IMPACT EVALUATION OF AN ENERGY SAVINGS PLAN
PROJECT AT ELF ATOCHEM NORTH AMERICA

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SUMMARY

This impact evaluation of an energy conservation measure (ECM) that was recently installed at Elf Atochem North America (Atochem) was conducted for the Bonneville Power Administration (Bonneville) as part of an evaluation of its Energy Savings Plan (ESP) Program. The Program makes acquisition payments to firms that install energy conservation measures in their industrial processes. The objective of this impact evaluation was to assess how much electrical energy is being saved at Atochem as a result of the ESP and to determine how much the savings cost Bonneville and the region.

The impact of the ECM was evaluated with a combination of engineering analysis, financial analysis, site visit and interview, review of previous program submittals (Atochem's Proposal and Completion Report), and review of process evaluation results from 1989. The ECM itself consists of adding anode area to each of the sodium chlorate (chlorate) cells at Atochem's Tacoma facility. Increasing the anode area reduces the current density, which reduces cell resistance at the same current, thus reducing energy consumption at the same chlorate production rate.

Energy savings resulting from this ECM are expected to average about 24,000,000 kWh/yr or about 1000 kWh/ton of chlorate produced. The net cost of the ECM was \$1,410,400, and Atochem received a payment of \$212,500 from Bonneville for the acquisition of energy savings. The levelized cost of these energy savings to Bonneville will be 0.7 mills/kWh over the ECM's expected 15-year life, and the levelized cost to the region will be 5.7 mills/kWh.

Bonneville's offer to pay Atochem \$212,500 via the ESP Program was viewed by Atochem management as a big incentive that made a difference. In all likelihood, the ECM would not have been implemented without the acquisition payment until power costs increased. The acquisition payment reduced payback by 6 months and increased the internal rate of return by 3%, which was enough to make an otherwise marginal project attractive.

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IMPACT EVALUATION OF AN ENERGY SAVINGS
PLAN PROJECT AT ELF ATOCHEM NORTH AMERICA

1.0 INTRODUCTION

This letter report describes Pacific Northwest Laboratory's (PNL's)^(a) evaluation of the impact of an energy conservation measure (ECM) installed at Elf Atochem North America (Atochem) in Tacoma, Washington. When this project was first proposed to Bonneville, the proposing firm was called Pennwalt. Since then, Pennwalt was acquired by the French petroleum and chemical company, Elf Aquataine, and the name of the firm was changed to Atochem North America. Recently, Elf Aquataine decided to increase its visibility in the U.S., so the name of the company was changed to Elf Atochem North America.

The ECM at Atochem is one of about thirty energy conservation projects to have its impact evaluated by PNL. All of the projects have received or will receive acquisition payments from the Bonneville Power Administration (Bonneville) under the Energy Savings Plan (ESP) Program.

The ESP is being offered to acquire electrical energy savings in the industrial sector of the Pacific Northwest. For the Atochem project, the acquisition payment offered under the program was equal to the lesser of 5¢/kWh saved in the first year or 80% of eligible project costs, multiplied by 85%, up to a limit of \$212,500. The 85% factor is applied to this project because Atochem's serving utility, the City of Tacoma Department of Public Utilities (Tacoma City Light), does not obtain all of its power from Bonneville, and it is eligible for 85% of the cost share.

The general objective of the impact evaluation was to determine how much electrical energy is saved by the ECM and at what cost to Bonneville and to the region. In support of this general objective, answers were sought to the following questions:

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1. How much electrical energy is saved annually by the energy conservation measure in terms of kilowatt-hours and kilowatt-hours per unit of plant output? Also, did any fuel switching result from implementing this ECM?
2. If the ECM improved the productivity of the process, did the firm then increase output of the process to take advantage of the productivity improvement? Did the change in output result in a net increase or decrease in energy used by the process? Did the change in output cause changes in output at the firm's other plants in the region?
3. What was the net impact to the serving utility in terms of electrical energy consumption (in kilowatt-hours) from implementing the ECM?
4. What are the levelized costs of the ECM from the perspectives of Bonneville and the region?
5. How much of the ECM's impact can be attributed to the E\$P?

1.1 APPROACH FOR IMPACT EVALUATION

Before selecting individual energy conservation projects for impact evaluation, PNL developed a general impact evaluation methodology (Spanner, et al., 1988). The major finding of the methodology development was that in the industrial sector, the success, or value, of energy conservation projects must be evaluated on a case-by-case basis. Accordingly, the general methodology consists of a variety of impact evaluation techniques that can be applied to individual projects according to the specific circumstances.

