

**Impact Evaluation of a Mill Tailings
Thickener Installed at J. R. Simplot
Company's Smoky Canyon Mine Under
The Energy Savings Plan**

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Summary

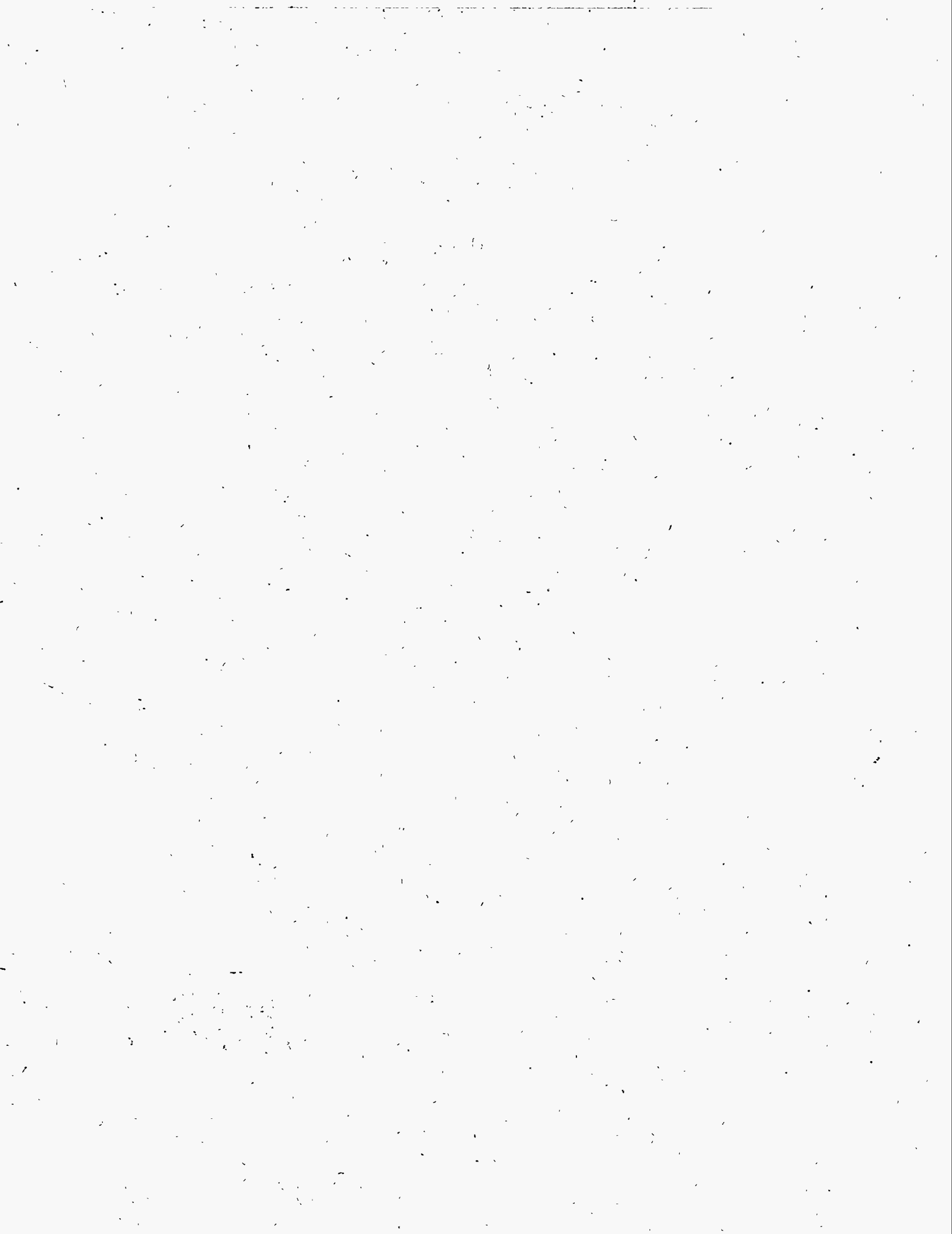
This impact evaluation of a mill tailings thickener that was recently installed at J. R. Simplot Company's (Simplot's) Smoky Canyon Mine near Afton, Wyoming was conducted for the Bonneville Power Administration (Bonneville) as part of an evaluation of its Energy Savings Plan (ESP) Program. The project consists of adding a mill tailings thickener to Simplot's phosphate mining facility. By adding the thickener at an elevation nearly as high as the mill, water recovered at the thickener can be pumped to the mill for reuse with less energy than was formerly required when all of the recovered water had to be pumped from a settling pond located at a much lower elevation. The objective of this impact evaluation was to assess how much electricity is being saved at Simplot as a result of the ESP and to determine how much the savings cost Bonneville and the region. The impact of the project was evaluated with a combination of engineering analysis, financial analysis, interviews, and submittal reviews (Simplot's proposal, proposal addendum, and completion report).

