185

IMPACT EVALUATION OF AN ENERGY SAVINGS PLAN
PROJECT AT GEORGIA-PACIFIC CORPORATION

G. E. Spanner
D. R. Dixon

February 1991

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

EXECUTIVE SUMMARY

This impact evaluation of an energy conservation measure (ECM) that was recently installed at Georgia-Pacific Corporation (Georgia-Pacific) 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 Georgia-Pacific 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, interviews, submittal reviews (Georgia-Pacific's Completion Report, Proposal, and Abstract), and process evaluation reviews. The ECM itself consists of replacing rod anodes with blade anodes in 31 Denora Mercury Cells for producing chlorine and sodium hydroxide. Changing the shape of the blades allows the cells to operate at lower voltage, thereby reducing the energy required.

Energy savings resulting from this ECM are expected to be up to 6,242,200 kWh/yr depending on the production level of the plant. On a per ton basis, this ECM will save from 46.2 to 69.4 kWh/ton of chlorine. The ECM cost \$418,176 to install, and Georgia-Pacific received payment of \$250,000 from Bonneville for the acquisition of energy savings. The levelized cost of these energy savings to Bonneville will be between 3.3 and 7.5 mills/kWh over the ECM's expected 15-year life, and the levelized cost to the region will be between 5.9 and 13.4 mills/kWh.

CONTENTS

EXECUTIVE SUMMARY	iii
1.0 INTRODUCTION	1.1
1.1 APPROACH FOR IMPACT EVALUATION	1.2
1.2 PROJECT DESCRIPTION	1.3
1.3 SUMMARY OF PROJECT IMPACTS	1.5
2.0 IMPACT EVALUATION	2.1
2.1 ENERGY SAVINGS AND FUEL SWITCHING	2.1
2.2 IMPACTS TO THE FIRM	2.3
2.3 IMPACTS TO THE UTILITY	2.4
2.4 LEVELIZED COSTS	2.5
2.4.1 Bonneville Perspective	2.5
2.4.2 Regional Perspective	2.6
2.5 IMPACT ATTRIBUTABLE TO E\$P	2.7
APPENDIX A - FINANCIAL EVALUATION DETAILS	A.1
APPENDIX B - COVER SHEET FROM GEORGIA-PACIFIC'S PROPOSAL	B.1

IMPACT EVALUATION OF AN ENERGY SAVINGS
PLAN PROJECT AT GEORGIA-PACIFIC CORPORATION

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 Georgia-Pacific Corporation (Georgia-Pacific, or G-P) in Bellingham, Washington. The ECM at Georgia-Pacific is one of nine energy conservation projects to have its impact evaluated by PNL. All nine 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 Georgia-Pacific 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, up to a limit of \$250,000.

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:

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?

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

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. The major finding of the methodology development was that in the industrial sector, energy conservation projects must be considered 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 replacing the rod anodes with blade anodes in the mercury cells at Georgia-Pacific, four techniques were selected from the general methodology: engineering analysis, financial analysis, site visit and interview, and review of Georgia-Pacific's submittals. On-site submetering by PNL was not necessary because the metering performed by Georgia-Pacific in accordance with E\$P program requirements is adequate to determine the project's impact. Because Georgia-Pacific was not interviewed during the process evaluation of the E\$P program, no process evaluation results are available for this project. However, questions pertinent to the impact evaluation that are ordinarily asked during a process evaluation interview were included in the impact evaluation interview.

Representatives from PNL visited Georgia-Pacific on July 25, 1990, to view the ECM firsthand and to conduct a technical interview with the plant's Manager of Chlor/Alkali Operations.

1.2 PROJECT DESCRIPTION

In the energy conservation project at Georgia-Pacific, rod anodes in 31 Denora Mercury cells (mercury cells) were replaced with blade anodes. Sodium salt is broken down in the cells according to the electrochemical reaction

to produce chlorine and sodium hydroxide. In theory, 3.15 volts are required to drive the reaction. In actual practice, however, additional voltage is required to overcome voltage drops and resistances that occur in the equipment. The actual voltage required to drive the reaction is described by the equation

$$\text{Actual voltage} = 3.15 \text{ volts} + k(I/A)$$

where I is the electrical current, A is the area of the cell, and k is the electrical efficiency coefficient, known as the "k factor." Replacing the rod anodes with blade anodes allows the mercury cells to operate at a lower k factor, thereby reducing the voltage and hence the electrical power required to drive the reaction.

