Harberger also addresses the question of how federal and provincial governments in Canada should respond to the crosshaul subsidy issue.

It is useful to clarify the relation of certain variables in Harberger's formal analysis to the discussion in the preceding section of this note. A key variable is the electric utility's long-run marginal avoidable cost for baseload capacity. Harberger intends the utility's avoided cost to be measured by the long-run marginal social opportunity cost of electric energy generated by the network, which will be greater than the long-run marginal cost from the utility's perspective if the economic opportunity cost of any of the utility's inputs, such as its cost of capital, is greater than its cost to the utility.

Harberger assumes that the utility in his analysis sets the price at which it will buy energy from cogenerators (P_v) at the long-run marginal social opportunity cost of electricity; that is, at the utility's avoided cost from society's point of view. P_c is the marginal cost of cogenerated power. In the case where the cogenerator has excess energy to sell, the difference between P_v and P_c measures both the cost saving to society per kWh of electricity produced by the cogenerator and the profit to the cogenerator per kwh of power sold to the utility. Harberger notes that under these conditions the perceived cost of power to the cogenerator is then equal to its social cost, which is the ideal situation. As already noted, however, these conditions are unlikely to prevail. Of course, simplifying assumptions of this sort (others are noted by the discussants of his paper) are normal in theoretical analysis, even in applied economics. Harberger's conclusions about the welfare effects of various pricing regimes for cogeneration can be adjusted to account for them.

Harberger's Results in a Current Setting

It is interesting to adjust the assumptions used in Harberger's paper to account for the fact that many utilities presently have surplus generating capacity. An important case in point is Ontario Hydro, which has lowered its estimates of long-run avoided cost, and hence what it is willing to pay for power from non-utility generators. It has also raised its industrial rates, such that Harberger's industrial rate, P_b, now exceeds the purchase price of power from the cogenerators, P_v. However, P_b may not exceed the long-run marginal social opportunity cost of utility-generated power. Thus, although Harberger's industrial rate subsidy variable (Z) is likely smaller, it may still be positive.

To the extent that the avoided marginal social opportunity cost of utility-generated power is lower on account of the surplus capacity, the social cost saving from cogeneration will be reduced. Similarly, private profits from selling electricity to the utilities (P_v - P_c) will also be reduced, possibly to the point of making third-party cogeneration financially unattractive. However, because it is based on the difference between P_b and P_c, load displace-

4/ Crosshauling in this context is defined as the sale to a utility of a negotiated amount of cogenerated electricity and the subsequent repurchase from the utility of the amount of electricity required by the firm for its own production purposes. No crosshauling occurs if a utility is willing to purchase only the excess power that a firm cogenerates; the upper limit on crosshauling is determined by a firm's total electricity consumption. As Harberger explains, a crosshaul subsidy can potentially arise whenever the price that an electric utility is willing to pay for cogenerated power is greater than the rates charged to industrial users.

ment by industrial cogenerators has become even more attractive. The uncertain issues for them are the technology and size of cogeneration unit to build. These will depend in part on how long the surplus capacity situation is expected to last and how the system expansion plans of the utilities evolve.

Despite the technical superiority of cogeneration, the future of cogeneration in Canada remains cloudy. In May 1993, for example, Ontario Hydro reduced its planned purhases of power from 16 non-utility generating stations by an average of 54% and delayed their start-up until 1997 (Mittelstaedt, 1993). At the same time, Ontario Hydro is discouraging the cogeneration plans of a number of municipalities seeking to displace load. These actions raise questions about whether municipalities and industries like pulp and paper are being held captive by the utilities. The answer would appear to be yes if, as the capacity surplus is reduced over time, the utilities expand their own systems at a marginal economic cost higher than could be obtained through cogeneration. Quebec Hydro's proposed Great Whale project may be a case in point.

In 1987 the Canadian Energy Research Institute reported the results of an industrial survey on cogeneration (Reinsch, 1987). Two of the study's recommendations referred to the appropriate role for government. One recognized the need for "government assistance to enhance the financial feasibility of projects exhibiting economic potential." The other, however, concluded that "(t)here is not a need in Canada for comprehensive legisation regarding the development of parallel power generation." (Reinsch, 1987, pp. 62-63) One wonders whether the second of these recommendations would be upheld if a similar survey were carried out today.

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