Based on this impact evaluation, energy savings from this project are expected to be 9,483,000 kilowatt-hours/year (kWh/yr) or 1.083 average megawatts (aMW). On a unit production basis, this project will save 7.21 kWh/mill product dry tonne (6.54 kWh/mill product dry ton). The project cost \$1,450,000 to install (approximately half spent in 1991 and half in 1992), and Simplot received payment of \$250,000 in 1993 from Bonneville for the acquisition of energy savings. The real levelized cost of these energy savings to Bonneville is 2.5 mills/kWh (in 1993 dollars) over the project's assumed 15-year life, and the real levelized cost to the region is 30.2 mills/kWh (in 1993 dollars), not including transmission and distribution effects.

Given the magnitude of the investment required to implement this project, the acquisition payment had a relatively minor impact on the economic feasibility compared to most other ESP projects. For example, based on the expected costs and energy savings presented in the addendum to the project proposal, the acquisition payment reduced the simple payback period from 4.9 to 4.1 years. Nevertheless, Simplot personnel indicated that the ESP provided the motivation to consider the project at all. The thickener would not have been installed without the acquisition payment from Bonneville. Therefore, all of the project's impact can be attributed to the ESP.

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1.0 Introduction

This report describes Pacific Northwest Laboratory's (PNL's)^(a) evaluation of the impact of an energy conservation project completed in the fall of 1992. The project (a mill tailings thickener) was installed at J.R. Simplot Company's (Simplot's) Smoky Canyon Mine in Caribou County, Idaho near Afton, Wyoming. The project at Simplot is one in a continuing series of industrial 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 reduce electricity consumption in the industrial sector of Bonneville's service territory. For the Simplot project, the acquisition payment offered under the program was equal to the lesser of 10¢/kilowatt-hour (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 electricity is saved by the project 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 **electricity is saved annually** by the energy conservation project in terms of kilowatt-hours, kilowatt-hours per unit of plant output (unit savings), and average megawatts (aMW)? Also, did any **fuel switching** result from implementing this project?
2. If the project 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 electricity consumption (in kilowatt-hours) from implementing the project?
4. What are the **real levelized costs** of the project from the perspectives of Bonneville and the region?
5. How much of the project's **impact can be attributed** to the ESP?

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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, 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 installing the mill tailings thickener at Simplot, four techniques were selected from the general methodology: engineering analysis, financial analysis (see Appendix A), site visit and interview, and review of Simplot's submittals. Submetering performed by Simplot in accordance with E\$P program requirements was relied upon by PNL to determine the project's impact.

Representatives from PNL visited Simplot on July 20, 1993, to view the project firsthand and to interview the Mill Superintendent and the Programs Specialist from the local utility, Lower Valley Power and Light.

1.2 Project Description

At its Smoky Canyon Mine, Simplot extracts phosphate (P_2O_5) ore using typical surface mining practices and beneficiates the ore at an adjacent mill. The beneficiated ore is pumped in slurry form to a fertilizer plant in Pocatello, Idaho, 145 km (90 miles) away. The ore is approximately 27% phosphate as mined, and is beneficiated to 31% at the mill before sending it to the fertilizer plant.

The tailings stream from the mill contains very fine (less than 37 microns in diameter) calcium oxide particles suspended in water. After separating the tailings from the water, the water is reused in the milling process. No liquid effluent leaves the property. The tailings remain in the settling ponds.

Before installing the thickener, the tailings and water were separated in a settling pond some distance from the mill, at an elevation 221 m (725 ft) below the mill (total dynamic head of 436 m [1,430 ft]). After settling, the water from the pond was pumped back up to the mill for reuse. Seven pumps (total power 2610 kW [3,500 hp]) were used to lift the water from the pond to the mill.