The chlor/alkali plant at Georgia-Pacific consists of 32 mercury cells, although one cell was converted to blade anodes as an experiment before G-P decided to submit an Abstract to Bonneville for an acquisition payment under the ESP. Therefore, this ECM consists of converting 31 cells to blade anodes. The cells themselves are large troughs that contain a shallow, flowing pool of liquid mercury. Above the mercury is a pool of brine into which the anodes are suspended. The anodes are covered by a flexible membrane to collect the gaseous products of the reaction. Bussbars are connected to the anodes and cathodes to provide electrical power to the cells.

Georgia-Pacific does not actually own the anodes, which are proprietary and are leased for \$3 per ton of chlorine produced, regardless of anode configuration (rod or blade). The anodes are typically refurbished about every 18-22 months, at which time the coating over the titanium structure is

replaced. Even though the blade anodes are expected to last longer between refurbishments, they will be refurbished at about the same frequency as the rod anodes were because the cell covers need replacement every 22 months anyway. Therefore, there are no significant non-energy savings from this ECM. The capital cost of this ECM was the one-time cost of converting the anodes from the rod configuration to the blade configuration at the anode vendor's plant. The conversions were completed over the course of a year as the anodes were removed from service for refurbishment on an accelerated schedule.

Roughly half of the chlorine produced at the plant is used for making wood pulp at Georgia-Pacific's adjacent mill and at a customer's mill in California; the other half is sold for water treatment in swimming pools and elsewhere. At about the time that all of G-P's cells were converted to blade anodes, the total market demand for chlorine dropped substantially for a variety of reasons. Consequently, Georgia-Pacific has only produced chlorine at about two-thirds of its normal capacity since this ECM was installed. Total market demand for chlorine may never completely recover, but Georgia-Pacific expects to get back to full production by about 1993, regardless. Georgia-Pacific believes that it is the low-cost producer of chlorine in the western region and that eventually it should operate at its capacity of 246 tons/day while the competition is forced to curtail production permanently.

As required by the ESP Program, Georgia-Pacific submitted three documents to Bonneville: an Abstract, a Proposal, and a Completion Report. The Abstract described the ECM in general terms and laid out Georgia-Pacific's expectations with regard to costs and benefits. Included was a calculation of the ECM's expected simple payback. The Proposal described the ECM in greater detail and included a slightly revised estimate of expected costs and energy savings. A Completion Report was submitted to Bonneville after the ECM was installed and Georgia-Pacific 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.

The total cost to Georgia-Pacific for this ECM was \$418,176, and Bonneville paid \$250,000 for the energy saved.

1.3 SUMMARY OF PROJECT IMPACTS

This E\$P project, or ECM, is expected to save up to 6,242,200 kilowatt-hours annually, depending on future production levels at Georgia-Pacific's chlor/alkali plant. The project will result in chlorine being produced with 46.2 to 69.4 kWh/ton less electricity.

Over the assumed 15-year life of this ECM, levelized costs to Bonneville will be between 3.3 and 7.5 mills/kWh (1 mill = 1/1000 of a dollar), and cost to the region will be between 5.9 and 13.4 mills/kWh. These costs are in real dollars and do not include additional savings that accrue if transmission losses are considered. The minimum levelized cost to Bonneville including transmission losses will be 3.2 mills/kWh and the minimum cost to the region will be 5.8 mills/kWh.