To evaluate the impact of adding anode area to each of the sodium chlorate (chlorate) cells at Atochem, five techniques were selected from the general methodology: engineering analysis, financial analysis (see Appendix A), site visit and interview, review of Atochem's submittals, and review of process evaluation results from 1989. Onsite submetering by PNL was not necessary because the metering performed by Atochem in accordance with E\$P program requirements was adequate to determine the project's impact.

Representatives from PNL visited Atochem on June 4, 1992, to view the ECM firsthand and to conduct an interview with the Manager of Technology and Engineering for the Industrial Chemicals Group and the Plant Process Engineer for Chlorate Operations.

1.2 PROJECT DESCRIPTION

Atochem originally proposed the following two measures to reduce energy consumption in its chlorate cells: 1) Narrowing the anode-cathode gap in the chlorate cells currently using wide-gap technology (about 46% of total cells), and 2) adding additional anode area to all chlorate cells. Both of these measures work by reducing the current density, which in turn reduces cell resistance at a given amperage and production level, thus reducing cell energy consumption per unit of chlorate produced. The anode area was increased as planned in all chlorate cells, but only 10 of the wide-gap cells were converted to narrow-gap technology. Performance measurements for the 10 cells converted to narrow-gap technology indicated a negligible advantage, so this measure was not fully implemented.

Energy savings were verified by comparing energy consumption and chlorate production records before and after installation of the ECM. Metering at the Atochem plant allows direct measurement of chlorate cell power consumption. The directly measured figure can also be calculated by subtracting the other metered components from the total consumption metered for the entire plant. Chlorate production was based on the capacities of storage tanks, railroad tank cars, and barges taking delivery.

Atochem submitted three documents to Bonneville: an Abstract, a Proposal, and a Completion Report. The Abstract and Proposal described the ECM and presented Atochem's expectations with regard to costs and benefits. Included was a calculation of the ECM's expected simple payback. A Completion Report was submitted to Bonneville after the ECM was installed and Atochem had verified the resulting energy savings. This document listed the actual costs of the ECM along with a calculation of the energy savings that had been achieved. A copy of the cover sheet from the Proposal is included as Appendix B.

The ECM cost \$1,500,400 to install, which included about \$170,000 for recoating the old anode blades, which would have been done in a few years anyway. When the ECM was implemented, the remaining life in the old anode blade coatings was estimated by Atochem to have a value of about \$80,000, which was "written off." Thus, the net energy conservation investment was estimated by PNL to be \$1,410,400. Abstract and proposal preparation costs totaling about \$27,000 were also incurred by Atochem. Bonneville paid \$212,500 for the energy saved.

1.3 SUMMARY OF PROJECT IMPACTS

This E\$P project, or ECM, is expected to save about 24,000,000 kWh annually.

Over the assumed 15-year life of this ECM, the levelized cost to Bonneville will be 0.7 mills/kWh (1 mill = 1/1000 of a dollar), and cost to the region will be 5.7 mills/kWh. These costs are in real 1990 dollars and do not include additional savings that accrue if transmission and distribution losses are considered. The levelized cost to Bonneville including transmission and distribution losses will be 0.6 mills/kWh, and the cost to the region will be 5.3 mills/kWh.

Without the acquisition payment from Bonneville, this ECM did not meet Atochem's funding criteria; however, it did meet the criteria with the acquisition payment. Therefore, we conclude that it would not have been installed in the absence of the E\$P.

2.0 IMPACT EVALUATION

The following section addresses the five major objectives of the impact evaluation as stated in the introduction.

2.1 ENERGY SAVINGS AND FUEL SWITCHING

1. *How much electrical energy is saved annually by the ECM in terms of kilowatt-hours and kilowatt-hours per unit of plant output? Also, did any fuel switching result from implementing this ECM?*

Energy Savings

Energy consumption and chlorate production records from July, 1987 through June, 1988 defined the reference performance prior to installing the ECM. Actual production in tons is considered proprietary by Atochem, so such data are not disclosed in this impact evaluation report. Average monthly production during this period was at capacity. The overall average energy consumption per ton was 5701 kWh. During the site visit and interview Atochem presented energy consumption and chlorate production records from January, 1991 through April, 1992. Installation of the ECM was completed in November, 1990. The average monthly production during this period was about 86% of capacity. The overall average energy consumption per ton was 4570 kWh.