The energy conservation project consisted of adding a thickener at an elevation 46 m (150 ft) (total dynamic head of 119 m [390 ft]) below the mill to separate much of the water from the tailings stream before sending a more concentrated tailings stream to the settling pond. By reclaiming water at an elevation closer to the mill, the required pumping energy was substantially reduced. The connected pumping power at the thickener is 520 kW (700 hp). Even with the thickener, there is still water pumped from the pond to the mill, but only one 373 kW (500 hp) pump is required for this.

Simplot submitted three documents to Bonneville: a proposal (February 1990), a proposal addendum (November 1990), and a completion report (May 1993). The proposal described the energy conservation project and presented Simplot's cost and benefit expectations. Included was a calculation of the project's expected simple payback. A completion report was submitted to Bonneville after the project was installed and Simplot had verified the resulting energy savings. This document listed the actual costs of the project along with a calculation of the energy savings that had been achieved. A copy of the cover sheet from the completion report is included in Appendix B.

Simplot verified energy savings by metering energy consumption at the thickener and settling pond for about 5 months after the project was completed and comparing actual consumption with the thickener to predicted consumption without the thickener for the same production conditions. Historical data describing mill production and energy consumption at the settling pond were used to develop an equation for predicting energy consumption with the old system as a function of mill production. Energy savings calculated for the test period were extrapolated to estimate annual energy savings.

The total cost to Simplot for this project was \$1,450,000, and Bonneville paid \$250,000 for the energy saved, which was the maximum E\$P payment allowed for this project.

1.3 Summary of Project Impacts

This E\$P project is expected to save 9,483,000 kWh annually or 1.083 aMW. Over the assumed 15-year life of this project, the levelized cost to Bonneville is 2.5 mills/kWh (1 mill = 1/1000 of a dollar), and the cost to the region is 30.2 mills/kWh. These costs are in real 1993 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 is 2.3 mills/kWh, and the cost to the region is 28.1 mills/kWh.

Compared to many other ESP projects, the acquisition payment from Bonneville did not have a significant impact on economic feasibility because of the magnitude of the investment required. For example, based on the expected costs and energy savings presented in the addendum to the project proposal, the acquisition payment reduced the simple payback period from 4.9 to 4.1 years. Nevertheless, Simplot personnel indicated that the ESP provided the incentive for them to consider the project, where they may not have otherwise. Therefore, we conclude that the project would not have been installed in the absence of the ESP.

2.0 Impact Evaluation

The following section addresses the five major objectives of the impact evaluation, as previously stated in Section 1.0.

2.1 Energy Savings and Fuel Switching

How much electricity is saved annually by the project in terms of kilowatt-hours, kilowatt-hours per unit of plant output, and average megawatts? Also, did any fuel switching result from implementing this project?

Energy Savings

Simplot metered energy consumption at the thickener and tailings pond from December 17, 1992 through May 17, 1993. Total energy consumption for this period was 3,364,800 kWh while production was 610,007 tonnes (672,406 tons)^(a). Energy consumption without the thickener was estimated based on historical energy consumption and production data. Monthly data collected from January 1989 through September 1990 were used to develop Equation 1, which predicts monthly energy consumption based on monthly production. Note that Equation 1 is different from a similar equation presented in Simplot's addendum to the proposal because an "outlier" was removed from the original 21-month data set. Production data for the test period were applied to Equation 1 to yield an estimated consumption with the old system of 7,222,141 kWh.

$$\begin{aligned} \text{Monthly kWh} &= 330,512 + 8.9315 * \text{monthly production (tonnes)} & (1) \\ &(\text{Monthly kWh} = 330,512 + 8.1027 * \text{monthly production [tons]}) \end{aligned}$$

The energy consumption figures reported above for the test period were extrapolated to a year and adjusted to the expected average annual production rate of 1.32 million tonnes (1.45 million tons). The resultant annual energy consumption figures are 15,537,646 kWh for the old system and 7,219,428 kWh for the new system, for a savings of 8,318,218 kWh with the mill tailings thickener.

Neither the above figures nor the annual energy savings reported by Simplot in their completion report include the impact of recently opening a lower settling pond. The upper settling pond has nearly

(a) A second set of data indicated that production was 610,530 tonnes (672,983 tons).

filled with tailings, so the tailings stream from the thickener must now flow down to the lower tailings pond, and reclaimed water must be pumped from the lower tailings pond to the upper settling pond first, and then back up the hill to the thickener.