Without the acquisition payment from Bonneville, this ECM did not meet Georgia-Pacific'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

This ECM will result in electricity savings of 46.2 to 69.4 kWh/ton of chlorine produced. Depending upon production levels at the plant, the energy savings attributable to the switch from rod anodes to blade anodes will be up to 6,242,200 kWh/yr. The voltage reduction from replacing the rod anodes with blades is calculated as follows:

$$\begin{aligned}\text{Voltage reduction} &= \text{voltage(rod)} - \text{voltage(blade)} \\ &= [3.15 + k(\text{rod})(I/A)] - [3.15 + k(\text{blade})(I/A)] \\ &= (I/A)[k(\text{rod}) - k(\text{blade})]\end{aligned}$$

For any given k value and current (I), the savings (in kilowatt-hours) from replacing the rod anodes with blades is

$$\text{Savings (kWh)} = (\text{voltage reduction}) \cdot (\text{no. of cells}) \cdot (\% \text{ of cells on-line}) \cdot (I) \cdot (24 \text{ hours}) \cdot (362 \text{ days}) / (96\% \text{ rectifier efficiency})$$

$$\text{Savings (kWh)} = (I/19.44 \text{ m}^2)[k(\text{rod}) - k(\text{blade})] \cdot (31 \text{ cells}) \cdot (.96) \cdot (I) \cdot (24) \cdot (362) / (.96)$$

$$\text{Savings (kWh)} = 13,854 \cdot [k(\text{rod}) - k(\text{blade})] \cdot (I)^2$$

If we use the data from Georgia-Pacific's completion report, the maximum savings at 225 kAmps, which corresponds to 88,000 tons of Chlorine per year is

$$\text{Savings (kWh)} = 13,854 \cdot (0.0921 - 0.0832) \cdot (225)^2$$

$$\text{Savings (kWh)} = 6,242,200 \text{ kWh/yr}$$

Figure 2.1 shows the relationship between energy savings and the amount of chlorine produced. In the figure, the vertical distance from the dashed

FIGURE 2.1. Total Energy Savings at Various Production Levels

line to the solid line (across the shaded area) represents the energy savings at various production levels that are attributable to the switch from rod anodes to blade anodes. The blank area represents the savings that would accrue by reducing the production level even if the anodes were never replaced. For the purposes of this impact evaluation, only energy savings attributable to replacement of the anodes are considered. The savings from reduced production levels are included in the figure only as a convenience to illustrate the relationship between energy savings and production levels.

As the figure shows, the maximum savings resulting from anode replacement occur at 88,000 tons/year, the maximum production rate with the old rod anodes. At production levels greater than this, the total savings decrease until no net savings occur at the maximum production level with the new blade anodes. In other words, operating the plant at its maximum capacity with the blade anodes does not result in a net reduction in electricity consumption because the plant consumes power at the same rate (34.4 MW) as before the

anodes were replaced. At this production rate, however, the plant is producing chlorine with 69.4 kWh/ton less electricity so that efficiency improvements do occur even at maximum plant output (90,000 tons/year).

Fuel Switching

Because the production of chlorine and sodium hydroxide is an electrochemical process, fuel switching away from electricity is not an option. Georgia-Pacific does not cogenerate any electricity at its mill in Bellingham, so all electricity used for processing at the mill is obtained directly from Bonneville.

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 this ECM did indeed improve the productivity of the chlor/alkali production process. When Georgia-Pacific originally proposed to install blade anodes in place of rod anodes, it expected to maintain the same level of electricity consumption and to increase chlorine production through improved energy efficiency. By the time all of the cells were converted, however, total market demand for chlorine had dropped significantly, and G-P found that it had to reduce production to match market conditions. The drop in market demand for chlorine was caused by several factors, most notably concerns about dioxins in the pulp industry.

At full production, the chlor/alkali plant at G-P draws 34.4 MW and produces 246 tons of chlorine per day with blade anodes. Before the anodes were converted, the plant drew the same amount of power but was capable of producing only 242 tons per day. Regardless of market conditions, the plant will draw no more than 34.4 MW because its demand for electricity is limited by the current-carrying capability of the cells. At all levels of production, the plant is more energy-efficient with the blade anodes; therefore, chlorine will

be produced in the future with energy savings of 46.2 to 69.4 kWh/ton (60,000 and 90,000 tons of chlorine/year, respectively) depending on production rate.