Energy consumption per ton is affected by the production rate as well as the technology employed. Linear regression of the post-installation energy consumption and production data was employed to predict an energy consumption rate of 4665 kWh/ton at maximum production rates. Thus, the expected energy savings per ton would be about 1000 kWh.

The production capacity of the Tacoma Atochem plant is limited by rectifier amperage. Atochem attempts to operate 24 hours/day for 360 days/yr. Historically, the annual production rate was about 96% of capacity and has never been below 77% of capacity. Since the ECM was installed, market conditions have limited production to an average annual rate of 82% of capacity. The downturn in demand was attributed to the current recession and was expected to last through 1992. Recovery from the recession and new markets at pulp and paper mills were expected to increase chlorate demand in the future.

Obviously, estimating future production requires some speculation. An average annual production rate of 24,000 tons was presumed for analytical purposes. Thus, the average annual energy savings was estimated to be 24,000,000 kWh (24,000 tons/yr * 1,000 kWh/ton = 24,000,000 kWh/yr).

Fuel Switching

Chlorate production is an electrolytic process that requires electricity to convert sodium chloride and water into sodium chlorate and hydrogen. Other energy forms cannot substitute for electricity. Therefore, no fuel switching occurred. Atochem uses the hydrogen in its boilers to produce process steam, but does not cogenerate any power. All power is provided by the serving utility, Tacoma City Light.

2.2 IMPACTS TO THE FIRM

2. *If the ECM improved the productivity of the process, did the firm then increase output of the process to take advantage of the productivity improvement? Did the change in output result in a net increase or decrease in energy used by the process? Did the change in output cause changes in output at the firm's other plants in the region?*

Installation of the ECM improved the productivity of the process by reducing the electrical energy required per ton of chlorate produced. The production rate was not increased, however, because the plant was already operating at or near capacity and the ECM did not increase production capacity. The plant's production is limited by rectifier amperage and the ECM only reduced voltage. Nor was production expected to be reduced at Atochem's chlorate plant in Portland. Atochem indicated that market conditions and demand have a greater influence on production level than production cost for both plants. In addition, because of differences in product characteristics and customers, production decisions for the two plants are generally made independently.

2.3 IMPACTS TO THE UTILITY

3. *What is the net impact to the serving utility in terms of electrical energy consumption (in kilowatt-hours) from implementing the ECM?*

Because there is no cogeneration or other complicating factors in this project, all of the energy savings from this ECM will be reflected in reduced load at the serving utility, Tacoma City Light. The net impact to the serving utility from this ECM will be a 24,000,000 kWh/yr reduction in electrical load.

2.4 LEVELIZED COSTS

4. *What are the levelized costs of the ECM from the perspectives of Bonneville and the region?*

Levelized annual costs are used to compare the attractiveness of various projects or investment alternatives. The levelized cost is the annual cost that would be incurred over the life of the project, accounting for the time value of money. (See Appendix A for complete definitions and formula.) Levelized costs provide a single figure of merit for comparing energy conservation alternatives. In addition, levelized costs can be used to compare conservation projects with options for new generating capacity and to optimize the ranking of these options. The objective of using levelized costs to evaluate these energy conservation measures is to determine the financial impact of each ECM to Bonneville (\$/kWh saved) and to the region (Bonneville and Atochem combined).

In the industrial sector, it is not possible to accurately predict the life of an ECM because any number of external factors could cause the ECM to have longer or shorter life than expected when it is installed. To allow comparisons of levelized costs among projects installed under the E\$P, all ECMs are assumed to have a life of 15 years. Even though some ECMs will have longer or shorter lives, 15 years is considered a conservative but likely life for typical ECMs in the industrial sector.

2.4.1 Bonneville Perspective

To determine the levelized costs to Bonneville and to the region, we must know the project costs (acquisition payment, capital costs, etc.) and the energy savings, and must assume a discount rate and ECM life. With energy savings of 24,000,000 kWh/yr, the project's levelized cost from Bonneville's perspective will be 0.7 mills/kWh (see Appendix A). Bonneville's levelized

cost decreases to 0.6 mills/kWh when transmission and distribution losses are considered. These losses increase the energy savings at the point of generation by 7.5%.