Energy consumption at the lower settling pond was calculated with and without the thickener based on operating data provided by Simplot during the site visit. Specifically, the total dynamic head was estimated to be about 50 m (about 160 feet); pump and motor efficiencies were assumed to be 85% and 95%, respectively. When the mill is operating, the average flow from the settling ponds is 379 liters per second (lps) (6000 gpm) without the thickener, but only 69 lps (1100 gpm) with the thickener. Flow reduces to 63 lps (1000 gpm) in either situation when the mill is not running. An annual production rate of 1.32 million tonnes (1.45 million tons) requires the mill to operate about 6300 hours.

Based on the assumptions listed above, annual energy consumption at the lower settling pond was estimated to be 1,491,100 kWh without the thickener and 326,087 kWh with the thickener, for a net savings of 1,165,013 kWh. Thus, the total energy savings associated with installing the thickener were estimated to be 9,483,231 kWh/year (rounded to 9,483,000 kWh) or 1.083 aMW. This is about 1.4 million kWh/year greater than the savings reported in Simplot's completion report.

Fuel Switching

Fuel switching was not an option for this project and therefore did not occur.

2.2 Impacts to the Firm

If the project 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 project improved the productivity of the production process by reducing the amount of pumping work required to reclaim water from the tailings stream for the mill. Production at the Smoky Canyon Mine has gradually increased in the last several years to an annual rate of 1.32 million tonnes (1.45 million tons), which it plans to maintain for the foreseeable future. Production is tied directly to the demand for Simplot's phosphate-based fertilizer products. Simplot has no other phosphate mines in the region, so production cannot be shifted to Smoky Canyon to take advantage of its increased productivity.

2.3 Impacts to the Utility

What is the net impact to the serving utility in terms of electricity consumption (in kilowatt-hours) from implementing the project?

Because the project had no cogeneration or other complicating factors, all of the energy savings from this project will be reflected in reduced load at the utility, Lower Valley Power and Light. The net impact to the serving utility from this project is an electrical load reduction of 9,483,000 kWh/yr.

2.4 Real Levelized Costs

What are the real levelized costs of the project from the perspectives of Bonneville and the region?

Real 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. Levelized costs are calculated from the perspectives of Bonneville and the region (Bonneville and Simplot combined).

In the industrial sector, it is not possible to accurately predict the life of a project because any number of external factors could cause the project to have a longer or shorter life than expected when it is installed. To allow comparisons of levelized costs among projects installed under the ESP, all projects are assumed by PNL to have a life of 15 years for evaluation purposes. Even though some projects will have longer or shorter lives, 15 years is considered a typical life for projects in the industrial sector.

2.4.1 Bonneville Perspective

To determine the real levelized costs to Bonneville and to the region, we must know the project costs (acquisition payment, capital costs, etc.) and the energy savings, and we must assume a discount rate and project life. With energy savings of 9,483,000 kWh/yr, the project's levelized cost from Bonneville's perspective is 2.5 mills/kWh (in 1993 dollars; see Appendix A). Bonneville's levelized

cost decreases to 2.3 mills/kWh when transmission and distribution losses are considered. Including these losses allows for the comparison of conservation resources with generation, which is measured at the point of production rather than at the site of the end user (point of delivery).

The levelized costs calculated in this impact evaluation include the acquisition payment by Bonneville as well as the estimated administrative and evaluation costs associated with this project.

2.4.2 Regional Perspective

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

The real levelized cost (in 1993 dollars) to the region for acquiring annual energy savings of 9,483,000 kWh is 30.2 mills/kWh saved. Including transmission and distribution losses, the levelized cost decreases to 28.1 mills/kWh saved.

2.5 Impact Attributable to E\$P

How much of the project's impact can be attributed to the E\$P?

Unlike many E\$P projects, the acquisition payment had a relatively minor impact on economic feasibility due to the magnitude of the initial capital investment (\$1.45 million). For example, based on the expected costs and energy savings presented in the addendum to the project proposal, the acquisition payment reduced the simple payback period from 4.9 to 4.1 years. Nevertheless, Simplot personnel indicated that the E\$P provided the motivation to consider the project at all. Simplot's primary reason for installing the thickener was to save energy. Other potential benefits were too nebulous to include as part of the feasibility assessment. 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 E\$P.