Because of the reduction in market demand for chlorine, Georgia-Pacific plans to run its chlor/alkali plant at a power consumption rate of 24 MW (corresponding to a production rate of 208 tons/day) for the next year. Because G-P feels that it is the low-cost producer of chlorine in its market region (roughly the 5 westernmost states of the continental United States), it expects to get back up to full production by 1993 while its competitors are forced to curtail production, perhaps permanently.

If it is true that in the long run this ECM will cause G-P's competitors to produce less (and hence, to use less energy) while G-P's energy consumption remains fixed at its maximum, the questions of whether or not Bonneville will ultimately realize the maximum savings or a net decrease in energy consumption from this ECM are difficult to answer. Georgia-Pacific is in competition with seven other chlor/alkali plants in its market region, three of which are in Bonneville's service region (two in Tacoma and one in Portland). The other four plants are in California, Nevada, and British Columbia. With the information currently in hand, it is not possible to assess Georgia-Pacific's assertion that it is the low-cost producer, nor is it possible to predict which plants will curtail production if market demand for chlorine never resumes pre-1989 levels. However, Georgia-Pacific's California competitor recently announced that over the next two years, it will prepare to shut down its chlor/alkali plant permanently. This announcement lends some credibility to Georgia-Pacific's intention to eventually get back up to full production. As a result of this ongoing market uncertainty, the ultimate impact of this ECM on Bonneville is difficult to assess, except to say that chlorine will be produced at Georgia-Pacific using less electricity per ton than before the ECM was installed.

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 Georgia-Pacific is a Direct Service Industry that buys its power directly from Bonneville, no local utility is involved in this project. As described above, the net impact to Bonneville depends upon production levels at the plant. If the plant operates at its maximum capacity, there will be no net reduction in energy consumption, although more chlorine will be produced per kilowatt-hour consumed. If, on the other hand, the plant operates at significantly less than its maximum capacity, Bonneville will see a reduction in electricity consumption per ton of chlorine as well as a reduction in total consumption.

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 definition 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 Georgia-Pacific 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 was 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 paid, capital costs, etc.) and the energy savings, and must assume a discount rate and ECM life. The levelized costs for Georgia-Pacific are based on two levels of chlorine production: 88,000 tons/year (maximum production with the old rod anodes), and 60,000 tons/year (likely minimum production during the life of the ECM). At the higher production level, energy savings are 6,242,200 kWh/yr, while energy savings at the lower level are 2,774,300 kWh/yr. With energy savings of 6,242,200 kWh/yr, the project's levelized cost from Bonneville's perspective will be 3.3 mills/kWh (see Appendix A). At energy savings of 2,774,300 kWh/yr, Bonneville's levelized cost will be 7.5 mills/kWh. Bonneville's levelized cost at higher production decreases to 3.2 mills/kWh when transmission losses are considered and to 7.3 mills/kWh at the lower production rate. Transmission losses increase the energy savings at the source by 2.5%. In past impact evaluations for the ESP, both transmission and distribution losses were considered. Because G-P is a Direct Service Industry, however, only transmission losses are pertinent to this ECM.

The levelized costs calculated in this impact evaluation include the acquisition payment paid 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 the 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 Georgia-Pacific are combined. The acquisition payment paid by Bonneville is included as a cost to Bonneville and as a reduction in cost to Georgia-Pacific. 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 are shown for three separate cases in Table 2.1. These three cases span a likely range of production levels over

TABLE 2.1. Regional Levelized Cost at Various Production Levels

Production Level tons Cl ₂ /year)	Reduction in Net Energy Consumption	Bonneville Levelized Cost (mills/kWh saved)		Regional Levelized Cost (mills/kWh saved)	
		Without Transmission Effects	With Transmission Effects	Without Transmission Effects	With Transmission Effects
60,000	2,774,300	7.5	7.3	13.4	13.1
88,000	6,242,200	3.3	3.2	5.9	5.8
90,000	0	n/a	n/a	n/a	n/a