The levelized costs calculated in this impact evaluation include the acquisition payment by Bonneville but ignore any administrative or evaluation costs for the program. Data are not available to calculate these costs on a project-by-project basis, but they will be included in an impact evaluation report on the overall program.

2.4.2 Regional Perspective

To calculate the levelized cost to the region, the costs to Bonneville and Atochem are combined. The acquisition payment by Bonneville is included as a cost to Bonneville and as a reduction in cost to Atochem. This approach is taken because the acquisition payment has federal income tax consequences to the company and, therefore, is not a net zero cost to the region.

The levelized costs to the region for acquiring annual energy savings of 24,000,000 kWh is 5.7 mills/kWh saved. Including transmission and distribution losses, the levelized cost decreases to 5.3 mills/kWh saved.

2.5 IMPACT ATTRIBUTABLE TO E\$P

5. *How much of the ECM's impact can be attributed to the E\$P?*

Atochem evaluates potential plant improvement projects by calculating the impact on unit production cost as well as rate of return and payback. Atochem indicated that, in general, the rate of return should be greater than 20% or the payback period should be less than 4 years. In the Proposal to Bonneville, the project was estimated to cost \$1,490,000 and result in energy cost savings of \$277,200/yr. These figures result in a payback period of 5.4 years, or 4.6 years with the \$212,500 acquisition payment. Discussions with Atochem indicated that the energy savings predicted in the Proposal were conservative because Atochem understood that the entire acquisition payment would be withheld by Bonneville if the predicted energy savings were not achieved. (Actually, the penalty is only 20% of the acquisition payment if verified savings are less than 80% of estimated savings). In fact, Atochem

expected energy savings to be about 750 kWh/ton or \$337,500/yr. At this more realistic level of annual savings, the payback period would be 4.4 years without the acquisition payment and 3.8 years with the acquisition payment.

Discussions with Atochem personnel indicated that Bonneville's offer to pay Atochem \$212,500 via the ESP Program was viewed by their management as a significant incentive that made a difference. In all likelihood, the ECM would not have been implemented without the acquisition payment until power costs increased. The acquisition payment reduced payback by 7 months and increased the internal rate of return by 3%, which was enough to make an otherwise marginal project attractive. Thus, we conclude that this project would not have been implemented without the acquisition payment from Bonneville and that all of the project's impact can be attributed to the ESP.

3.0 REFERENCES

Spanner, G. E., D. R. Brown, D. R. Dixon, B. A. Garrett, R. W. Reilly, J. M. Roop, and S. A. Weakley. 1988. *Potential Techniques for Evaluating the Impact of Industrial Energy Conservation Projects under Bonneville's Energy Savings Plan*. Letter Report. PNL-6628, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

FINANCIAL EVALUATION DETAILS

APPENDIX A

FINANCIAL EVALUATION DETAILS

A.1 DEFINITIONS

Levelized Cost - A single figure of merit that expresses the cost per unit of benefit (in this case, energy savings) accounting for the time value of money. This annualized cost would be constant over the entire project life. An infinite number of cash flow scenarios (costs incurred at different times in the project life) could result in the same annualized cost.

Levelized Cost to Bonneville Power Administration (Bonneville) - The annualized costs to Bonneville, direct and indirect, per unit of energy saved by the conservation measure. Costs included are the acquisition payment and the program administrative costs (although no administrative costs are included in this analysis of the ECM at Elf Atochem North America (Atochem)).

Levelized Cost to the Region - The sum of annualized costs to Bonneville and Atochem per unit of energy saved by the energy conservation measure. This would include the same costs to Bonneville as above, plus the initial capital and ongoing incremental production costs to the firm. Any non-electrical savings that result from the ECM are not considered in this analysis.

A.2 LEVELIZED COST FORMULA

$$LC = \{[PVC I + PVIC I + (PVOM + PVPT + PVOTE) \cdot (1-itf) - PVD \cdot itf] / (1-itf)\} \cdot (CRF/AES)$$

where LC = levelized cost (real \$)

PVCI = present value of initial capital costs

PVIC I = present value of interim capital costs

PVOM = present value of operating and maintenance (O&M) costs

PVPT = present value of property taxes

PVOTE = present value of one-time expenses

itf = combined state and federal income tax fraction

PVD = present value of depreciation

CRF = capital recovery factor (spreads the costs over the project life in real dollar terms)

AES = annual energy savings (kWh/yr).