3.0 Glossary

Beneficiate - To improve the chemical or physical properties of an ore.

Flocculent - A chemical added to a dispersion of solids in a liquid to bring together the fine particles.

Tailings - The refuse material resulting from processing ore.



4.0 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

Real 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 (not the "adjusted system real levelized 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.

Real Levelized Cost to Bonneville Power Administration (Bonneville) - The annualized costs to Bonneville, direct and indirect, per unit of energy saved by the energy conservation project. Costs included are the acquisition payment and the program administrative costs, as well as the costs to evaluate the impact of this project.

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

A.2 Real Levelized Cost Formula

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

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 costs

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 real 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 7.12% (combines a real discount rate of 3.0% and an inflation rate of 4.0%). The costs are annualized over the life of the project using the capital recovery factor at a real discount rate of 3.0%, resulting in real levelized costs.
2. Annual energy savings (kWh/yr) are constant over the 15-year 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 (point of generation) 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 Simplot rather than a net-zero cost. This is done because Simplot will incur a tax liability from the acquisition payment, thus incurring a net cost to the region.

A.4 Bonneville Real Levelized Cost Calculations

Input:

Acquisition payment paid	= \$250,000 (1993\$)
Administrative and evaluation costs	= \$39,000 (mix of 1992\$ and 1993\$)
Tax rate	= 0%
Annual energy savings	= 9,483,000 kWh
Output: real levelized cost	= 2.5 mills/kWh (1993\$)

A.5 Regional Real Levelized Cost Calculations (Bonneville + Utility + Simplot)

A. Simplot

Input:

Equipment installation	= \$1,420,000 (mix of 1991\$ and 1992\$)
Administrative costs	= \$30,000 (mix of 1991\$ and 1992\$)
Acquisition payment received	= \$250,000 (1993\$)
Incremental maintenance per year	= \$145,000 (1993\$)
floculent	\$175,000
thickener - pumps	(\$30,000)
net increase	\$145,000
Tax rate (federal and state)	= 39.3%
Project life	= 15 years
Depreciation	= 7 years
Annual energy savings	= 9,483,000 kWh
Output: real levelized cost	= 27.7 mills/kWh (1993\$)

B. Regional real levelized cost = Bonneville levelized cost + Simplot levelized cost
= 2.5 mills/kWh + 27.7 mills/kWh
= 30.2 mills/kWh (1993\$)

A.6 Real Levelized Costs Allowing for Transmission and Distribution Losses

Transmission and distribution losses = 7.5%
Bonneville levelized cost = 2.5 mills/kWh/1.075 = 2.3 mills/kWh (1993\$)
Regional levelized cost = 30.2 mills/kWh/1.075 = 28.1 mills/kWh (1993\$)

Appendix B

Cover Sheet From Simplot's Completion Report

Appendix B

Cover Sheet From Simplot's Completion Report

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

JR Simplot Company
 Smoky Canyon Mine
 P.O.B. 1270
 Afton, Wyoming 83110

II. PROJECT IDENTIFICATION

Title	Name and Title of Project Manager or Other Contact	
Mill Tailings Thickener	Robert Black	
Location of Proposed Project	Mine Manager	
Smoky Canyon Mine, Caribou County, Idaho--20 miles west of Afton, WY	Area Code & Telephone No.	
	307-886-9861	
Standard Industrial Classification Code (SIC)	Utility Service Area	Portion of kWh purchased from servicing Utility
2819	Lower Valley P&L	100%

III. PROJECT SUMMARY

Brief Description of Proposed Project

Installation of a mill tailings thickener for power savings and process water reclaim.

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

Average Annual Energy Savings	Total Project Costs	Incentive Estimate	Incentive Type	Ratio of Incentive Estimate to Total Project Costs
7,244,290 kWh/yr	\$ 1,461,078	\$ 250,000	5¢ per kWh 80% of Project Costs	17.1%

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

Average Annual Energy Savings	Total Project Costs	Incentive Limit	Incentive Type	Ratio of Incentive Limit to Total Project Costs
7,244,290 kWh/yr	\$ 1,461,078	\$ 250,000	5¢ per kWh 80% of Project Costs	17.1%

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

Average Annual Energy Savings	Total Project Costs	Ratio of Actual Savings to Estimated Savings
8,111,035 kWh/yr	\$ 1,374,884	111.96%