the life of the project. The first case is a low production level (60,000 tons/year) that would represent the lower end of the expected range (calendar year 1990 production was actually 58,000 tons). The annual energy savings for this case is 2,774,300 kWh/yr, which results in a regional levelized cost of 13.4 mills/kWh. The second case is equivalent to the full plant capacity prior to the ECM (88,000 tons of chlorine/year). In its Completion Report, Georgia-Pacific used this level of production to calculate energy savings for the project. The annual energy savings for this case is 6,242,200 kWh/yr, which results in a regional levelized cost of 5.9 mills/kWh. The third case in the table is 90,000 tons of chlorine/yr, which is the plant's maximum capacity after switching to the more efficient blade anodes. No levelized costs were calculated for this case because at this production level, there is no net decrease in energy consumption even though chlorine is produced with less energy per ton.

Included in the costs to Georgia-Pacific are the capital costs for replacing the rod anodes with blade anodes in 31 production cells. Other savings (labor and material savings due to less frequent anode replacements) are not included in these levelized costs because they represent non-electrical benefits that are outside the scope of this impact evaluation.

Including transmission losses, the levelized cost decreases to 5.8 mills/kWh at a production rate of 88,000 tons/year, and to 13.1 mills/kWh at 60,000 tons/year.

2.5 IMPACT ATTRIBUTABLE TO ESP

5. How much of the ECM's impact can be attributed to the ESP?

When this project was originally proposed to Bonneville, it was expected to cost \$487,000 and result in electrical savings of \$144,000 per year for a simple payback of 3.4 years. Georgia-Pacific typically limits funding to those projects that result in simple payback of 3 years or less. In fact, this project had been proposed to upper management and was turned down before Bonneville offered an acquisition payment under the ESP. With a \$250,000 acquisition payment from Bonneville, the simple payback for this project was expected to become 1.6 years, which is well within G-P's normal funding criteria.

Regarding the project's technical risk, Georgia-Pacific had been investigating the switch to blade anodes for some time and had gone so far as to convert one cell to blades as a means of evaluating the technology. The converted cell performed up to expectations and, from a technical perspective, G-P was satisfied that switching to blade anodes was a sound idea.

Considering the facts presented above, 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.

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 - The annualized costs to Bonneville, direct and indirect, per unit of energy saved by the conservation measure. Costs included are the acquisition payment paid and the program administrative costs (although no administrative costs are included in this analysis of the ECM at Georgia-Pacific Corporation).

Levelized Cost to Region - The sum of annualized costs to Bonneville and Georgia-Pacific 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, minus any non-electrical savings that result from the ECM.

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

PVICI = 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. Equal annual energy savings--savings (kilowatt-hours) per year--is constant over the life of the project. This assumes no loss in efficiency of the equipment with time.
3. Transmission losses equal 2.5%, increasing the energy savings at the source by a corresponding 2.5%.
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 Georgia-Pacific rather than a net zero cost. This is done because Georgia-Pacific will incur a tax liability from the acquisition payment, thus a net cost to the region.

A.4 BONNEVILLE LEVELIZED COST CALCULATIONS

A.4.1 Chlorine Production Rate of 60,000 Tons/Yr

Input: one-time expenses

Acquisition payment paid (year 0) = \$250,000

Administrative costs (year 0) = \$0

Tax rate = 0%

Energy savings (annual) = 2,774,300 kWh

Output: levelized cost = 7.5 mills/kWh

A.4.2 Chlorine Production Rate of 88,000 Tons/Yr

Input: one-time expenses

Acquisition payment paid (year 0) = \$250,000

Administrative costs (year 0) = \$0

Tax rate = 0%

Energy savings (annual) = 6,242,200 kWh

Output: levelized cost = 3.3 mills/kWh

A.5 REGIONAL LEVELIZED COST CALCULATIONS (BONNEVILLE + GEORGIA-PACIFIC)

A.5.1 Chlorine Production Level of 60,000 Tons/Yr

A. Georgia-Pacific (These levelized costs are based on the replacement costs to change from the rod anodes to blade anodes for 31 cells.)