A.3 GENERAL ASSUMPTIONS

The following general assumptions were made in the levelized cost calculations:

1. All cash flows are expressed in nominal terms (with inflation) and are discounted to present value at a nominal discount rate of 8.15% (combines a real discount rate of 3.0% and an inflation rate of 5.0%). The costs are annualized over the life of the project using the capital recovery factor at a real discount rate of 3.0%.
2. Annual energy savings (kilowatt-hours per year) are constant over the life of the project. This assumes no loss in efficiency of the equipment with time.
3. Transmission and distribution losses equal 7.5%, increasing the energy savings at the source by a corresponding 7.5%.
4. In the regional cost calculation, the acquisition payment from Bonneville is treated as a cost to Bonneville and, at the same time, a cash inflow to Atochem rather than a net zero cost. This is done because Atochem will incur a tax liability from the acquisition payment, thus a net cost to the region.

A.4 BONNEVILLE LEVELIZED COST CALCULATIONS

Input:

Acquisition payment paid	= \$212,500
Tax rate	= 0%
Project life	= 15 years
Depreciation	N/A
Energy savings (annual)	= 24,000,000 kWh
Output: levelized cost	= 0.69 mills/kWh

A.5 REGIONAL LEVELIZED COST CALCULATIONS (BONNEVILLE + ATOCHEM)

A. Atochem

Input:

Equipment installation	= \$1,410,000
Proposal preparation	= \$27,000
Acquisition payment received	= \$212,500
Tax rate	= 34%
Project life	= 15 years
Depreciation	= 7 years for coatings; 10 years for anodes and other equipment
Energy savings (annual)	= 24,000,000 kWh

Output: levelized cost = 5.0 mills/kWh

B. Regional levelized cost = Bonneville levelized cost + Atochem levelized cost

$$= 0.69 \text{ mills/kWh} + 5.0 \text{ mills/kWh}$$

$$= 5.7 \text{ mills/kWh}$$

A.6 LEVELIZED COSTS ALLOWING FOR TRANSMISSION AND DISTRIBUTION LOSSES

Input: transmission and distribution losses = 7.5%

Bonneville levelized cost = $0.69 \text{ mills/kWh} / 1.075 = 0.64 \text{ mills/kWh}$

Regional levelized cost = $5.7 \text{ mills/kWh} / 1.075 = 5.3 \text{ mills/kWh}$

APPENDIX B

COVER SHEET FROM ATOCHEM'S PROPOSAL

Cover Sheet

Directions: Complete Sections I through IV and submit. Photocopy and complete Section V to submit with Project Proposal. Photocopy and complete Section VI to submit with the Completion Report.

I. SPONSOR INFORMATION

Name and Full Address of Sponsoring Entity

Pennwalt Corporation
Inorganic Chemicals Division
2901 Taylor Way
Tacoma, WA 98421

Mailing Address: P. O. Box 1297, Tacoma, WA 98401-1297

II. PROJECT IDENTIFICATION

Title Sodium Chlorate Cell Conservation Modification	Name and Title of Project Manager or Other Contact Jimmie R. Hodges Mgr. of Technology & Engineering Services Area Code & Telephone No. (206) 627-9101 Ext. 287
Location of Proposed Project Pennwalt Corporation 2901 Taylor Way Tacoma, Wa 98421	
Standard Industrial Classification Code (SIC) 2819	Utility Service Area Tacoma City Light

III. PROJECT SUMMARY

Brief Description of Proposed Project

Modification of sodium chlorate cells which reduces voltage and current density by a closer anode-cathode spacing and additional anode area. Reduces power without reducing production.

IV. ESTIMATED ENERGY SAVINGS AND COSTS (submit with Project Abstract)

Average Annual Energy Savings	Total Project Costs	Estimated Incentive	Incentive Type
14,442,086 kWh/yr	\$ 1,490,000	\$ 250,000	X 5¢ per kWh 80% of Project Costs

V. ESTIMATED ENERGY SAVINGS AND COSTS (submit with Project Proposal)

Average Annual Energy Savings	Total Project Costs	Estimated Incentive	Incentive Type
15,400,000 kWh/yr	\$ 1,490,000	\$ 212,500	5¢ per kWh X 80% of Project Costs

VI. MEASURED ENERGY SAVINGS AND COSTS (submit with Completion Report)

Average Annual Energy Savings	Total Project Costs	Ratio of Actual Savings to Estimated Savings
kWh/yr	\$	%

**DATE
FILMED
01/10/93**