Input: initial capital

Equipment = \$418,176

One-time expenses (revenues)

Acquisition payment received = (\$250,000)

Annual recurring expenses (revenues and savings)

None

Tax rate = 34%

Project Life = 15 years

Depreciation = 5 years

Energy savings (annual) = 2,774,300 kWh

Output: levelized cost = 5.9 mills/kWh

B. Regional levelized cost = Bonneville levelized cost + Georgia-Pacific levelized cost

= 7.5 mills/kWh + 5.9 mills/kWh

= 13.4 mills/kWh

A.5.2 Chlorine Production Level of 88,000 Tons/Yr

- A. Georgia-Pacific (These levelized costs are based on the replacement costs to change from the rod anodes to blade anodes for 31 cells.)

Input: initial capital

Equipment = \$418,176

One-time expenses (revenues)

Acquisition payment received = (\$250,000)

Annual recurring expenses (revenues and savings)

None

Tax rate = 34%

Project Life = 15 years

Depreciation = 5 years

Energy savings (annual) = 6,242,200 kWh

Output: levelized cost = 2.6 mills/kWh

- B. Regional levelized cost = Bonneville levelized cost + Georgia-Pacific levelized cost

= 3.3 mills/kWh + 2.6 mills/kWh = 5.9 mills/kWh

A.6 LEVELIZED COSTS ALLOWING FOR TRANSMISSION AND DISTRIBUTION LOSSES

A.6.1 Chlorine Production Level of 60,000 Tons/Yr

Input: transmission losses = 2.5%

Bonneville levelized cost = 7.5 mills/kWh/1.025 = 7.3 mills/kWh

Regional levelized cost = 13.4 mills/kWh/1.025 = 13.1 mills/kWh

A.6.2 Chlorine Production Rate of 88,000 Tons/Yr

Input: transmission losses = 2.5%

Bonneville levelized cost = 3.3 mills/kWh/1.025 = 3.2 mills/kWh

Regional levelized cost = 5.9 mills/kWh/1.025 = 5.8 mills/kWh

A.7 GEORGIA-PACIFIC SIMPLE PAYBACK CALCULATIONS

The simple payback calculations are based on data obtained during the site visit and from the Proposal that pertain to the anode replacement for 31 cells at Georgia-Pacific.

Input: initial capital

Equipment = \$487,000

One-time expenses (revenues)

Acquisition payment received = (\$250,000)

Annual recurring expenses (O&M)

None

Annual recurring savings

Electricity = \$144,000 (based on 6,239,000 kWh at \$0.02307/kWh)

Tax rate = 34%

Project Life = 15 years

Energy savings (annual) = 6,239,000 kWh

Output: Simple Payback = 1.6 years (with acquisition payment)

Simple Payback = 3.4 years (without acquisition payment)

APPENDIX B

COVER SHEET FROM GEORGIA-PACIFIC'S PROPOSAL

APPENDIX B

COVER SHEET FROM GEORGIA-PACIFIC'S PROPOSAL

PROPOSAL
Cover Sheet

Exhibit A **FEB 22 1988**
Page 1 of 1

Directions: Complete Sections I through IV and submit with Project Abstract. 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

Georgia-Pacific Corporation
300 Laurel Street
Bellingham, Washington 98225

II. PROJECT IDENTIFICATION

Title	Name and Title of Project Manager or Other Contact
Blade Anode Conversion	Brian J. Hagan
Location of Proposed Project	Manager, Chlor/Alkali Operat.
Bellingham, Washington	Area Code & Telephone No.
	(206) 733-4410
Standard Industrial Classification Code (SIC)	Utility Service Area
2812	Non-Aluminum DSI

III. PROJECT SUMMARY

Brief Description of Proposed Project

Replace existing anodes in the chlorine cells with an electrically more efficient blade design.

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

Average Annual Energy Savings	Total Project Costs	Estimated Incentive	Incentive Type
6,239,000 kWh/yr	\$ 487,000	\$ 250,000	☒ 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
6,302,300 kWh/yr	\$ 490,000	\$ 250,000	☒ 5¢ per kWh ☐ 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	\$	%